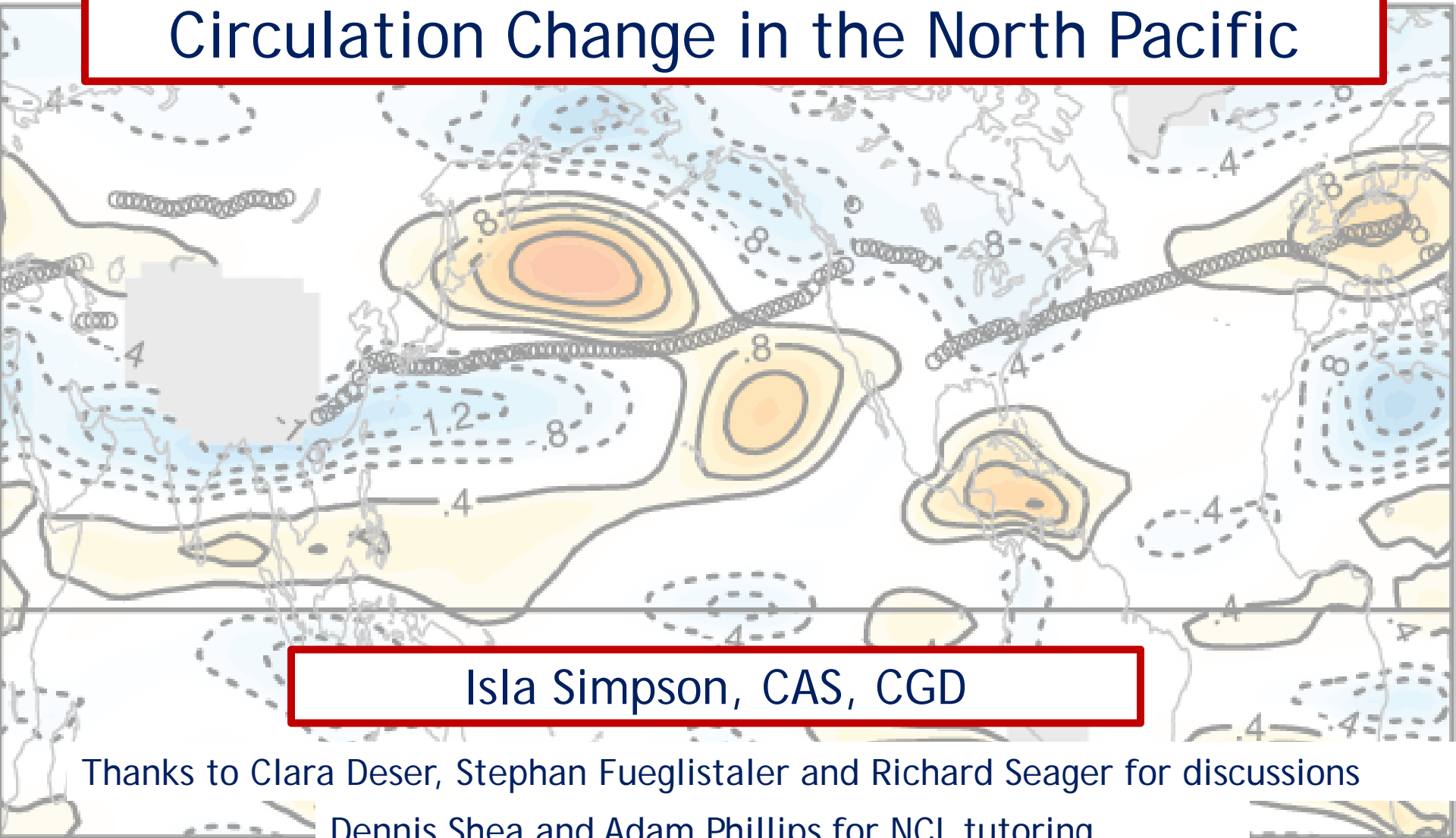


Model Diversity in Future Predicted Circulation Change in the North Pacific



Isla Simpson, CAS, CGD

Thanks to Clara Deser, Stephan Fueglistaler and Richard Seager for discussions

Dennis Shea and Adam Phillips for NCL tutoring

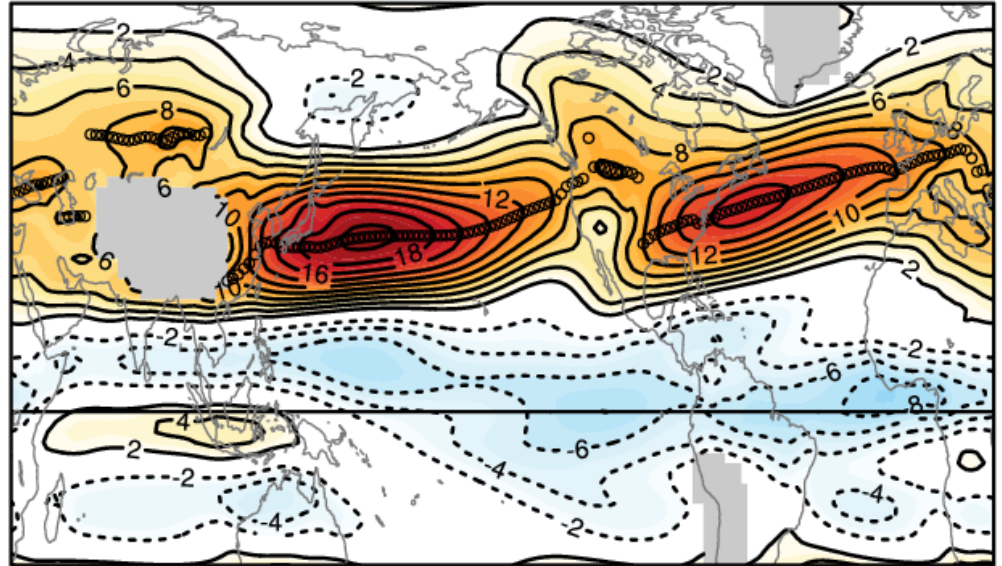
35 CMIP5 Models

DJF season

- **PAST** = 1979-2005 of *historical*
- **FUTURE** = 2070-2099 of *RCP8.5*

700hPa zonal wind
Multi-Model Mean

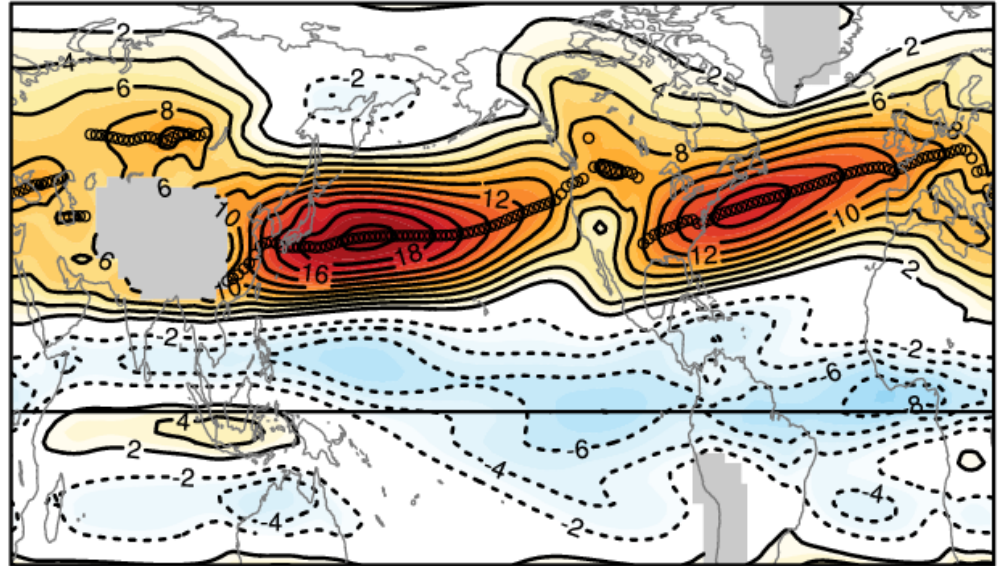
Past Climatology



- Local Jet Maximum

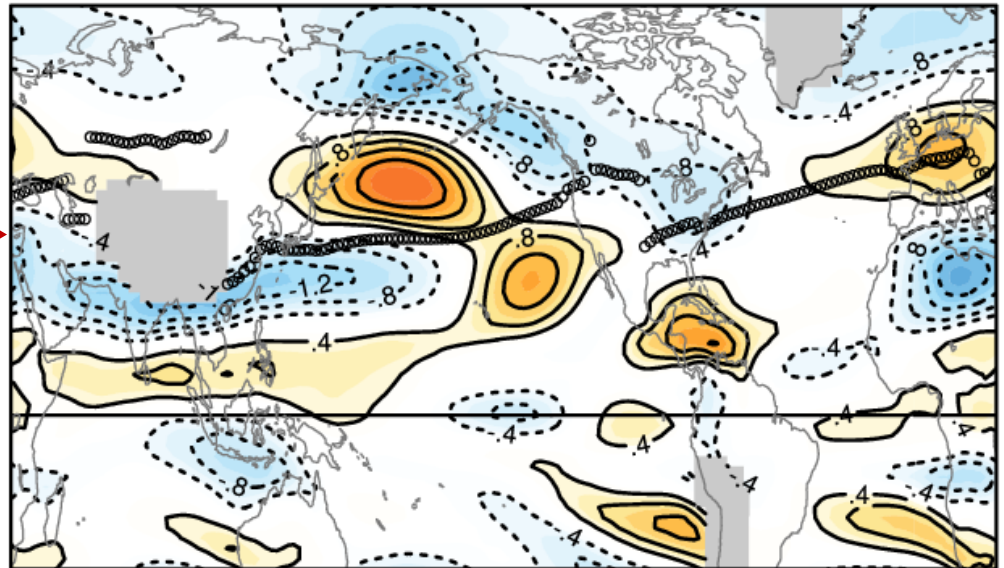
700hPa zonal wind Multi-Model Mean

Past Climatology



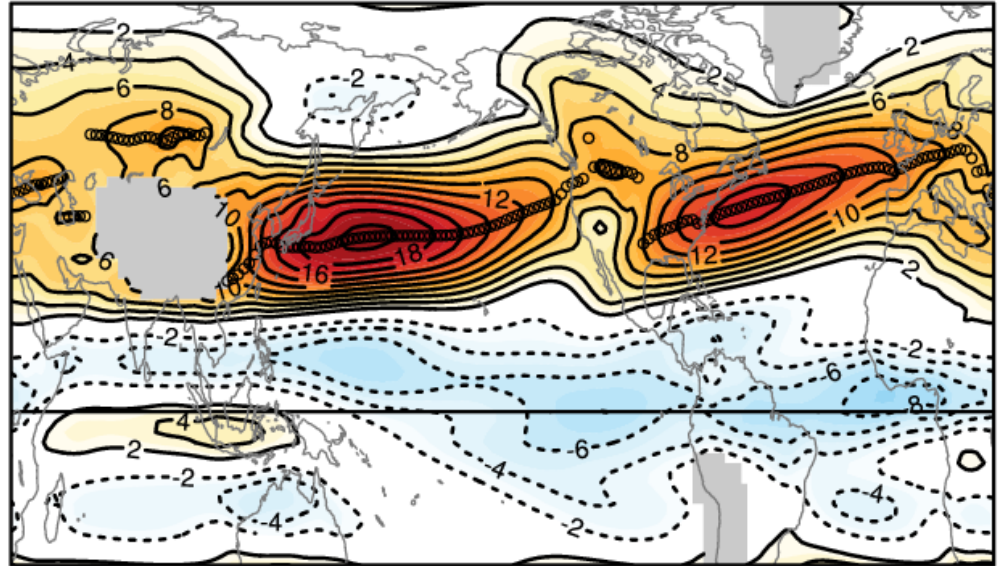
• Local Jet Maximum

Future-Past difference



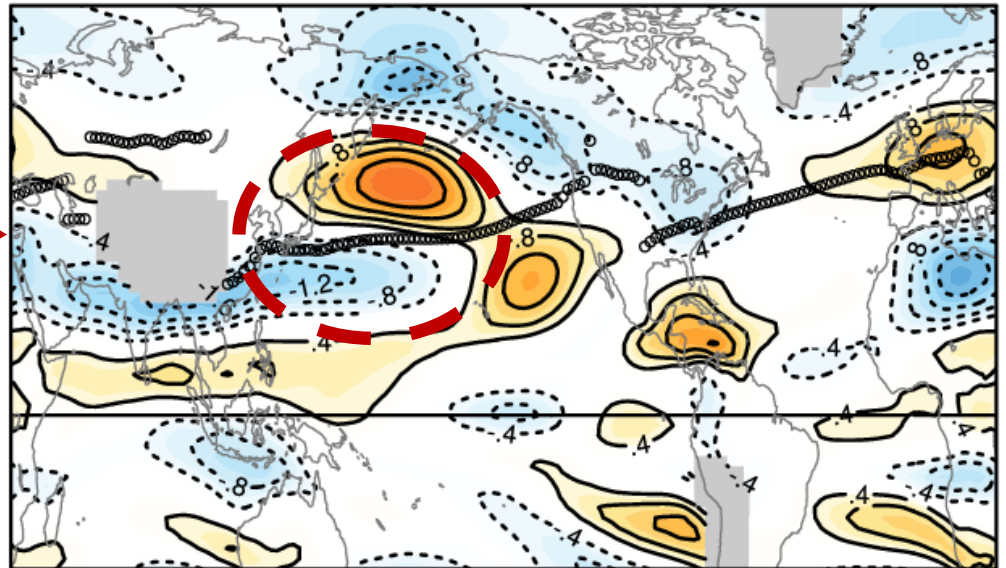
700hPa zonal wind Multi-Model Mean

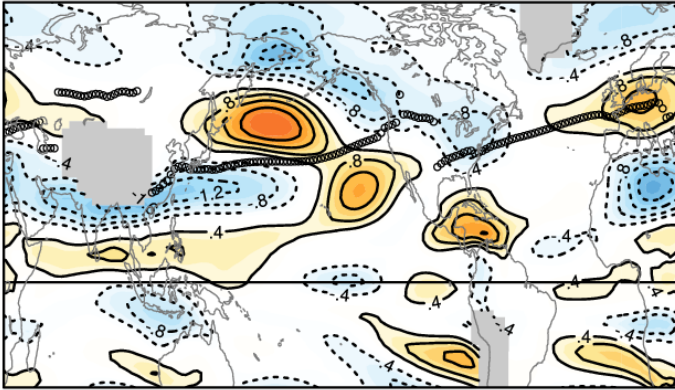
Past Climatology



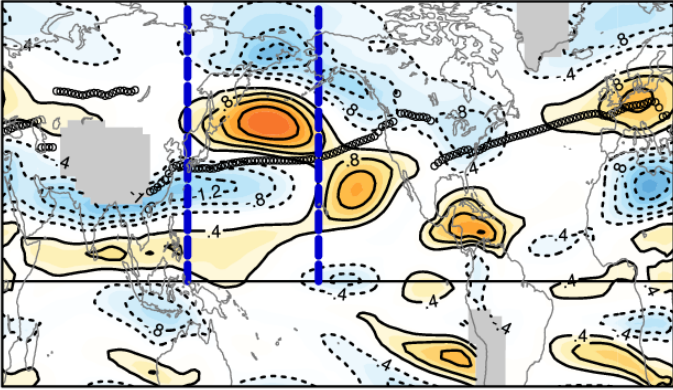
• Local Jet Maximum

Future-Past difference

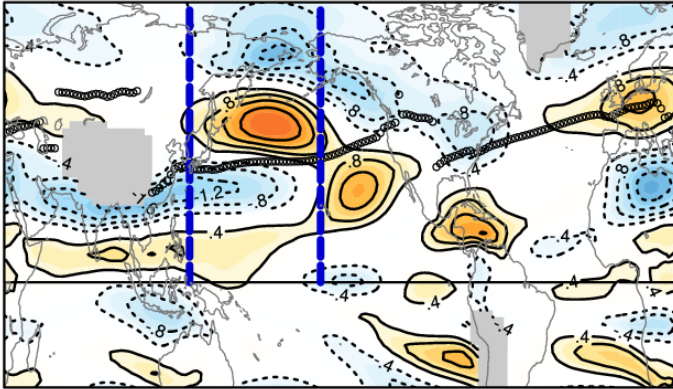




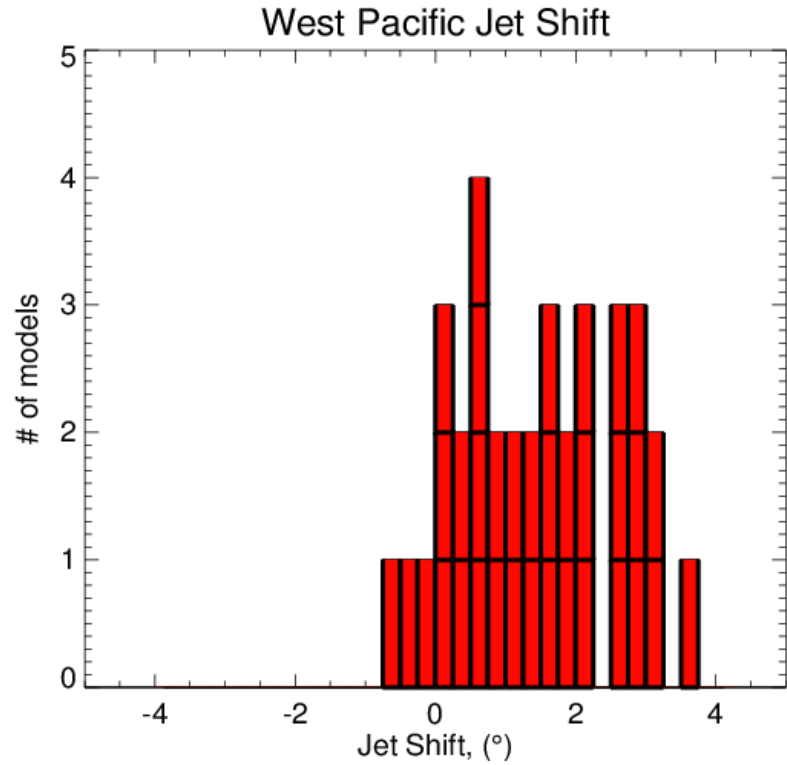
West Pacific Jet Shifts

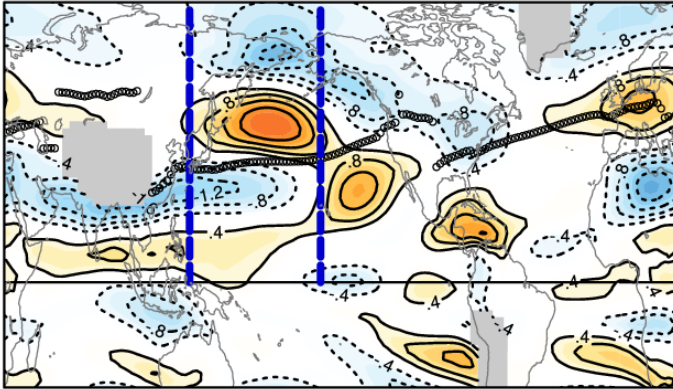


West Pacific Jet Shifts

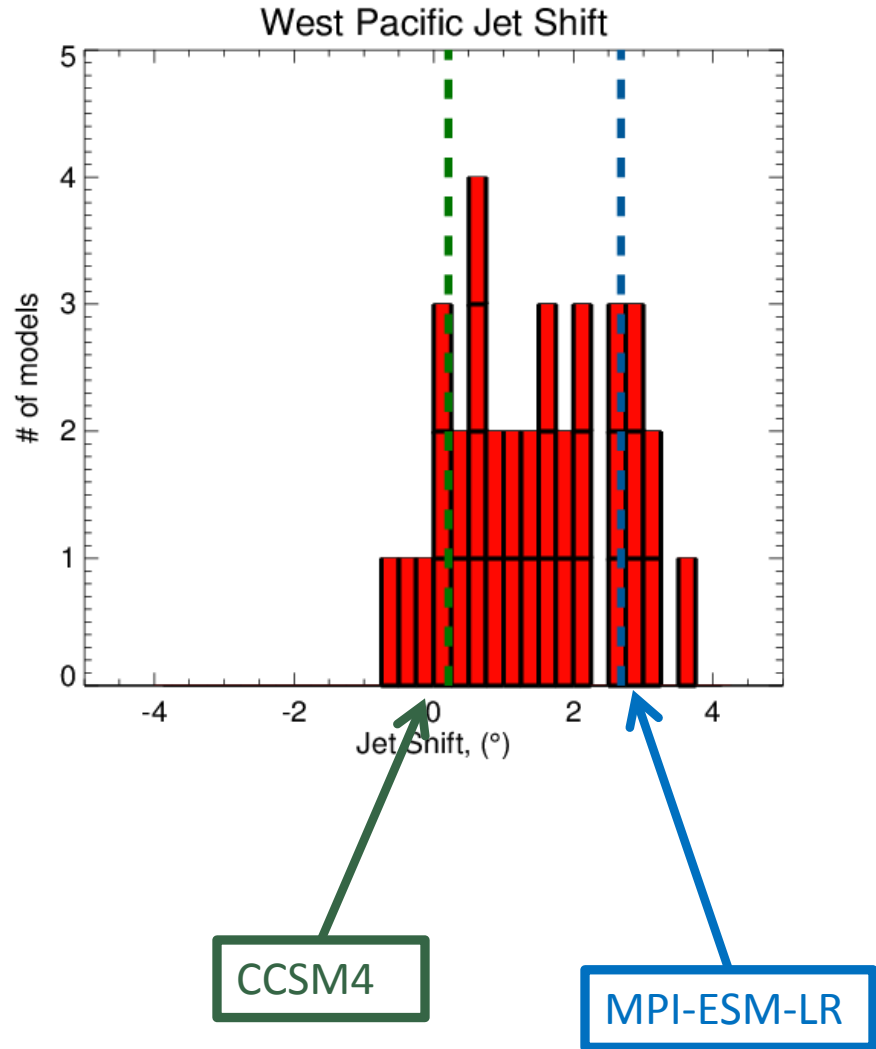


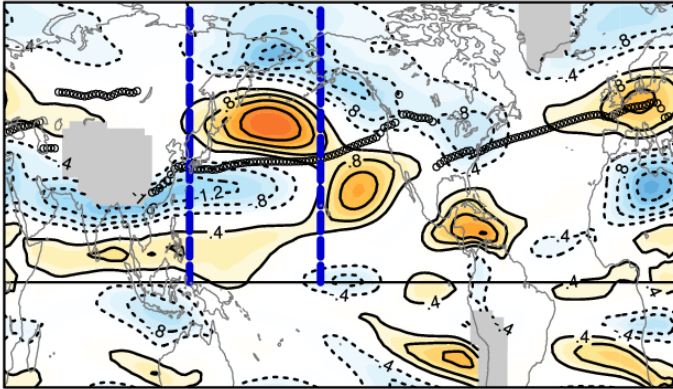
West Pacific
Jet Shifts





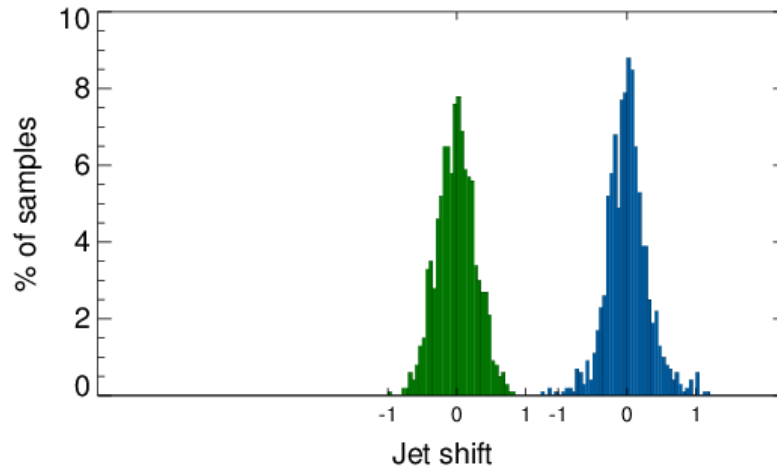
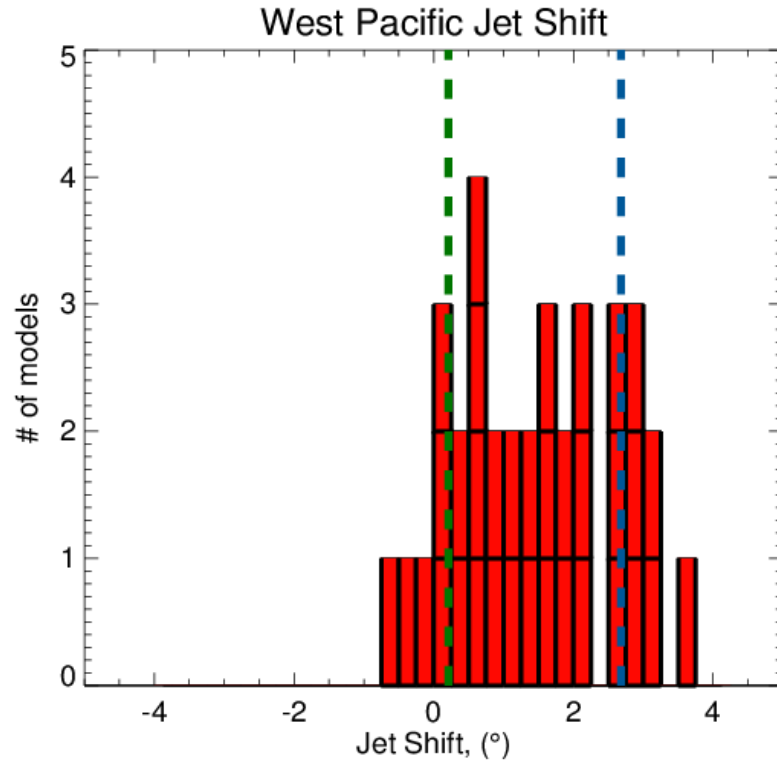
West Pacific
Jet Shifts

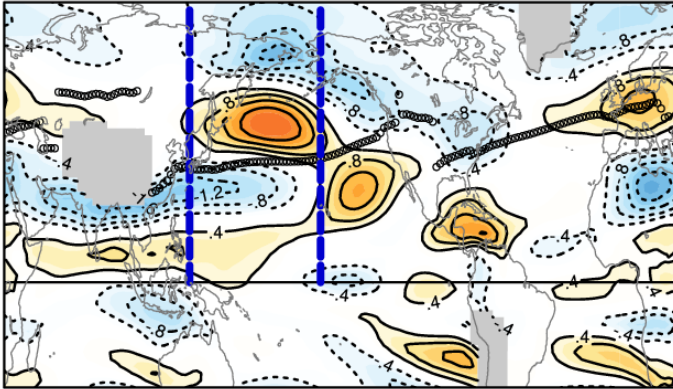




West Pacific Jet Shifts

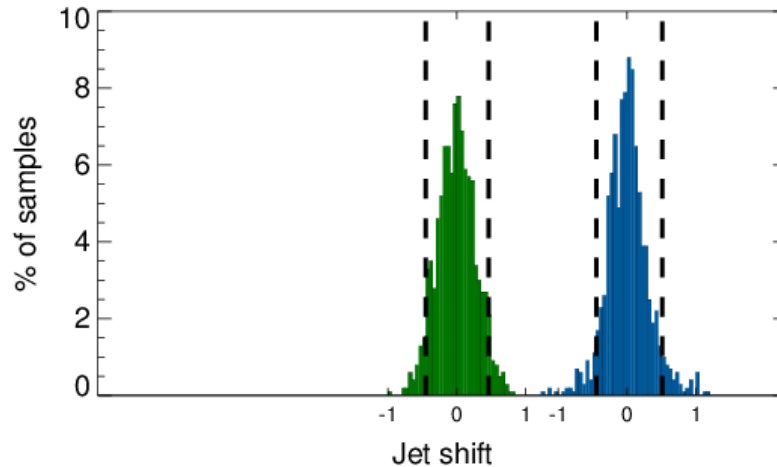
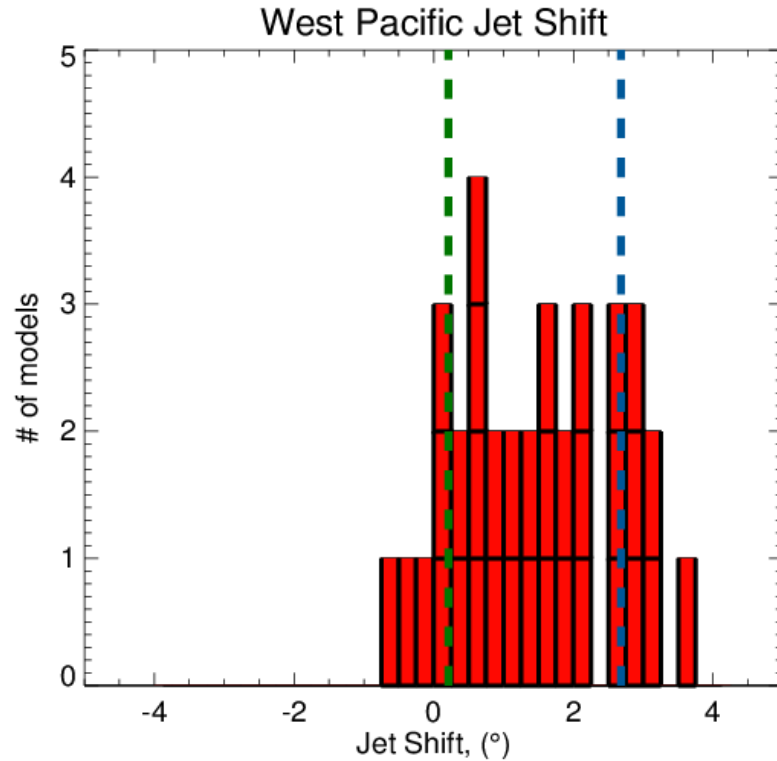
Distribution of jet shifts between pairs of 30 year samples taken at random from the piControl simulation (500y from CCSM4, 1000y from MPI-ESM-LR)

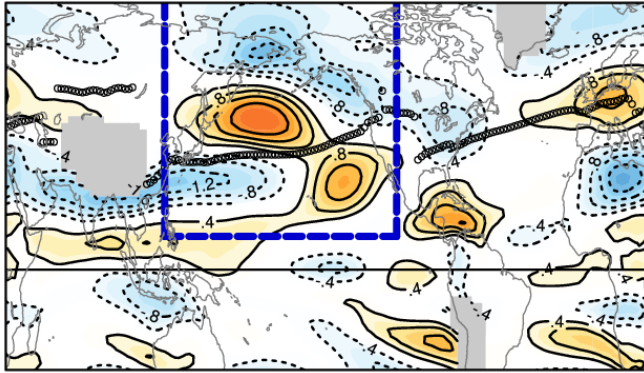




West Pacific Jet Shifts

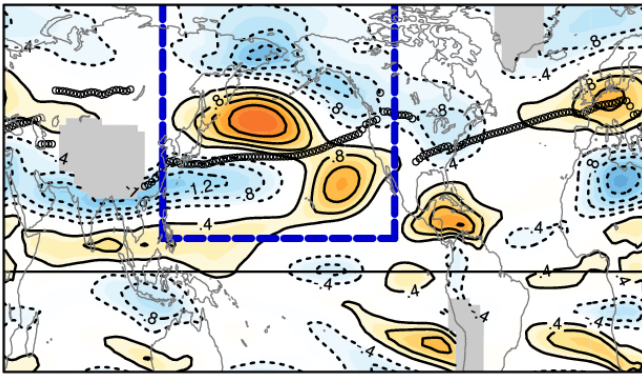
Distribution of jet shifts between pairs of 30 year samples taken at random from the piControl simulation (500y from CCSM4, 1000y from MPI-ESM-LR)



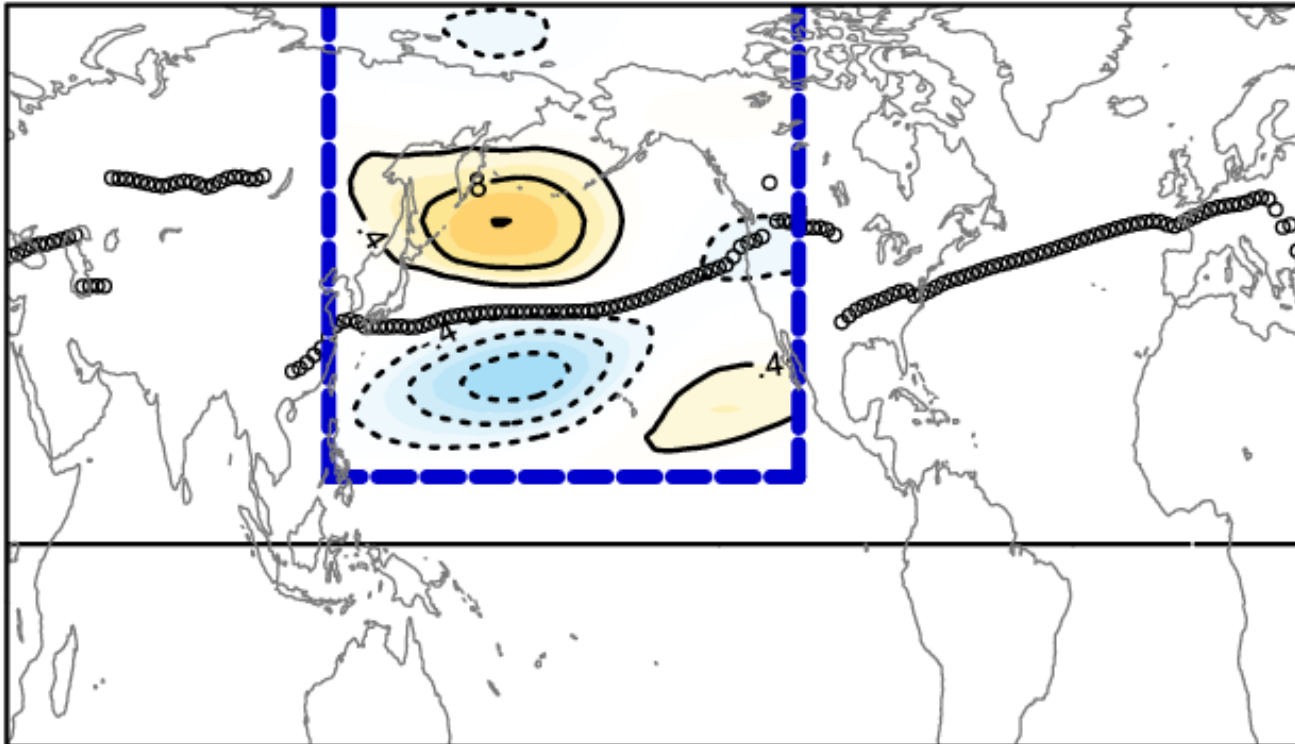


EOF analysis (across models)
of zonal wind response

EOF analysis (across models) of zonal wind response



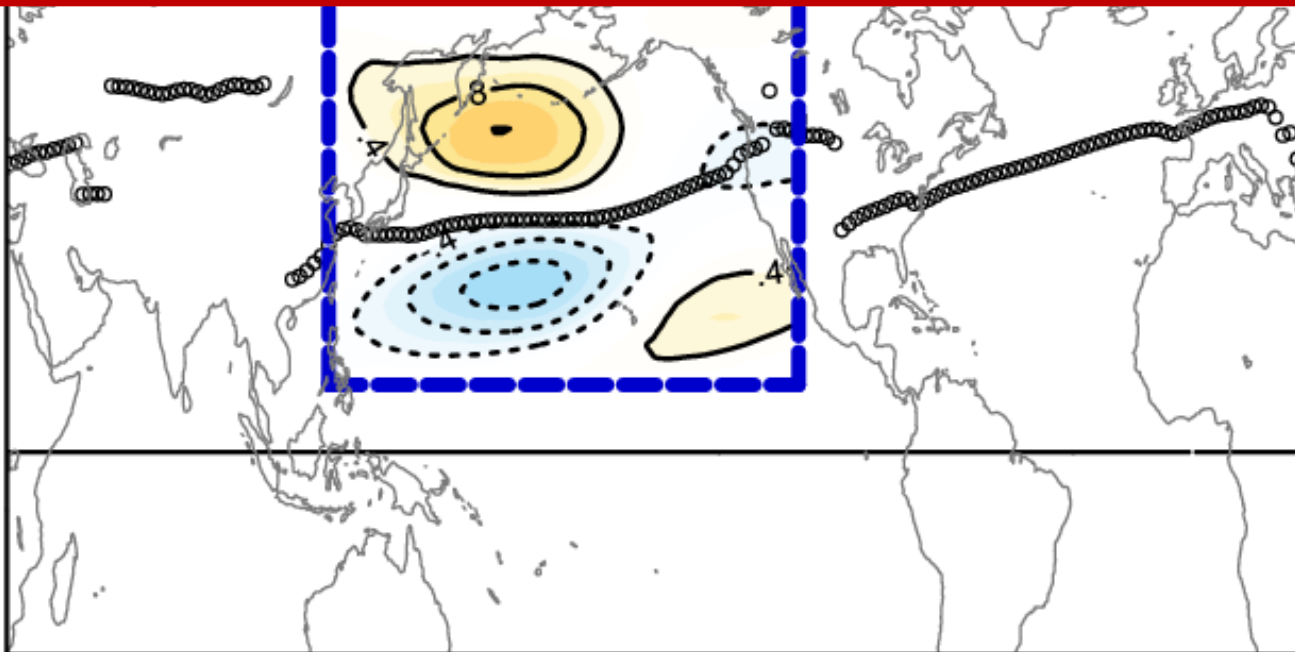
EOF1, 37.5% of variance explained



Use the EOF Index as a measure of a models behaviour in the extra-tropical west Pacific

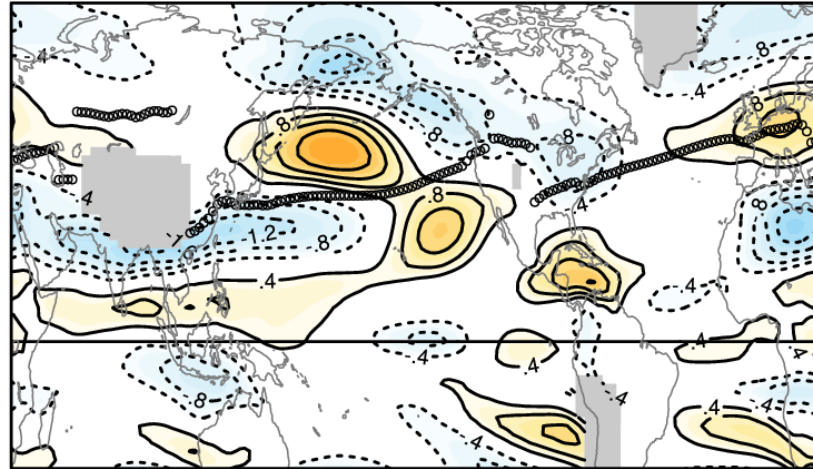
25% most positive EOF1 = Poleward Models

25% most negative EOF1 = Not Poleward Models



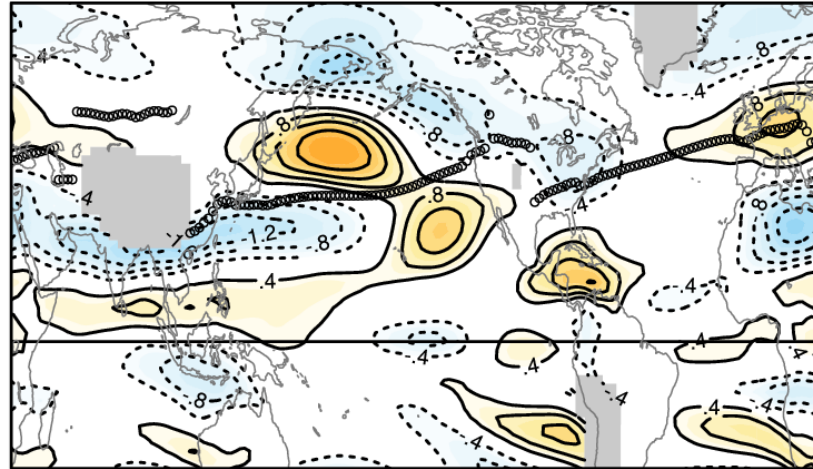
700hPa zonal wind, Future - Past difference

Multi-Model Mean

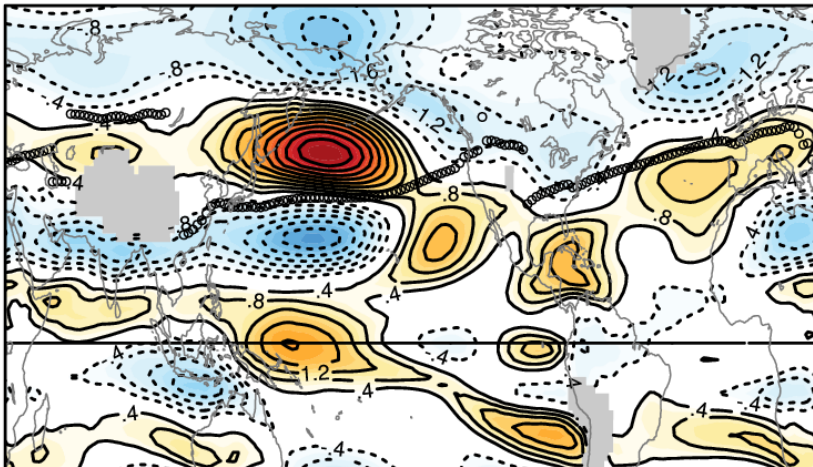


700hPa zonal wind, Future - Past difference

Multi-Model Mean

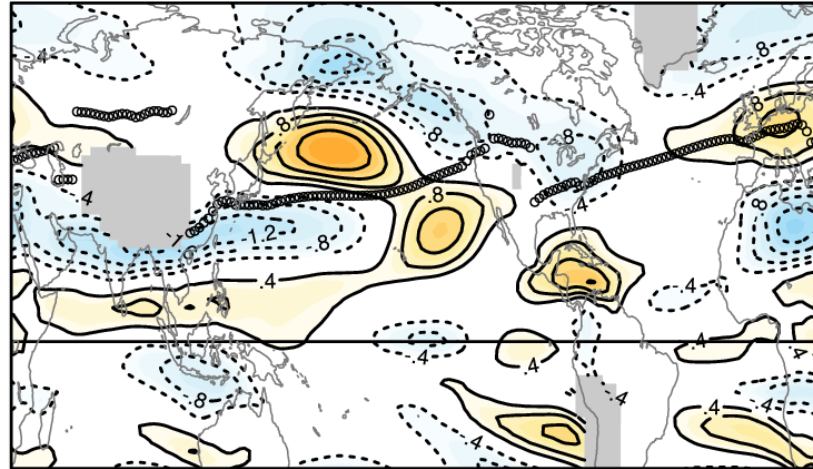


Poleward Models

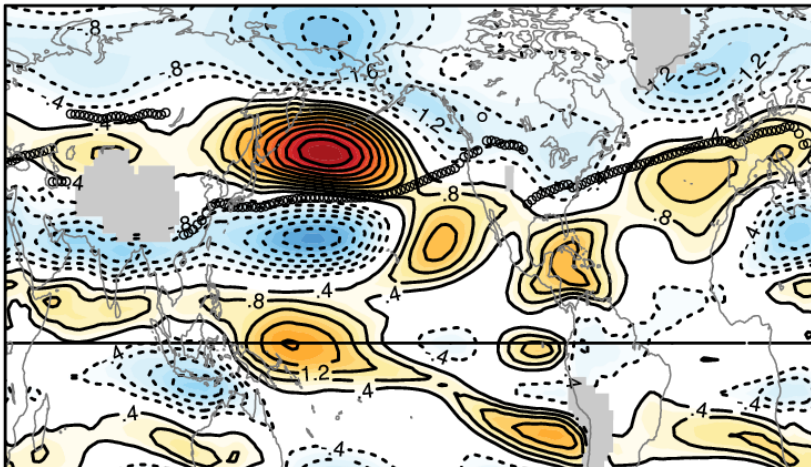


700hPa zonal wind, Future - Past difference

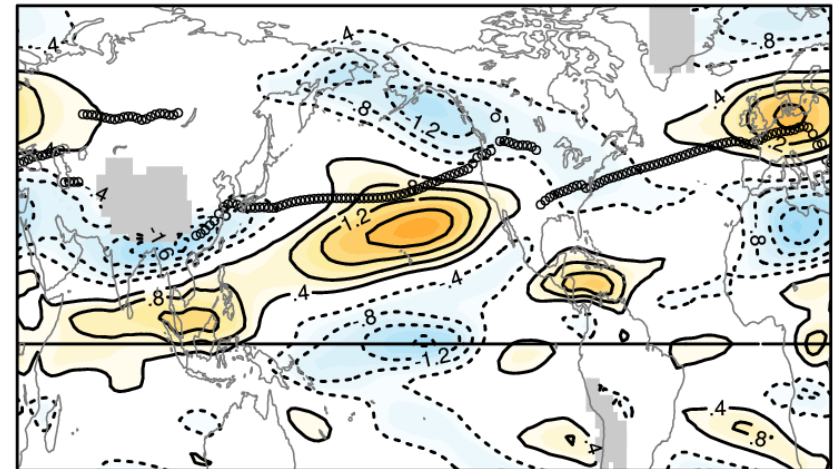
Multi-Model Mean



Poleward Models

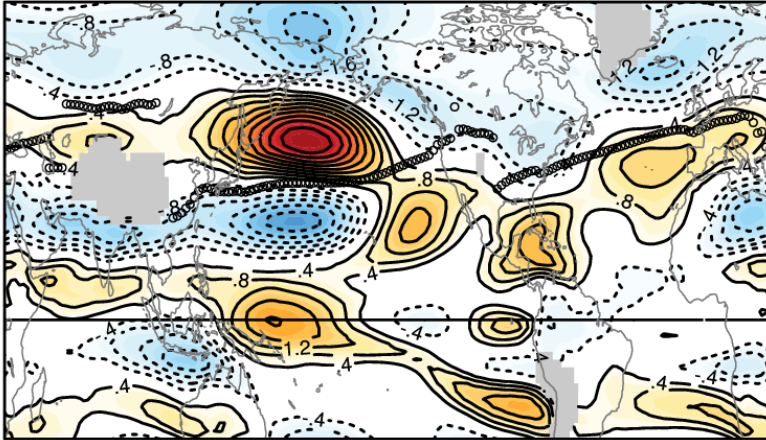


Not Poleward Models

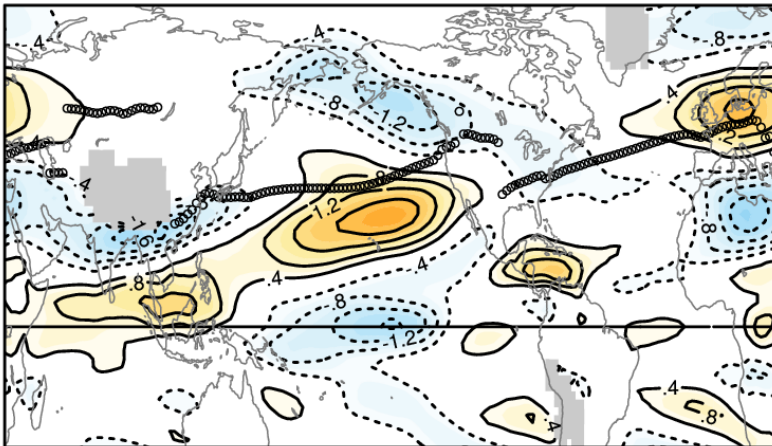


700hPa zonal wind, Future - Past difference

Poleward Models

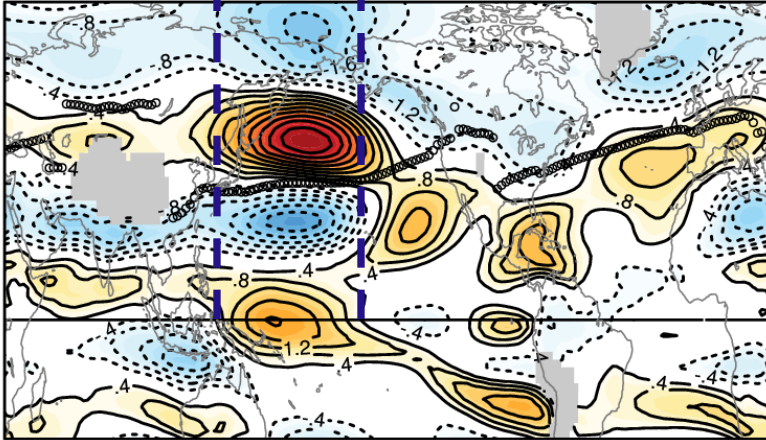


Not Poleward Models

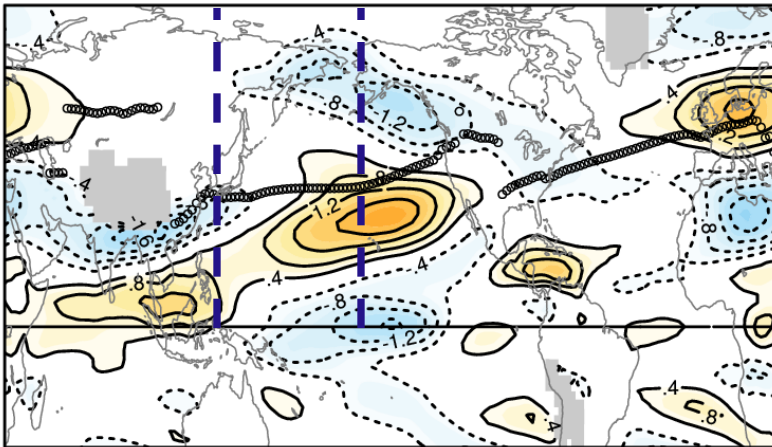


700hPa zonal wind, Future - Past difference

Poleward Models

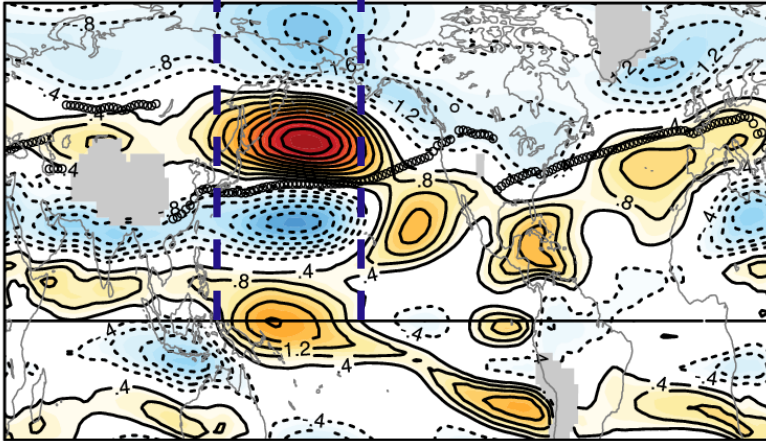


Not Poleward Models

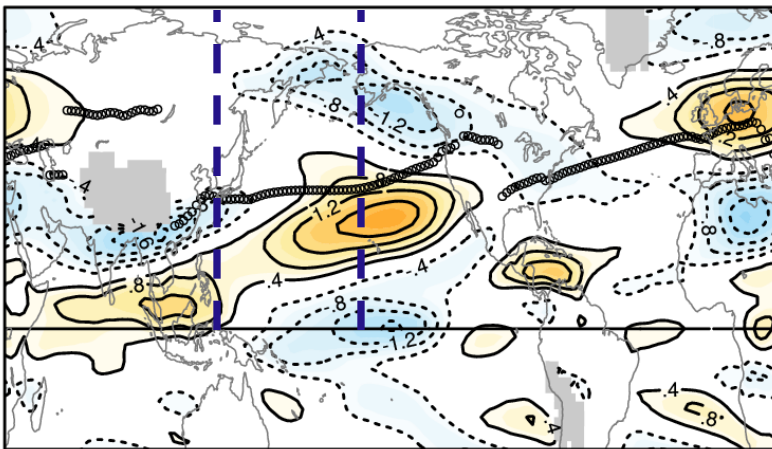


700hPa zonal wind, Future - Past difference

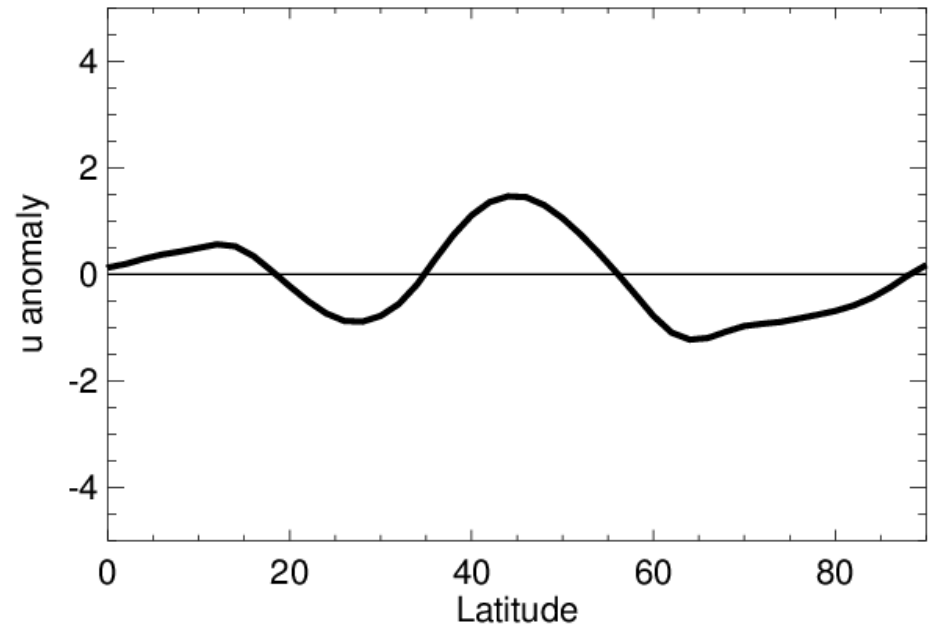
Poleward Models



Not Poleward Models



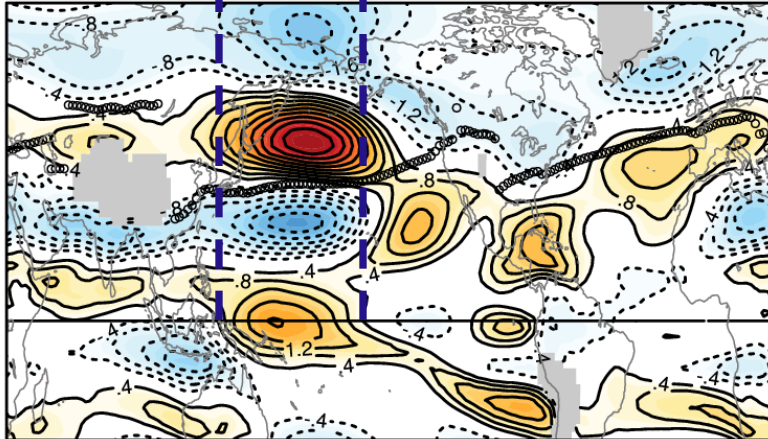
West Pacific anomalies



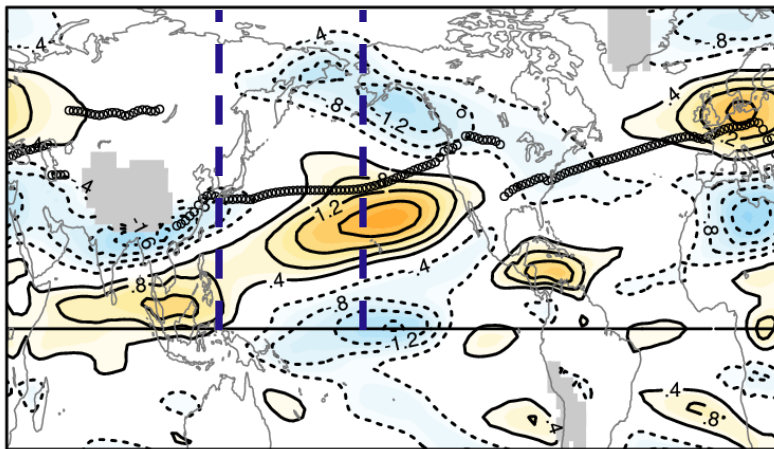
— Multi-model Mean

700hPa zonal wind, Future - Past difference

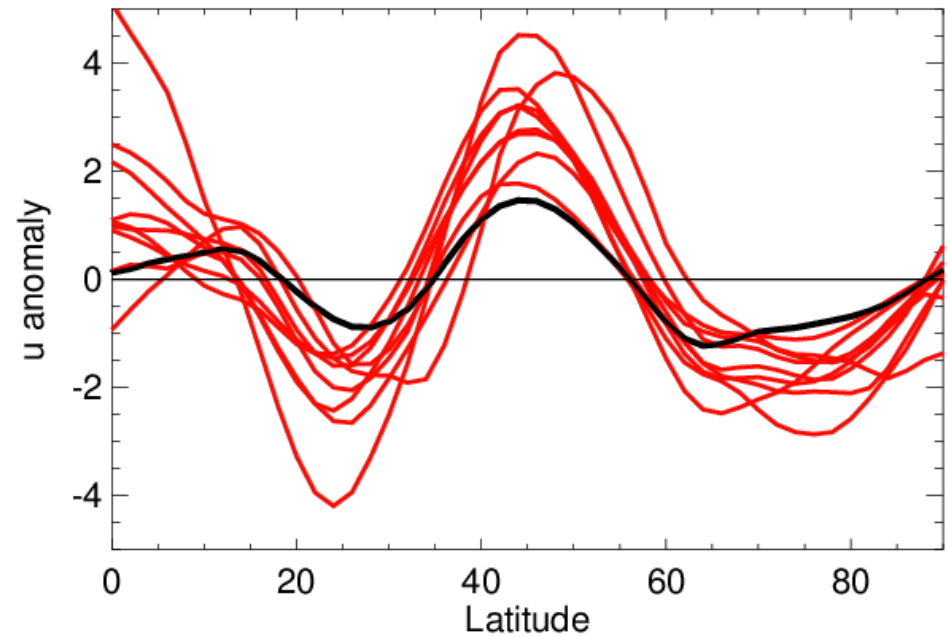
Poleward Models



Not Poleward Models



West Pacific anomalies

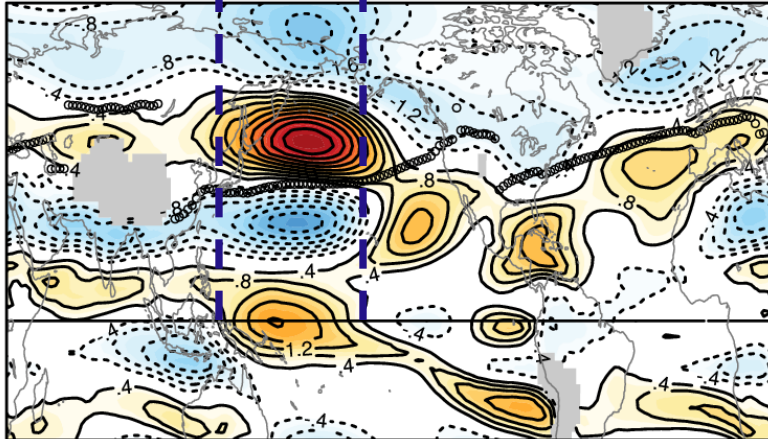


— Multi-model Mean

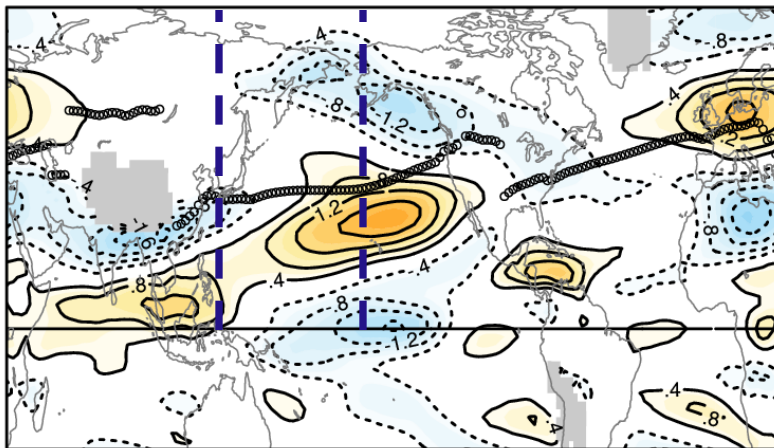
— Poleward Models

700hPa zonal wind, Future - Past difference

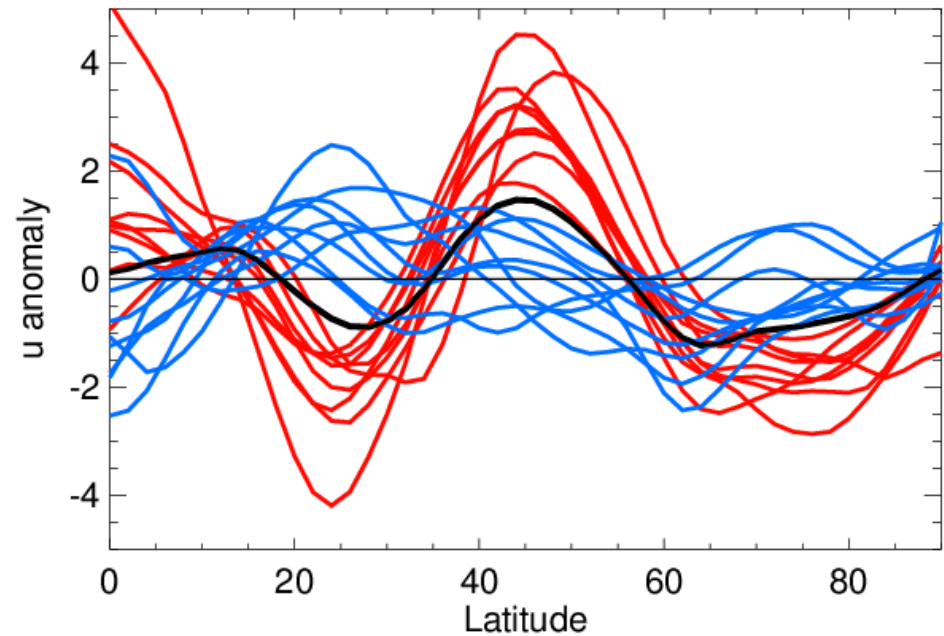
Poleward Models



Not Poleward Models



West Pacific anomalies



- Multi-model Mean
- Poleward Models
- Not Poleward Models

Poleward Models

CMCC-CM
CMCC-CMS
CSIRO-Mk3-6-0
GISS-E2-R
IPSL-CM5A-MR
MIROC5
MPI-ESM-LR
MPI-ESM-MR
MRI-CGCM3

Not Poleward Models

BNU-ESM
CanESM2
CCSM4
CNRM-CM5
FIO-ESM
GFDL-ESM2G
GFDL-ESM2M
inmcm4
NorESM1-ME

Poleward Models

CMCC-CM
CMCC-CMS
CSIRO-Mk3-6-0
GISS-E2-R
IPSL-CM5A-MR
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CSIRO-Mk3-6-0
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Not Poleward Models

BNU-ESM
CanESM2
CCSM4
CNRM-CM5
FIO-ESM
GFDL-ESM2G
GFDL-ESM2M
inmcm4
NorESM1-ME

Why this distinct behavior between these groups of models?

Possible Influences on the Extra-tropical Pacific

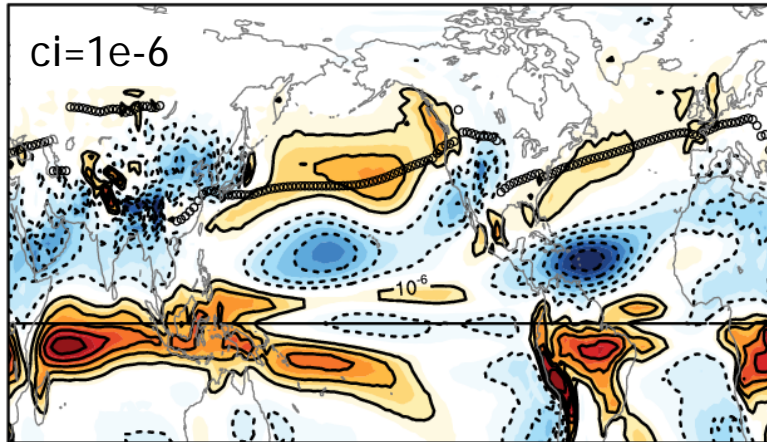
- Diabatically forced stationary waves from the tropics
- Orographically forced stationary waves
- Local extra-tropical diabatic forcing of the circulation
- Local changes in transient eddies

Possible Influences on the Extra-tropical Pacific

- Diabatically forced stationary waves from the tropics
- Orographically forced stationary waves
- Local extra-tropical diabatic forcing of the circulation
- Local changes in transient eddies

250hPa Divergence and Divergent Meridional Wind

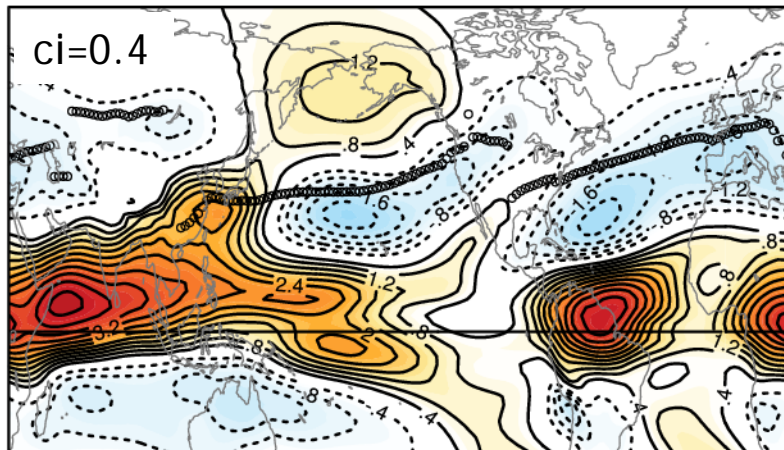
Divergence (Past)



Multi-Model Mean
Past Climatologies

Divergence

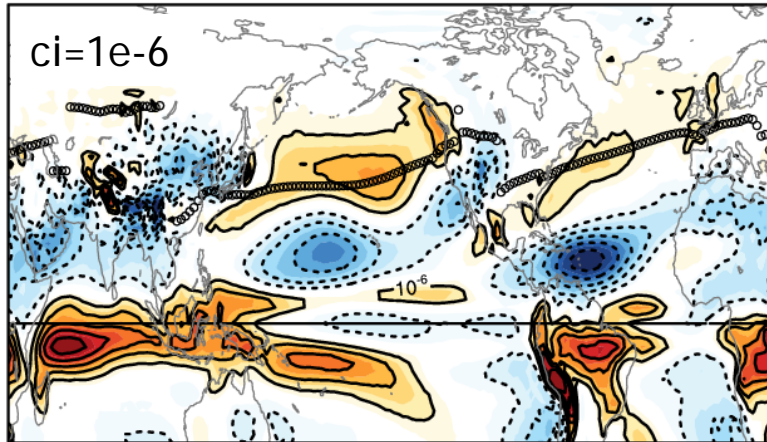
Divergent v (Past)



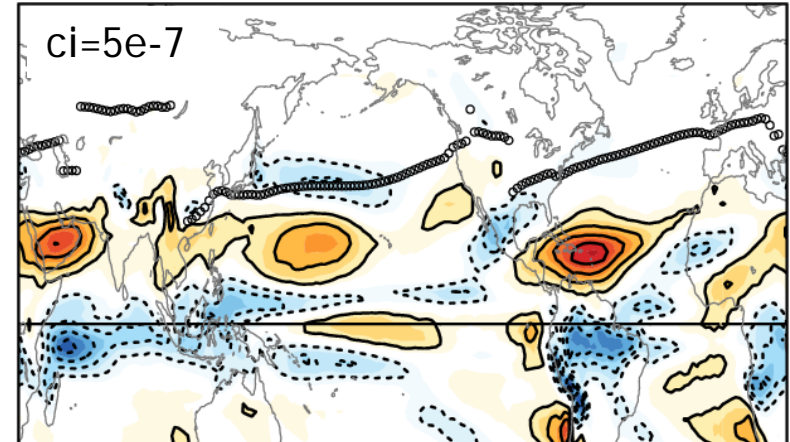
Divergent v

250hPa Divergence and Divergent Meridional Wind

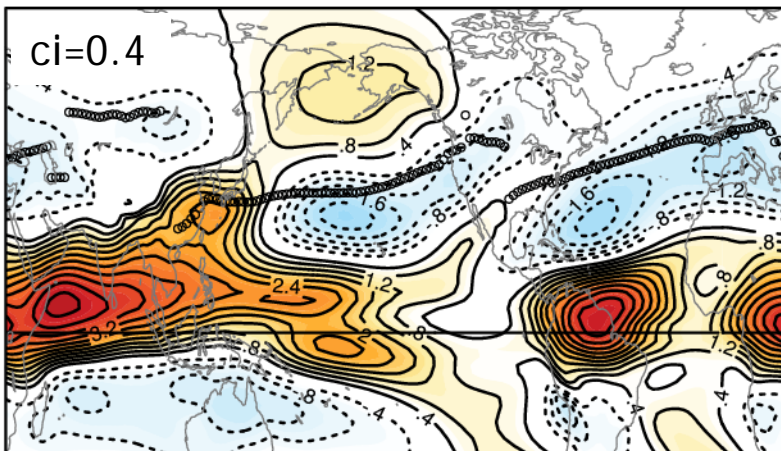
Divergence (Past)



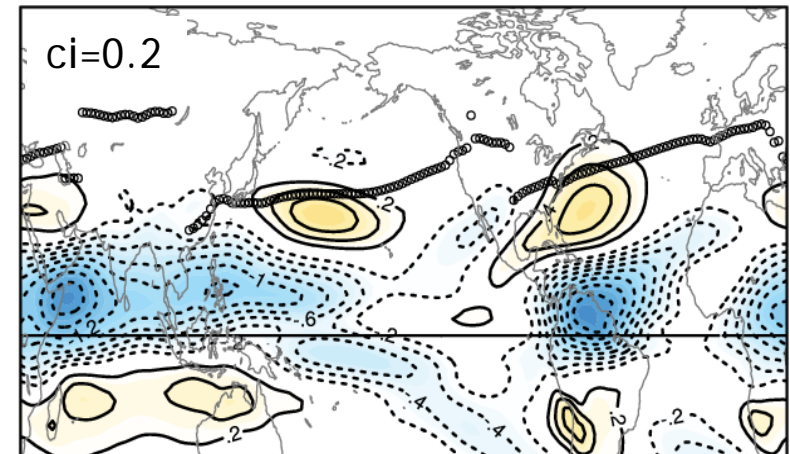
Divergence (Future-Past)



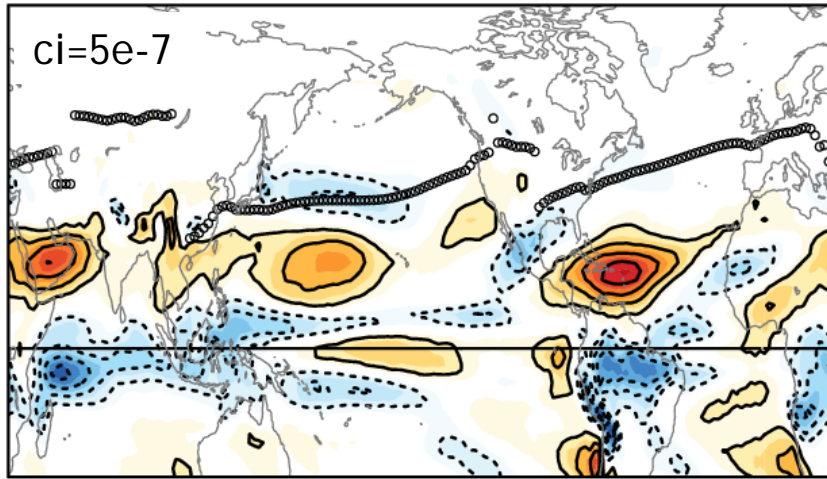
Divergent v (Past)



Divergent v (Future-Past)

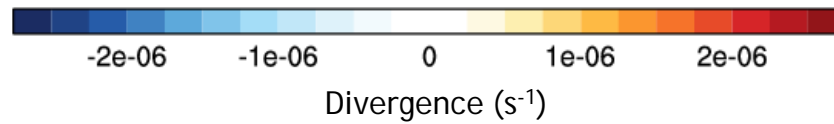


Divergence (Future-Past)

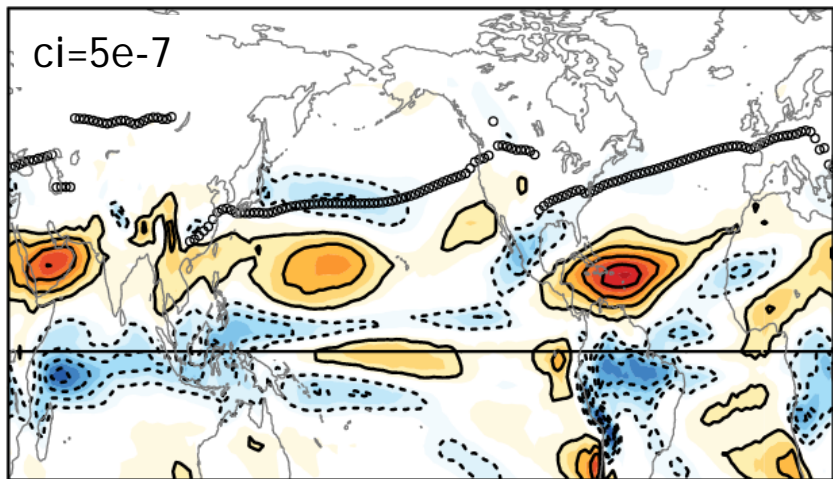


250hPa Divergence

Multi-Model Mean
(Future-Past)



Divergence (Future-Past)

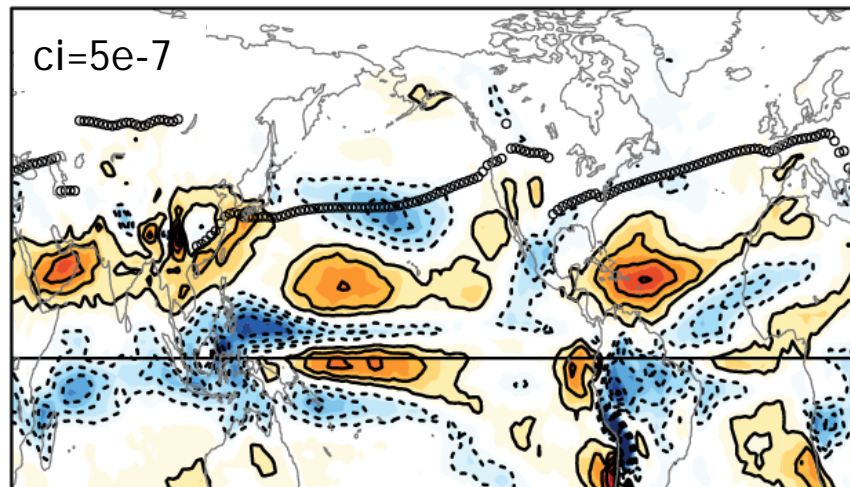


250hPa Divergence

Multi-Model Mean
(Future-Past)



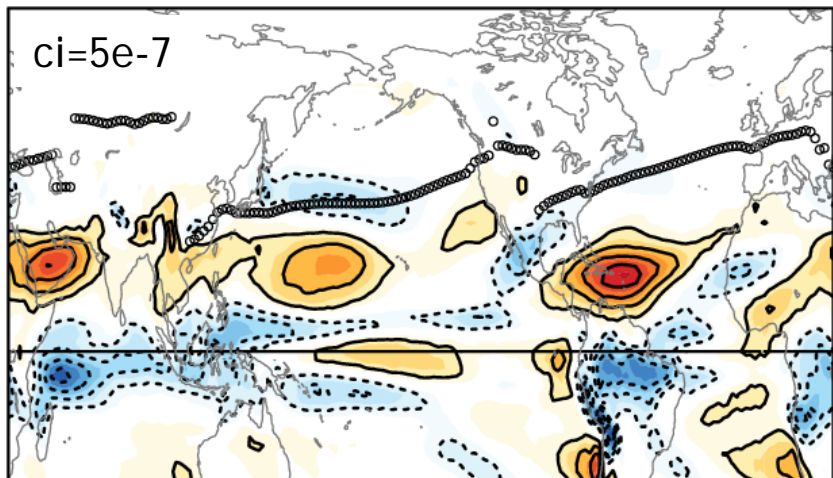
Poleward models



-2e-06 -1e-06 0 1e-06 2e-06

Divergence (s^{-1})

Divergence (Future-Past)

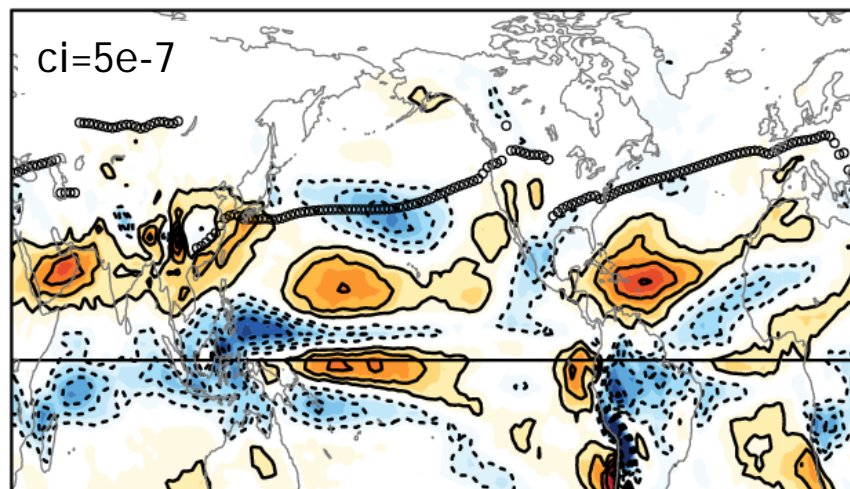


250hPa Divergence

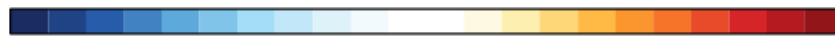
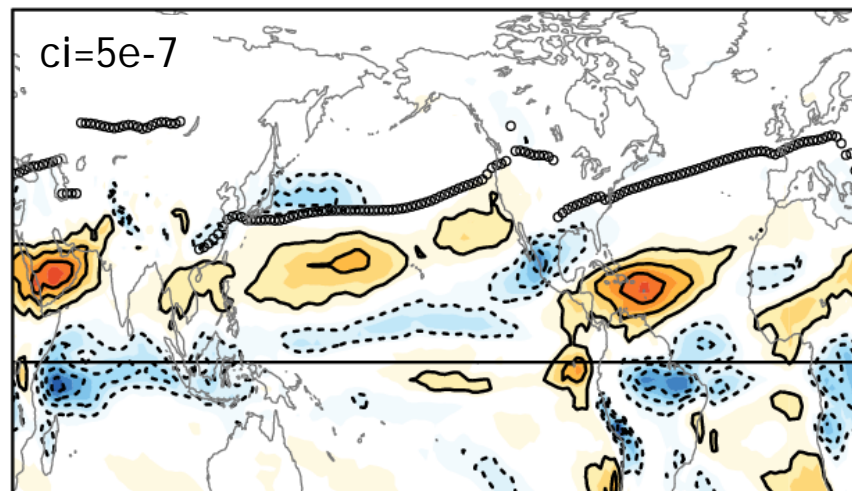
Multi-Model Mean
(Future-Past)



Poleward models



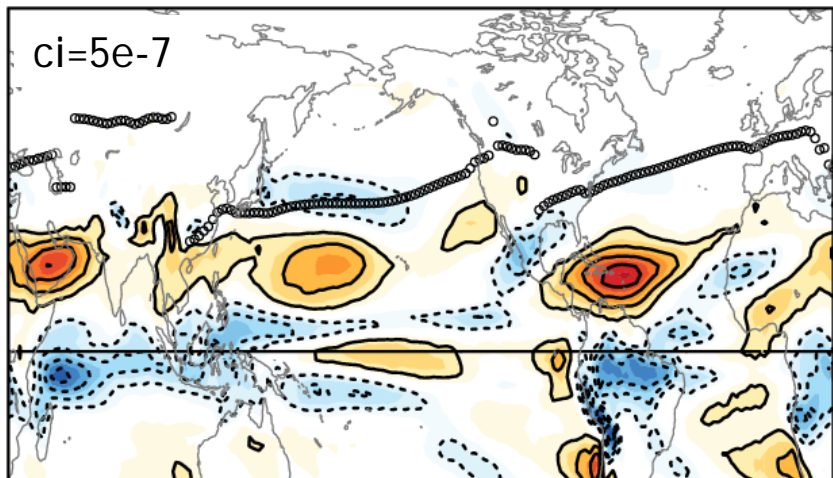
Not Poleward models



-2e-06 -1e-06 0 1e-06 2e-06

Divergence (s⁻¹)

Divergence (Future-Past)

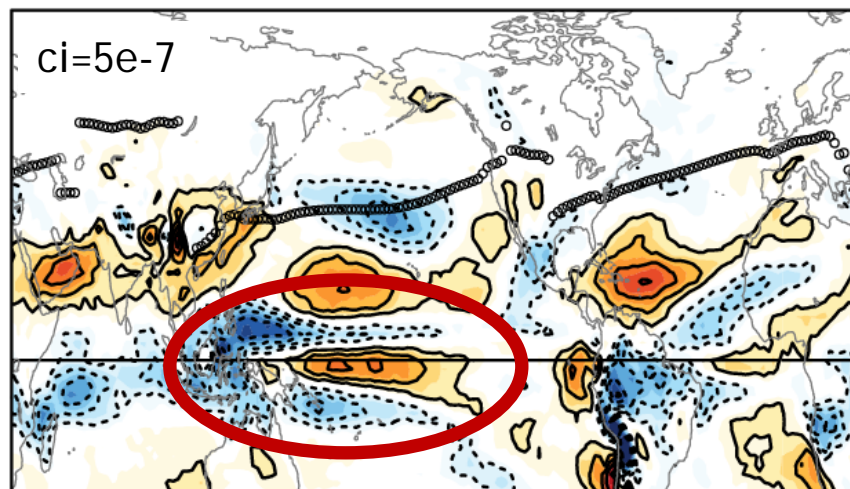


250hPa Divergence

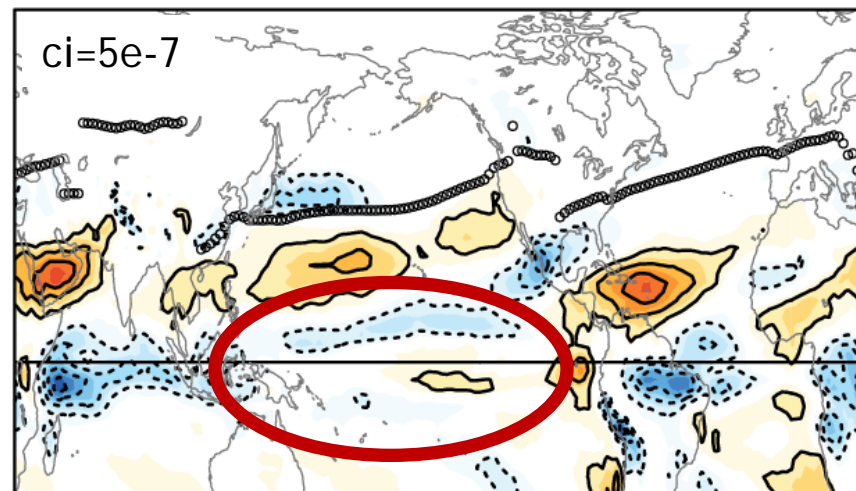
Multi-Model Mean
(Future-Past)



Poleward models



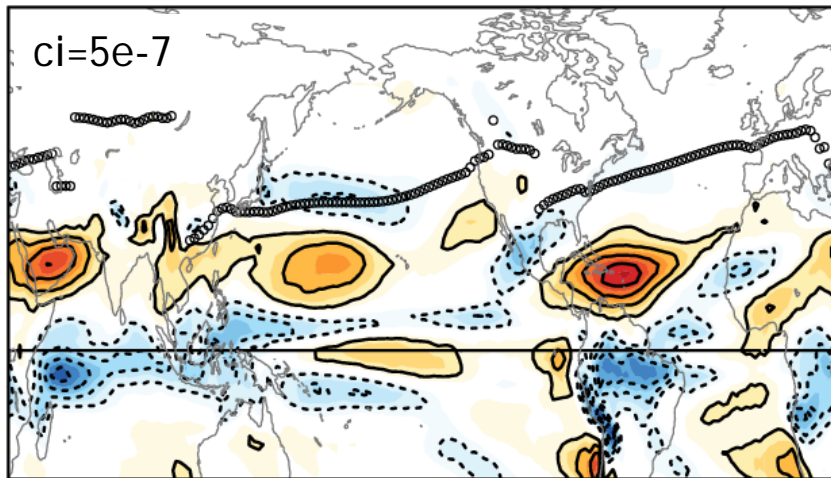
Not Poleward models



-2e-06 -1e-06 0 1e-06 2e-06

Divergence (s⁻¹)

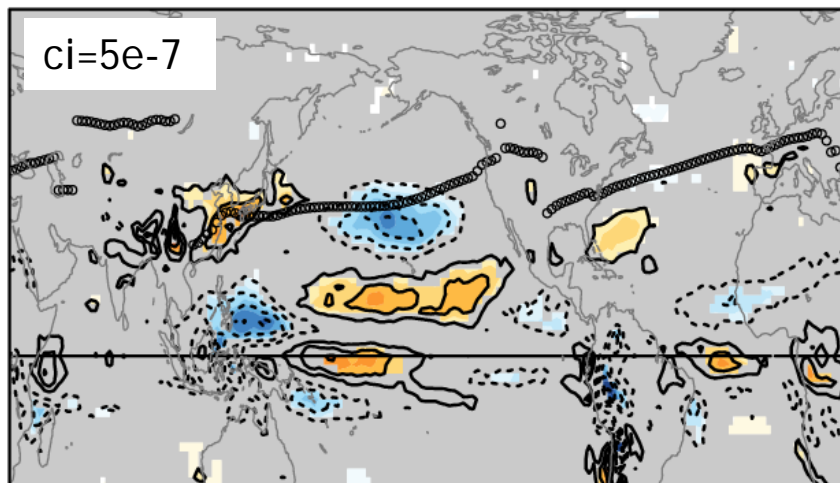
Divergence (Future-Past)



250hPa Divergence

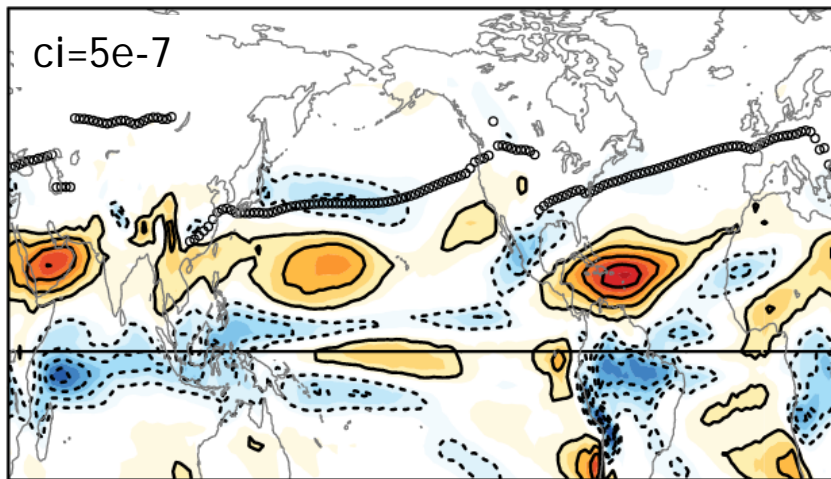
Multi-Model Mean
(Future-Past)

Poleward - Not Poleward



Grey = Not statistically significant

Divergence (Future-Past)

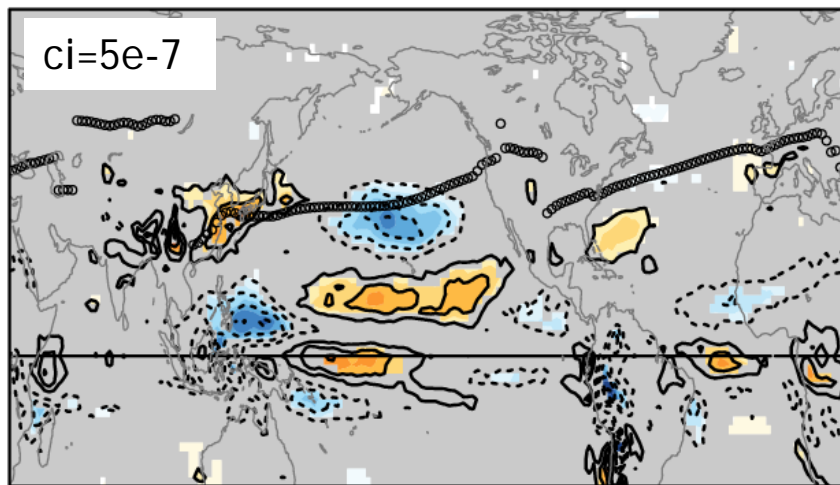


250hPa Divergence

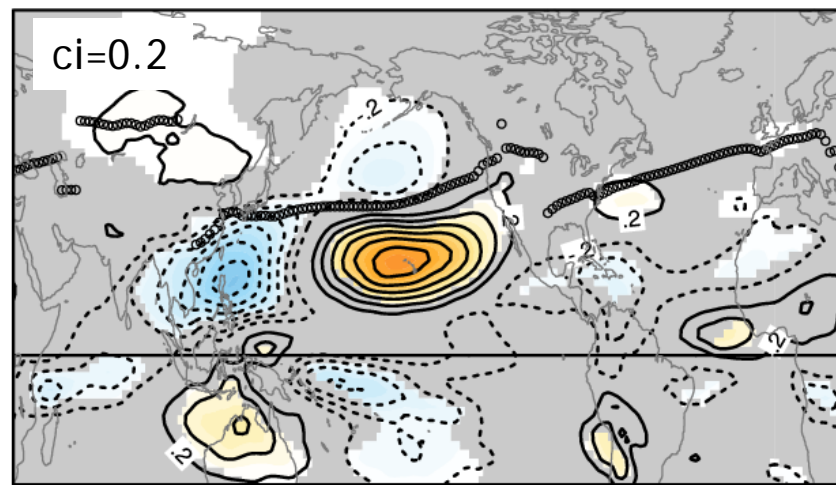
Multi-Model Mean
(Future-Past)

Divergent v

Poleward - Not Poleward

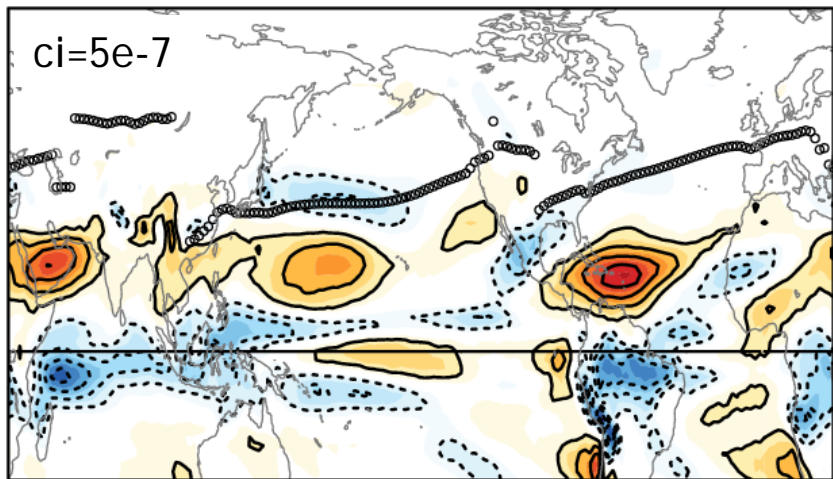


Poleward - Not Poleward



Grey = Not statistically significant

Divergence (Future-Past)



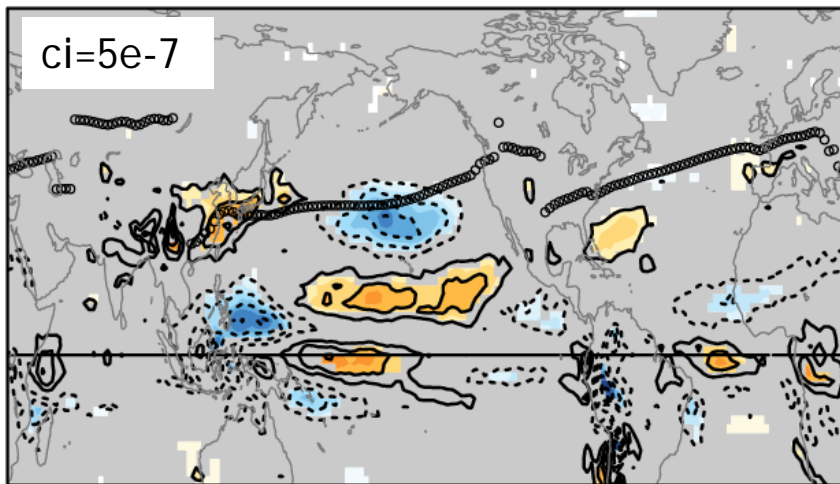
250hPa Divergence

Multi-Model Mean
(Future-Past)

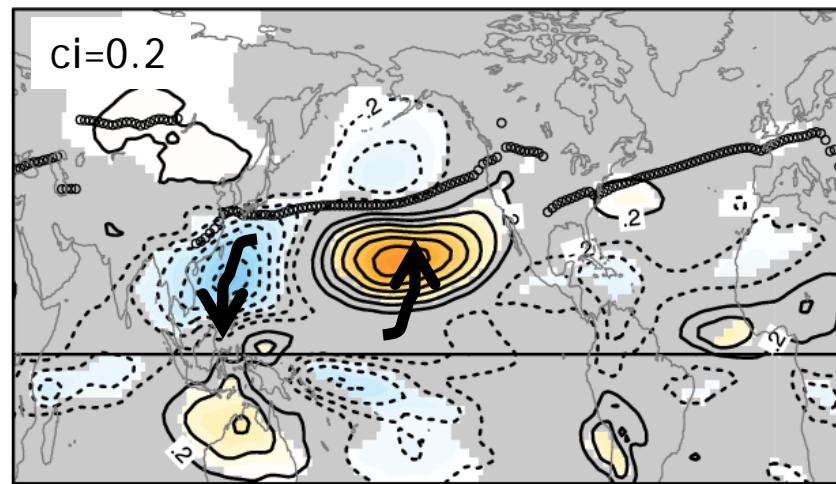
Divergent v



Poleward - Not Poleward

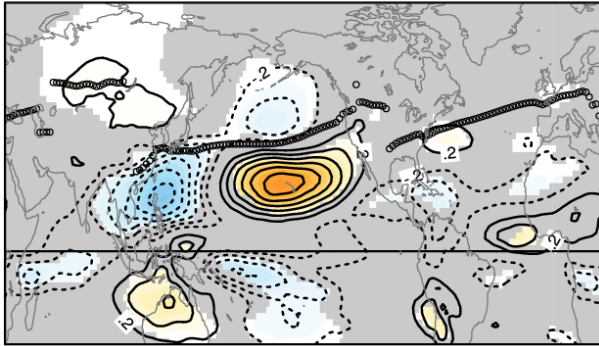


Poleward - Not Poleward



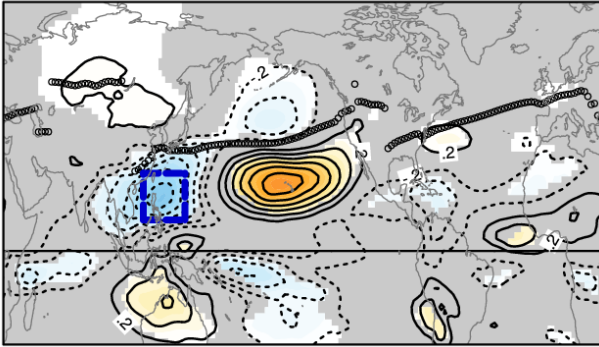
Grey = Not statistically significant

Poleward - Not Poleward



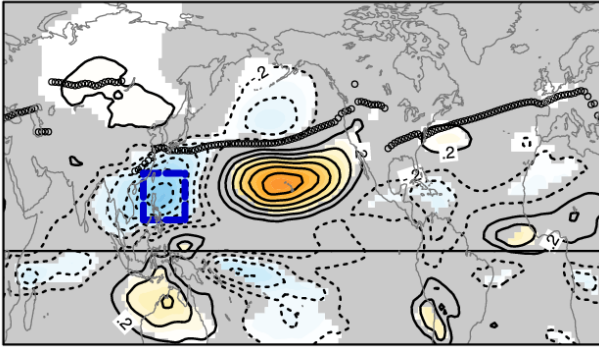
Divergent v in Blue Box

Poleward - Not Poleward



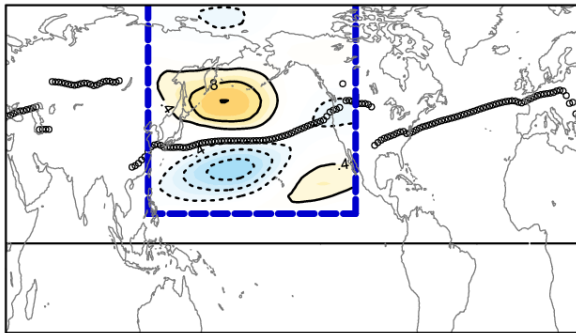
Divergent v in Blue Box

Poleward - Not Poleward



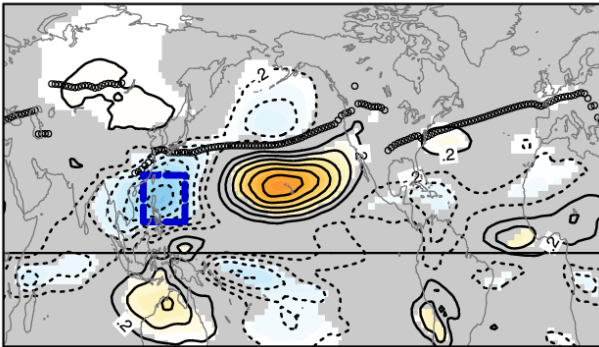
VS

EOF Index



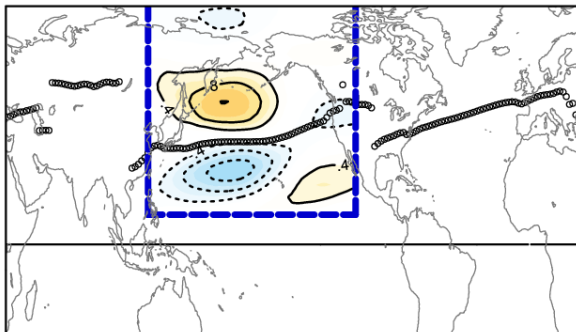
Divergent v in Blue Box

Poleward - Not Poleward

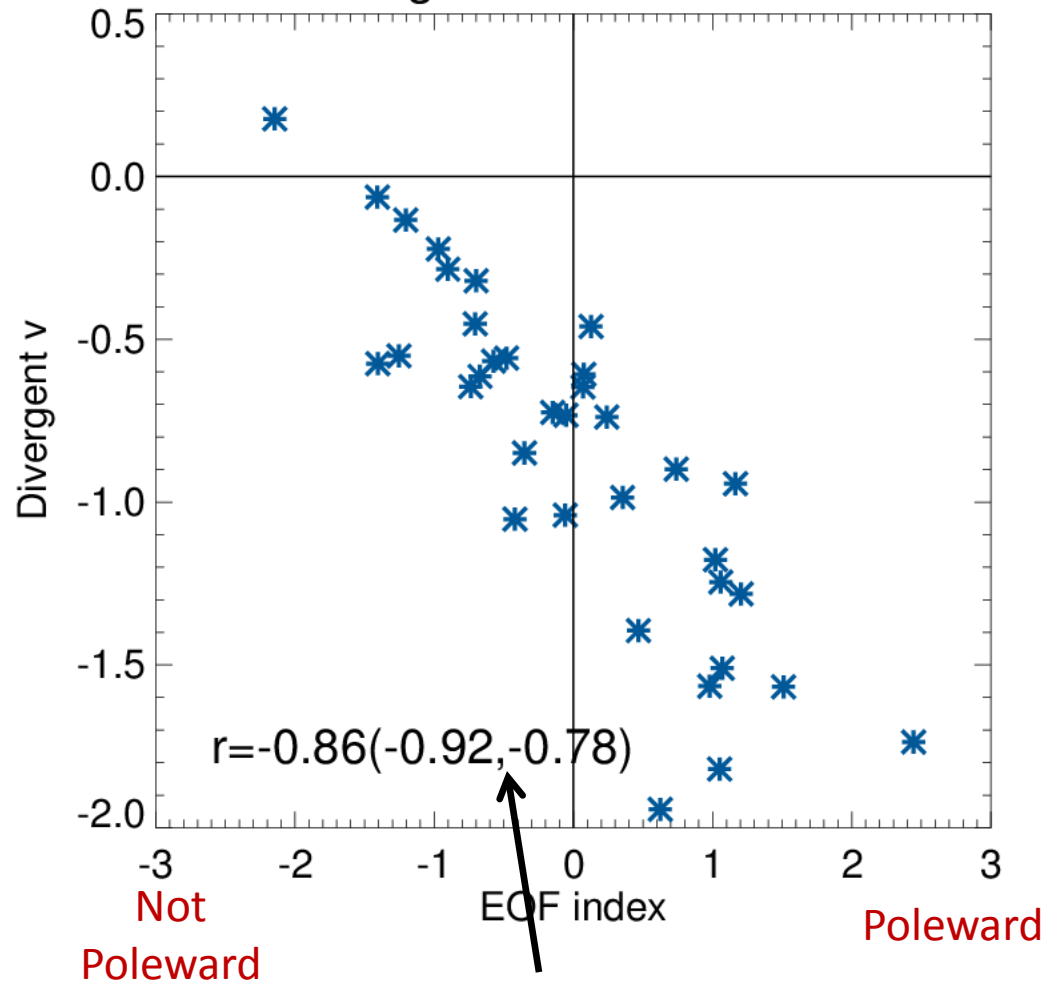


VS

EOF Index



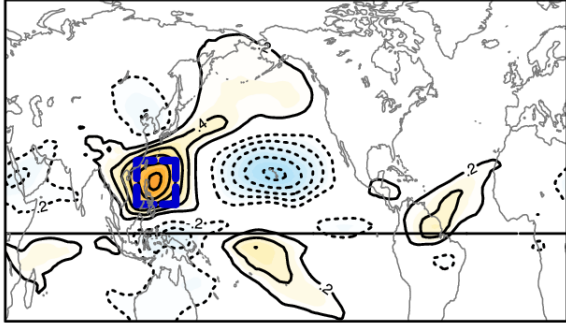
Divergent v vs EOF index



95% bootstrapping confidence interval

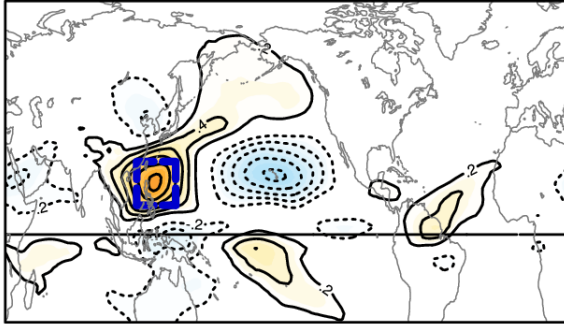
Regressions onto divergent v in the natural variability of CCSM4

250hPa Divergent v

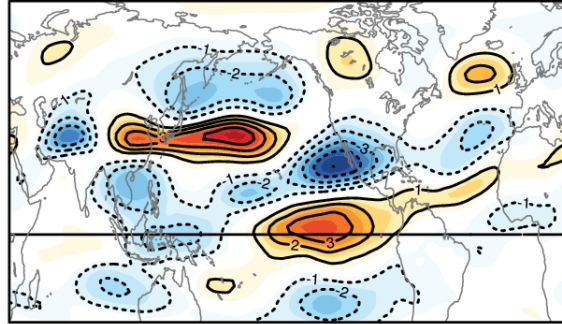


Regressions onto divergent v in the natural variability of CCSM4

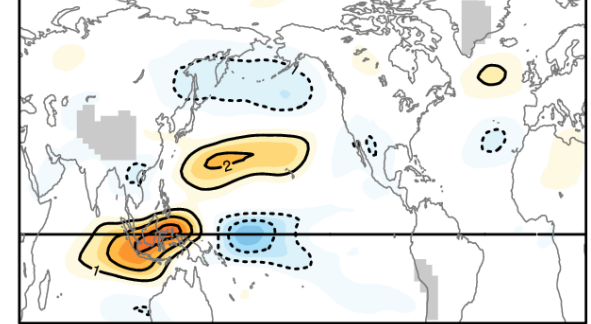
250hPa Divergent v



250hPa zonal wind

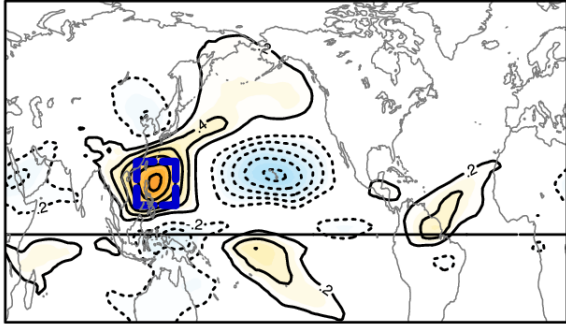


700hPa zonal wind

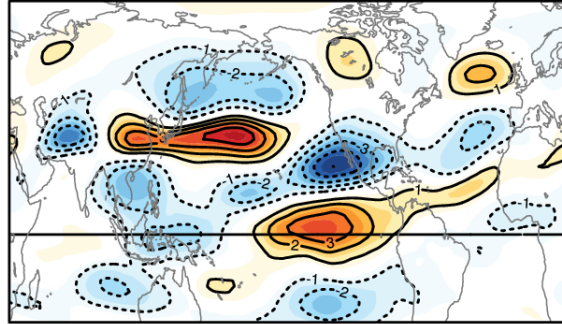


Regressions onto divergent v in the natural variability of CCSM4

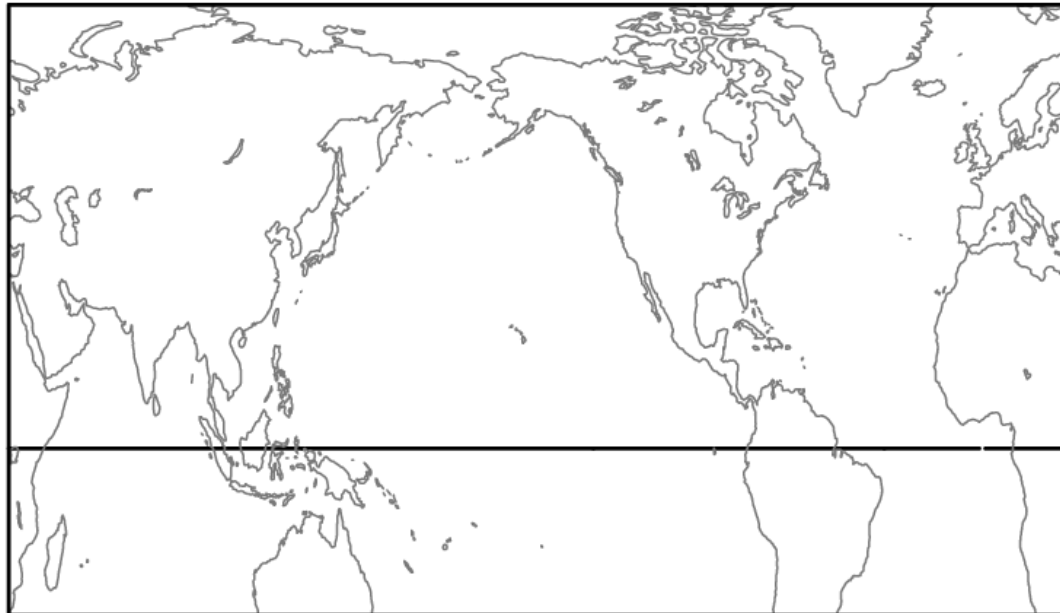
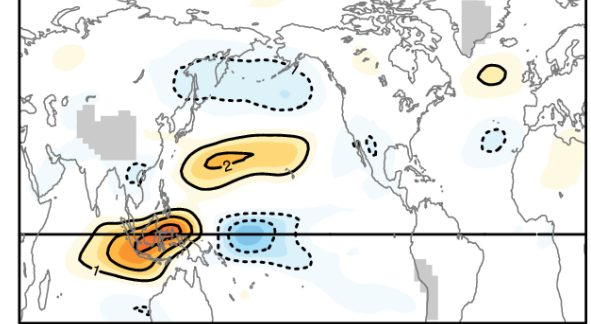
250hPa Divergent v



250hPa zonal wind

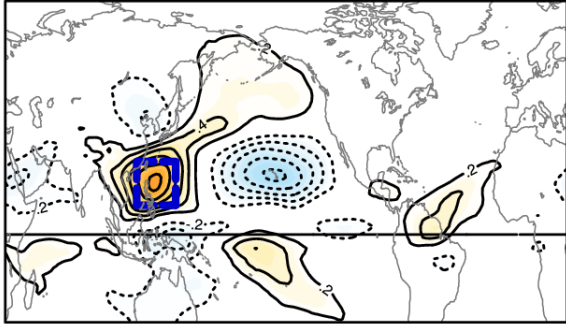


700hPa zonal wind

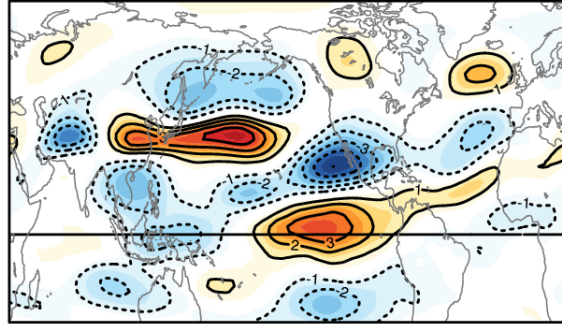


Regressions onto divergent v in the natural variability of CCSM4

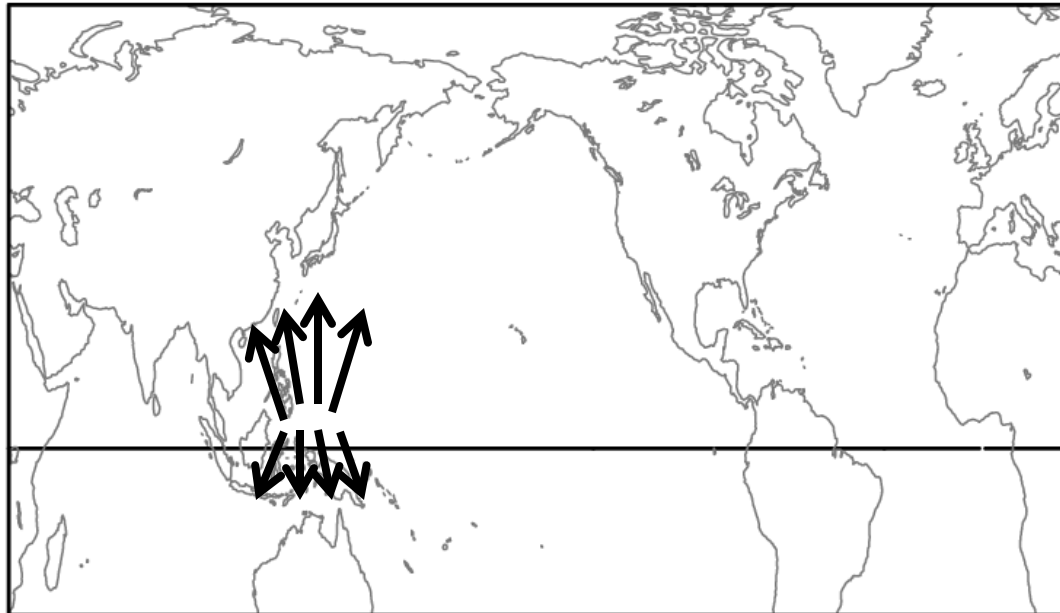
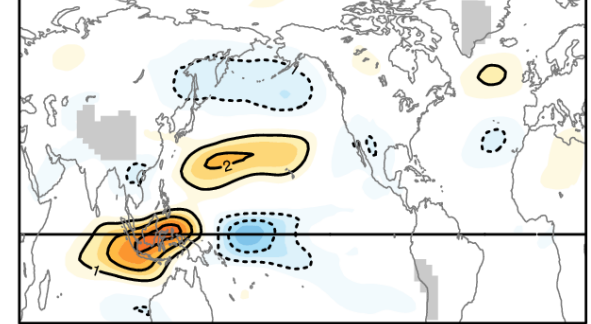
250hPa Divergent v



250hPa zonal wind

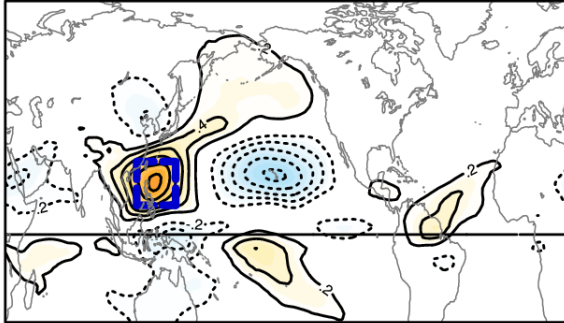


700hPa zonal wind

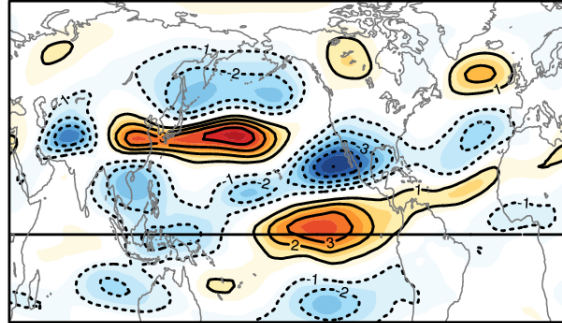


Regressions onto divergent v in the natural variability of CCSM4

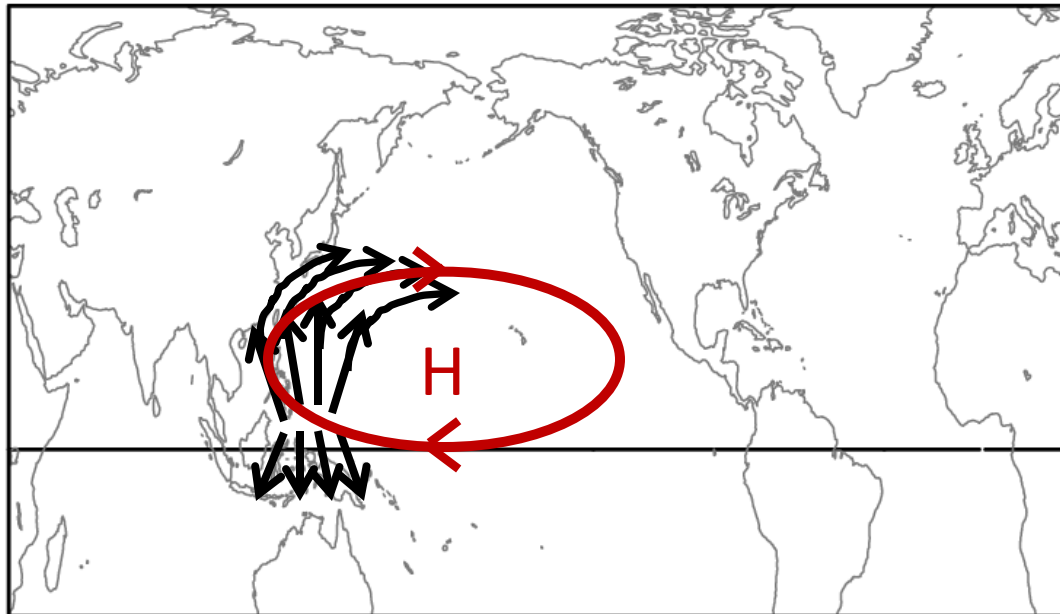
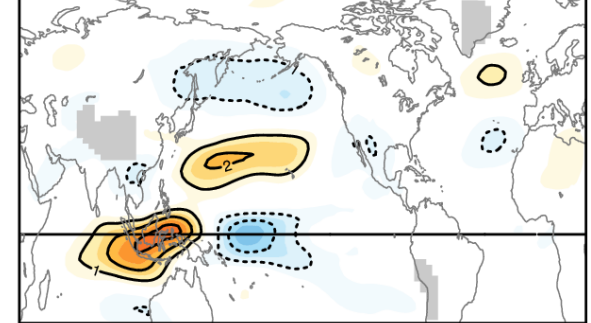
250hPa Divergent v



250hPa zonal wind

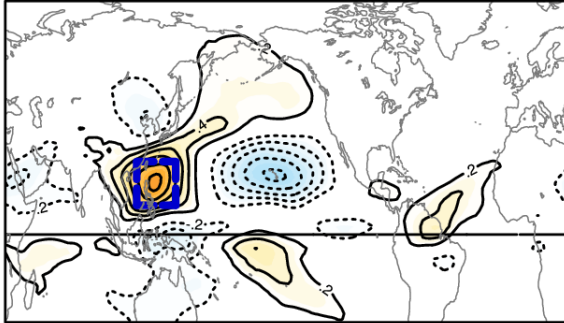


700hPa zonal wind

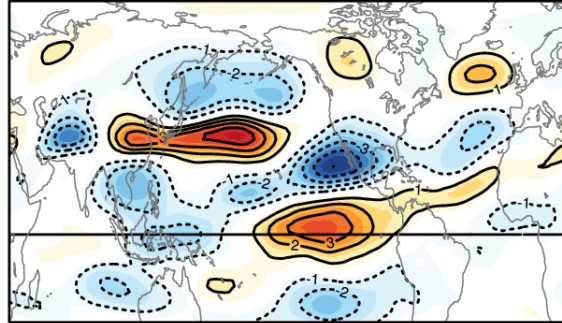


Regressions onto divergent v in the natural variability of CCSM4

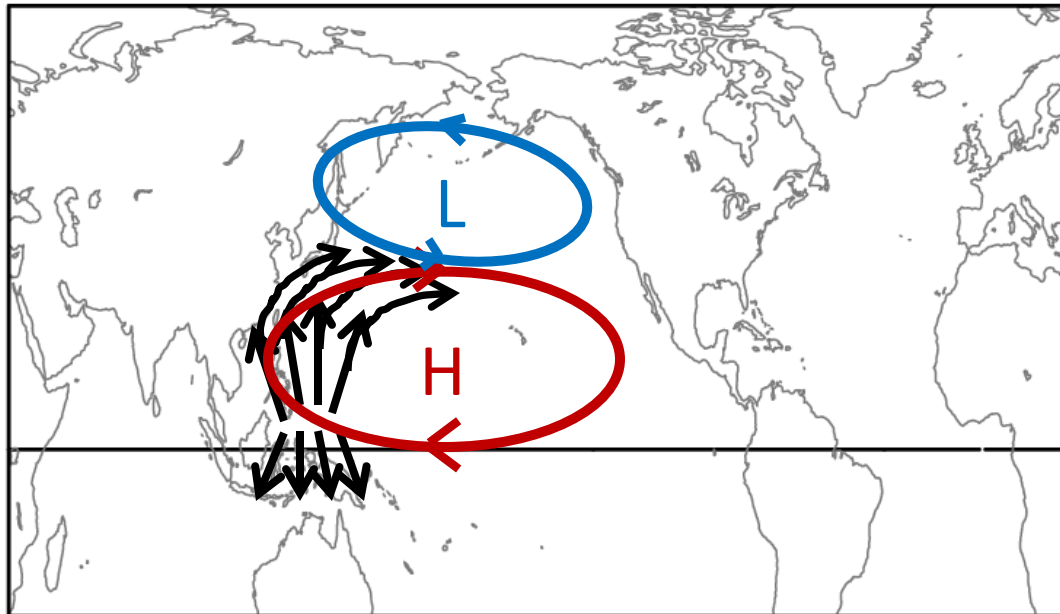
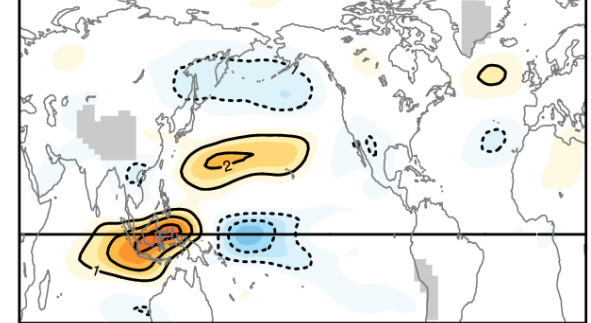
250hPa Divergent v



250hPa zonal wind

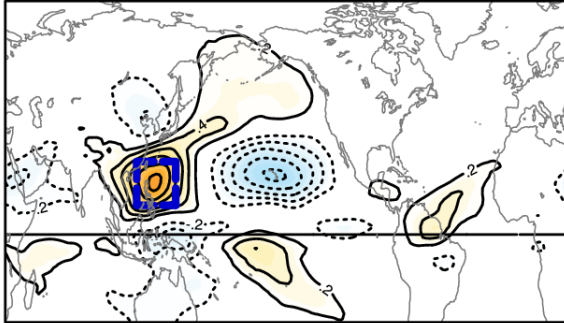


700hPa zonal wind

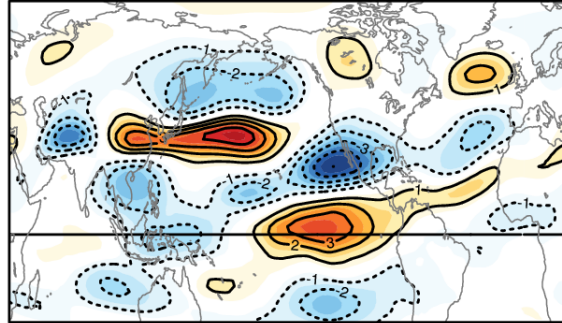


Regressions onto divergent v in the natural variability of CCSM4

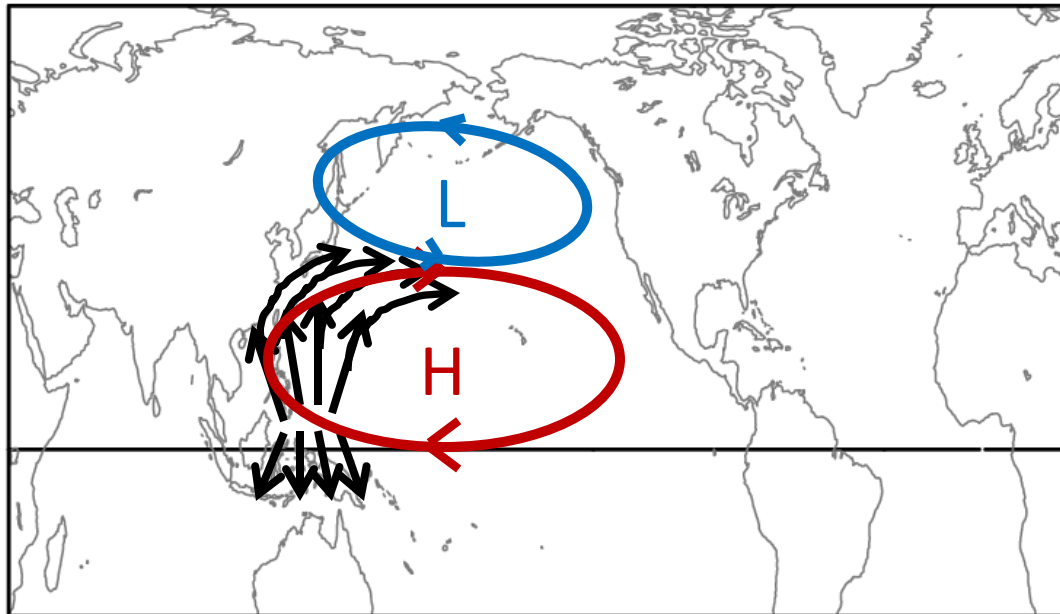
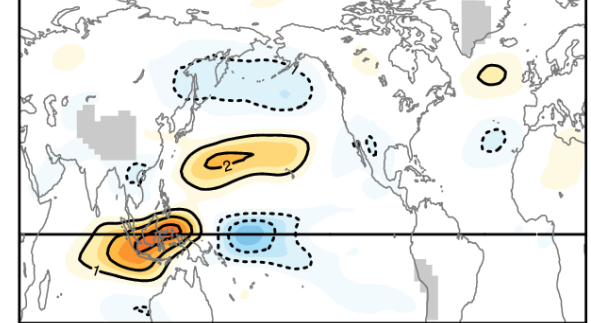
250hPa Divergent v



250hPa zonal wind

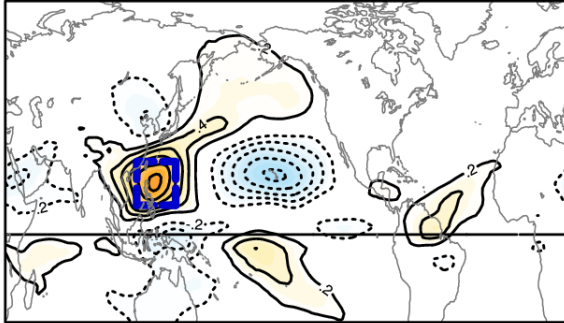


700hPa zonal wind

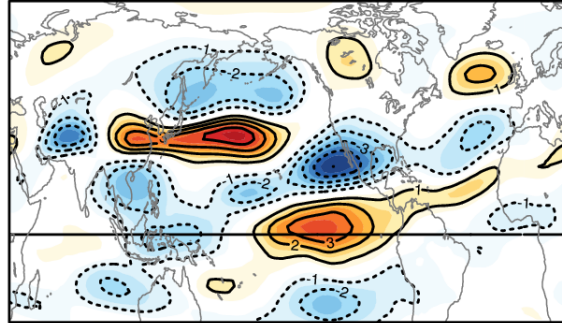


Regressions onto divergent v in the natural variability of CCSM4

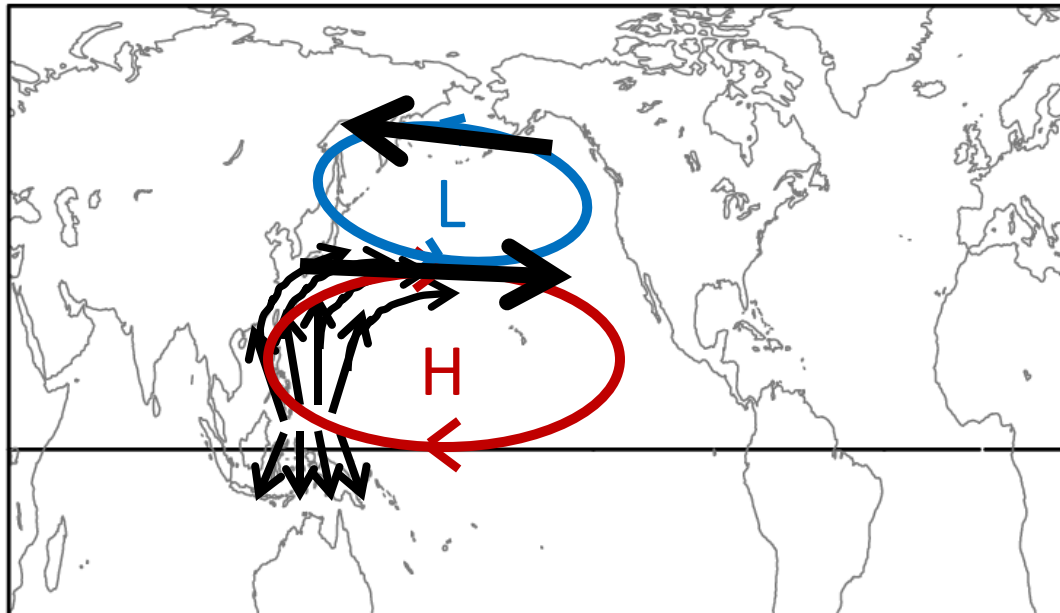
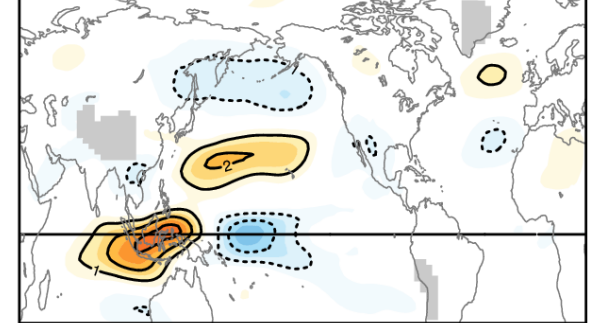
250hPa Divergent v



250hPa zonal wind

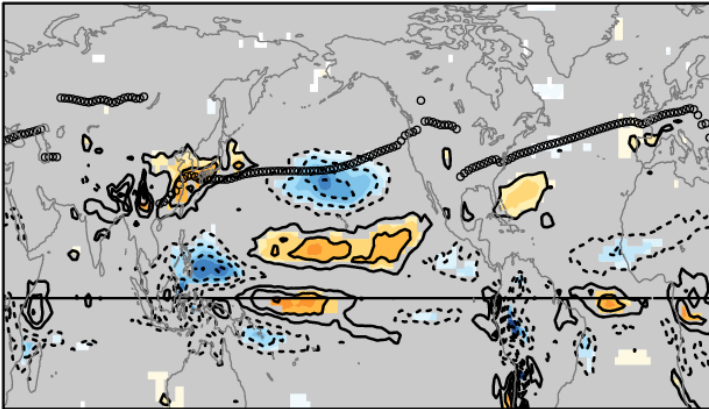


700hPa zonal wind

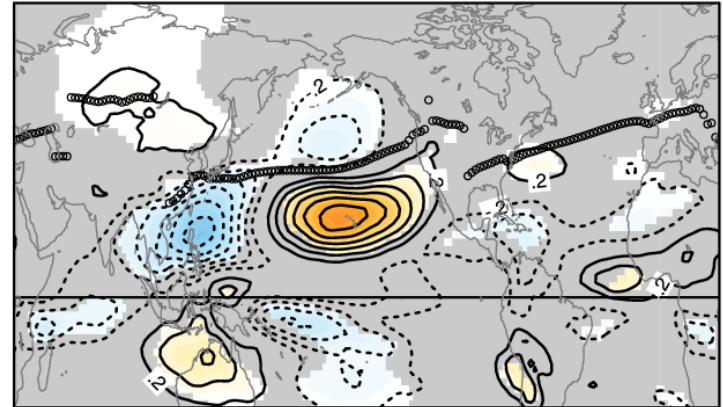


A reasonable hypothesis is that the difference between the Poleward and the Not Poleward models arises from their different behaviors in the tropics.

Poleward - Not Poleward

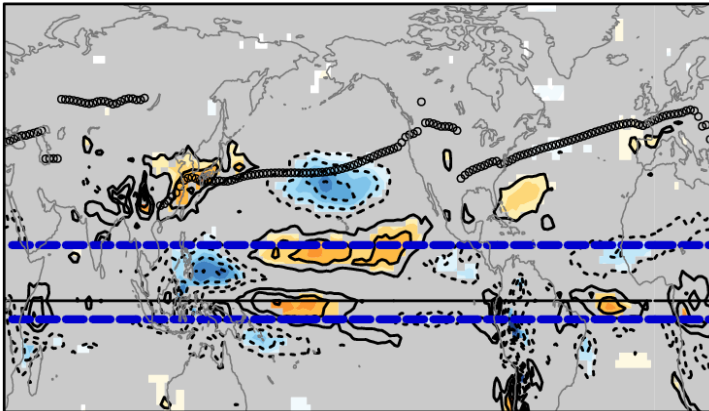


Poleward - Not Poleward

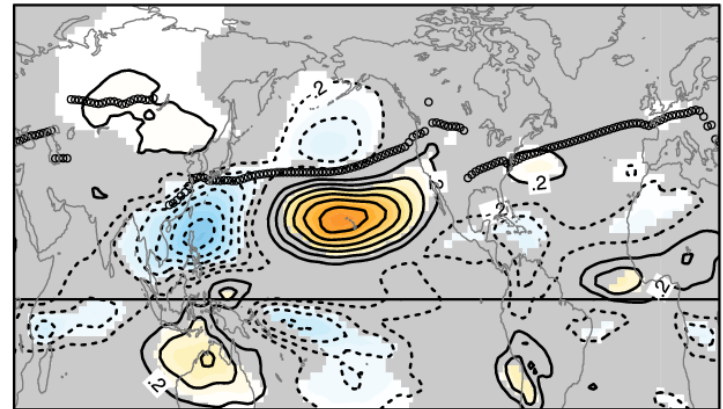


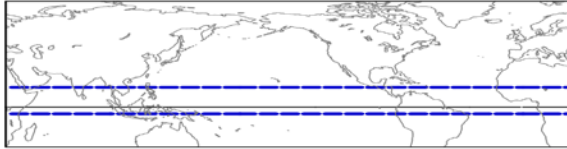
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Poleward - Not Poleward

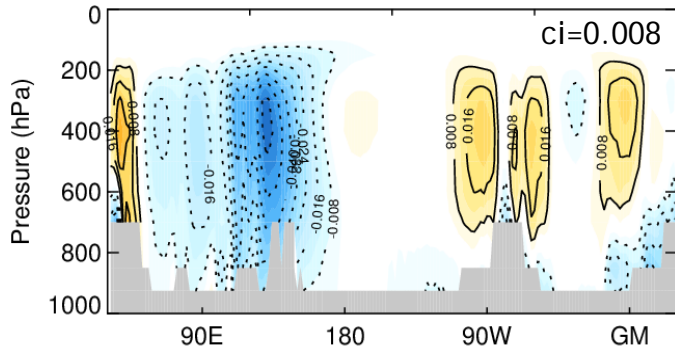


Poleward - Not Poleward



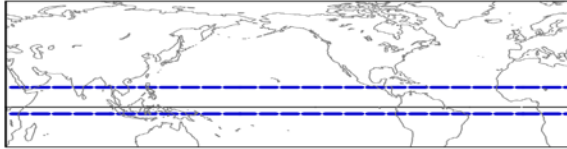


Past

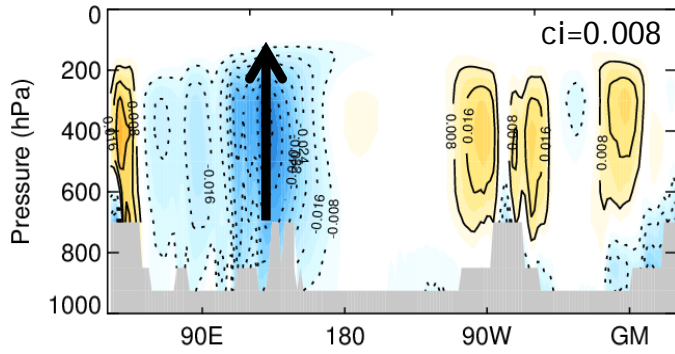


Multi-model mean past climatology

Vertical Velocity

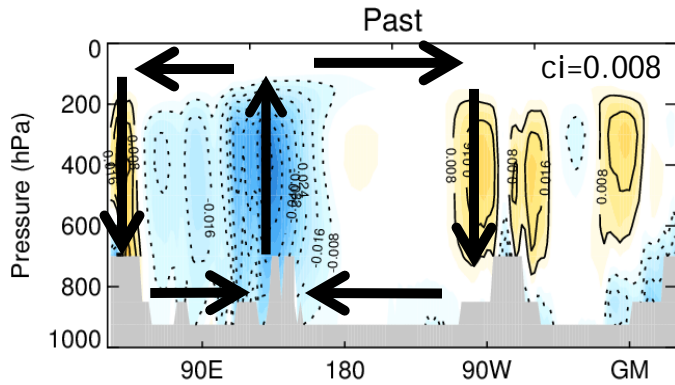
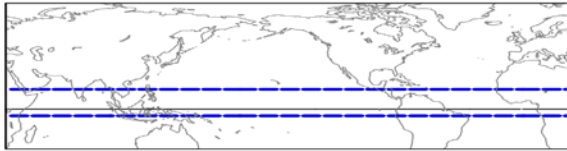


Past

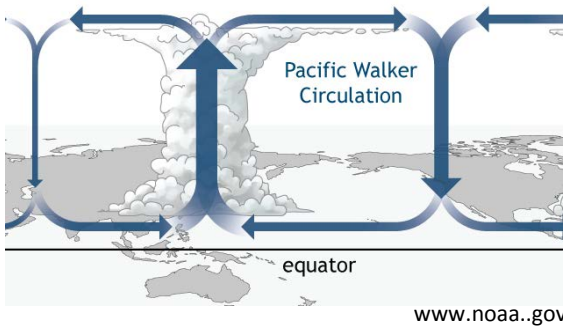


Multi-model mean past climatology

Vertical Velocity

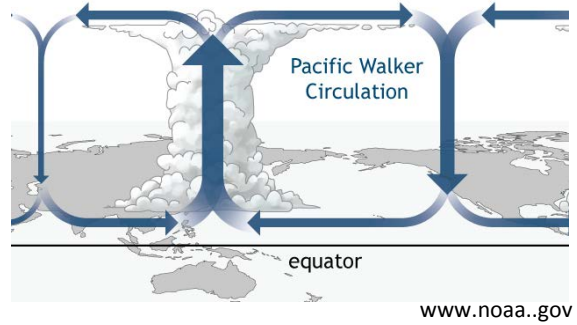
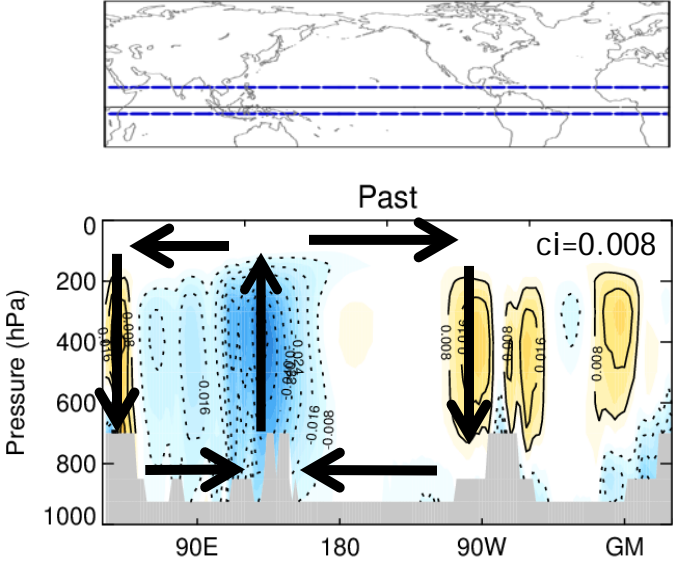
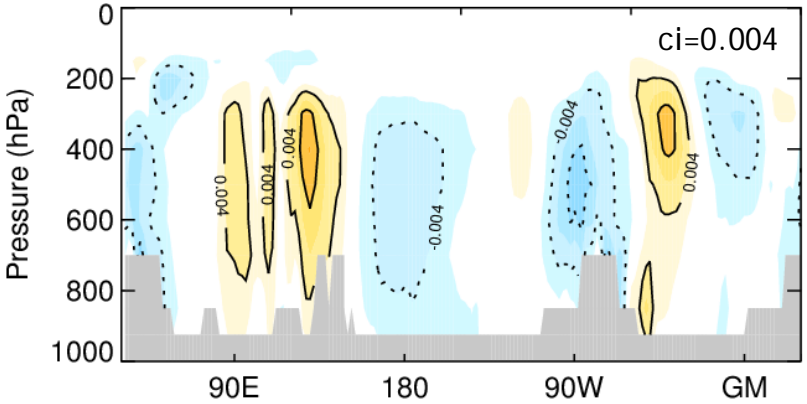


Multi-model mean past climatology



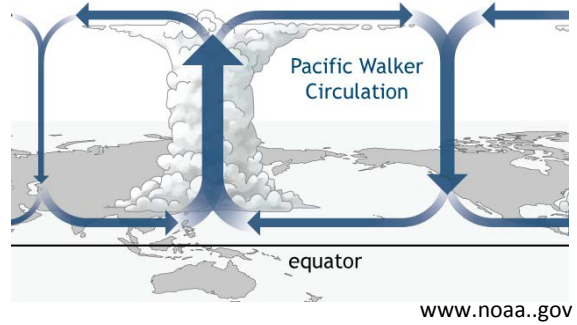
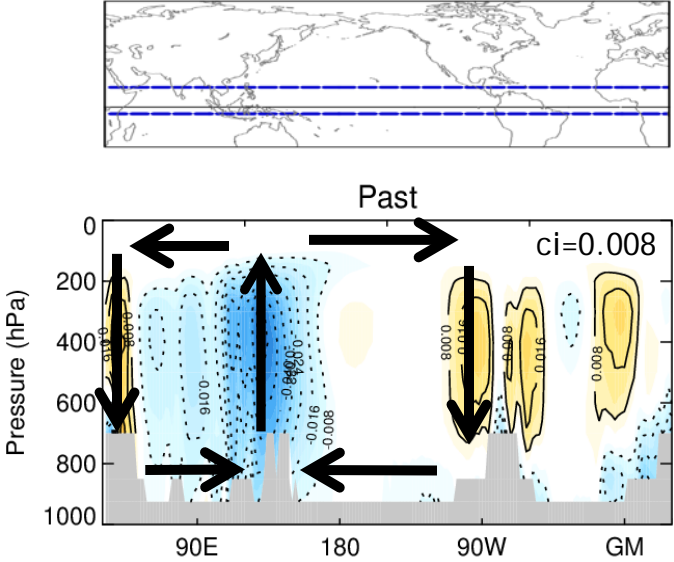
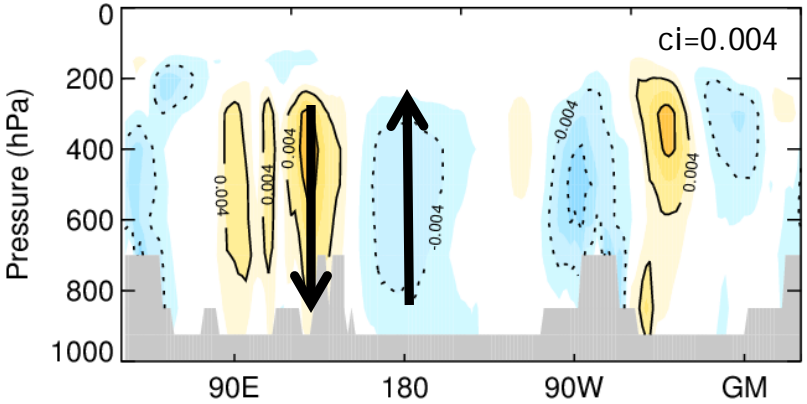
Vertical Velocity

Future-Past



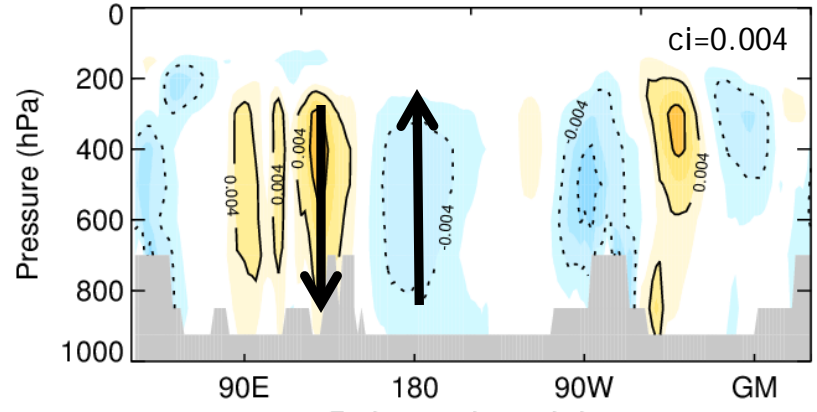
Vertical Velocity

Future-Past

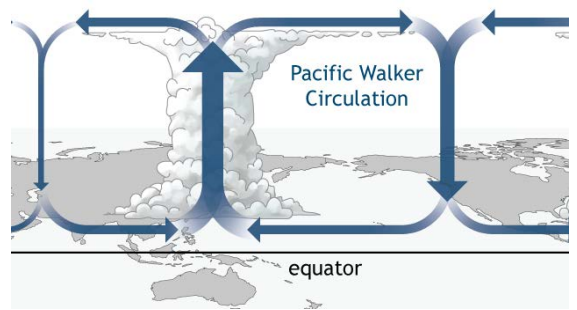
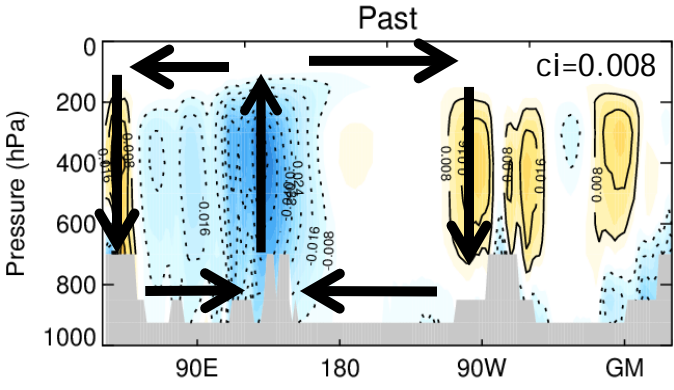
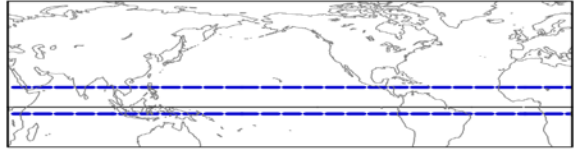
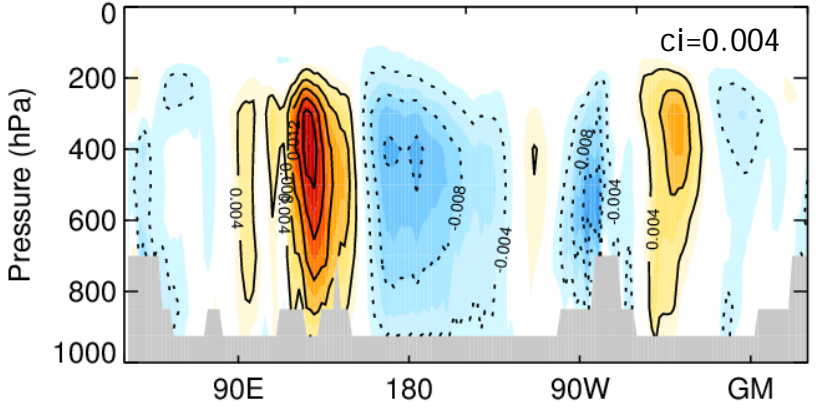


Vertical Velocity

Future-Past



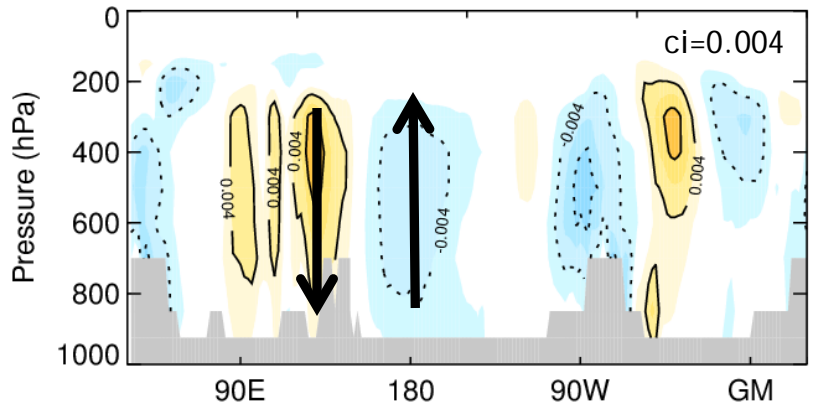
Poleward models



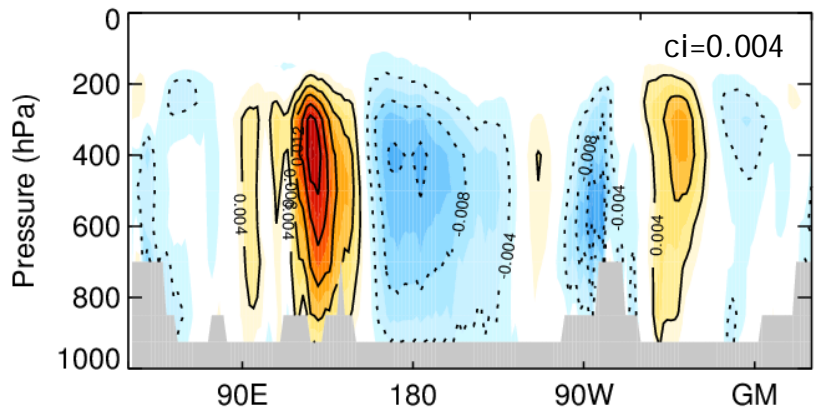
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Vertical Velocity

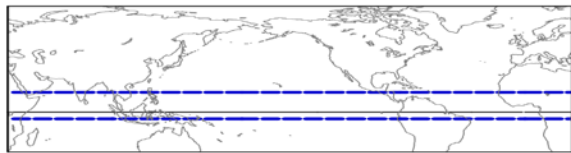
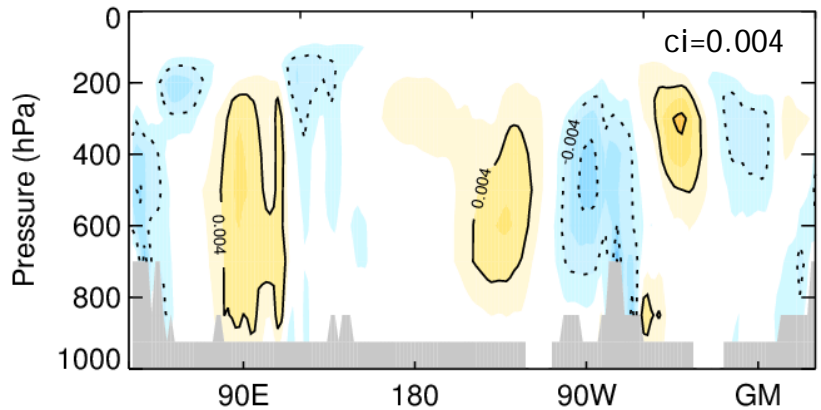
Future-Past



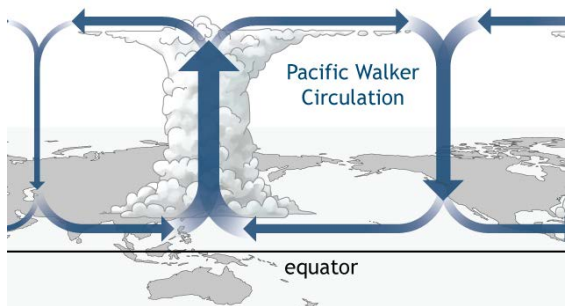
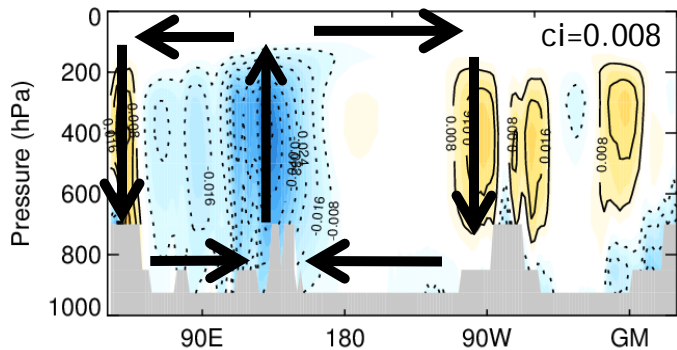
Poleward models



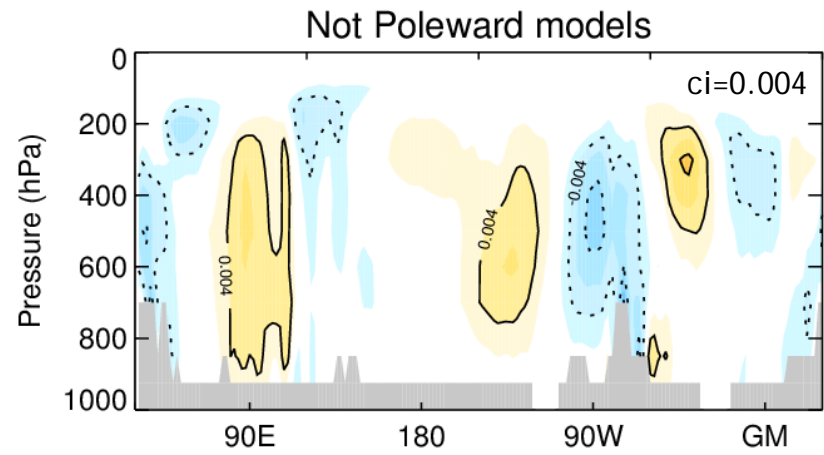
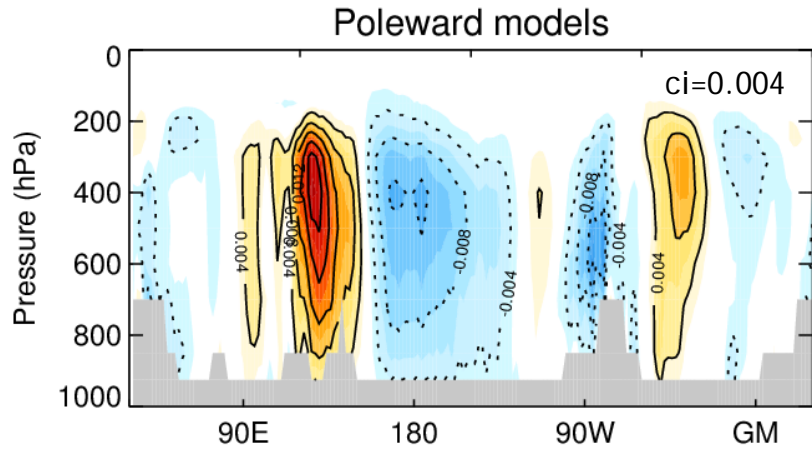
Not Poleward models



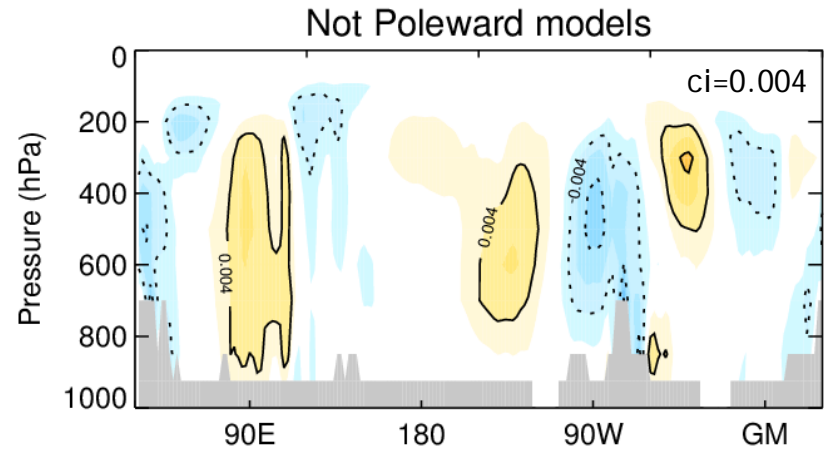
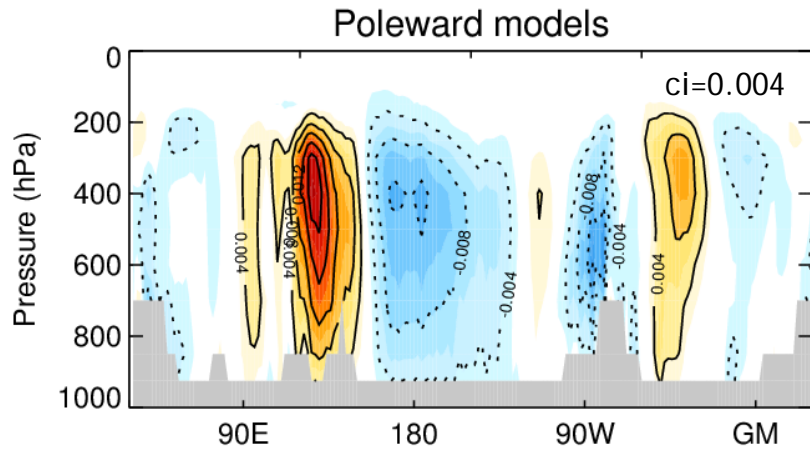
Past



Vertical Velocity

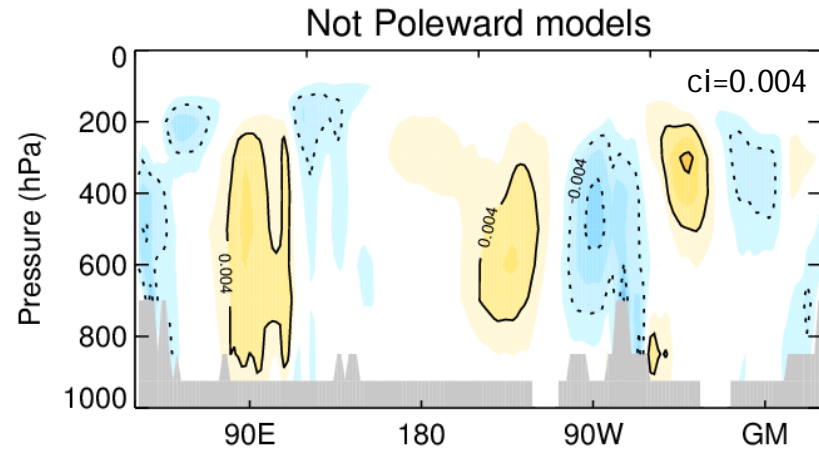
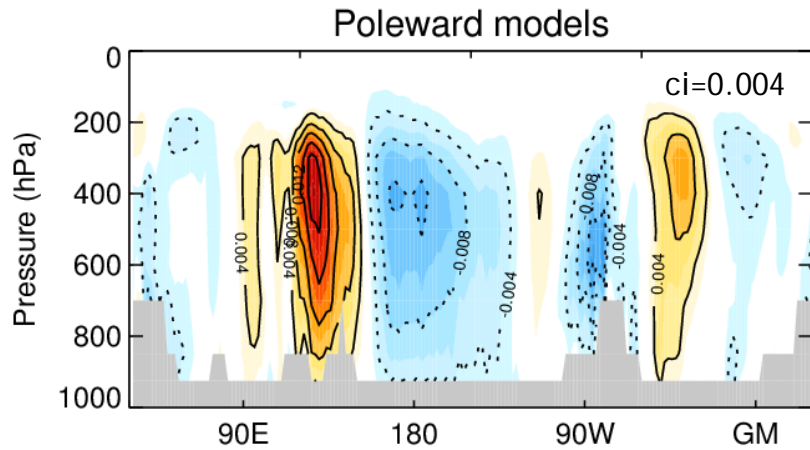


Why this difference?



Why this difference?

$$Q = - \left(\frac{P}{P_o} \right)^{\kappa} \omega \left(\frac{\partial \theta}{\partial p} \right)$$

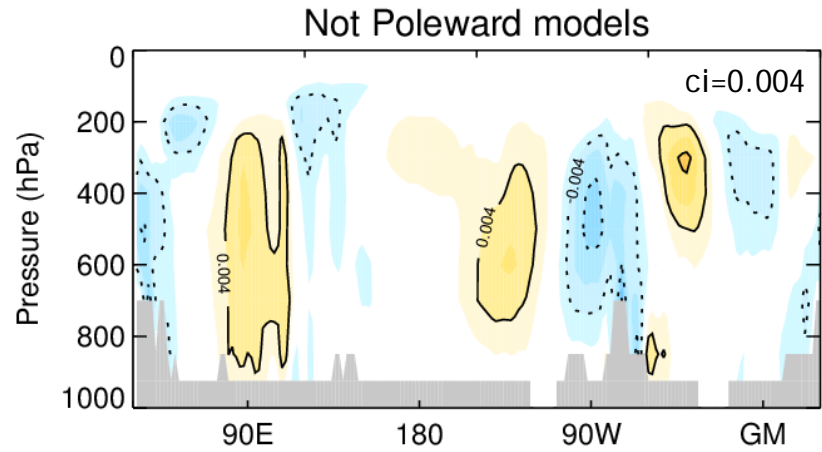
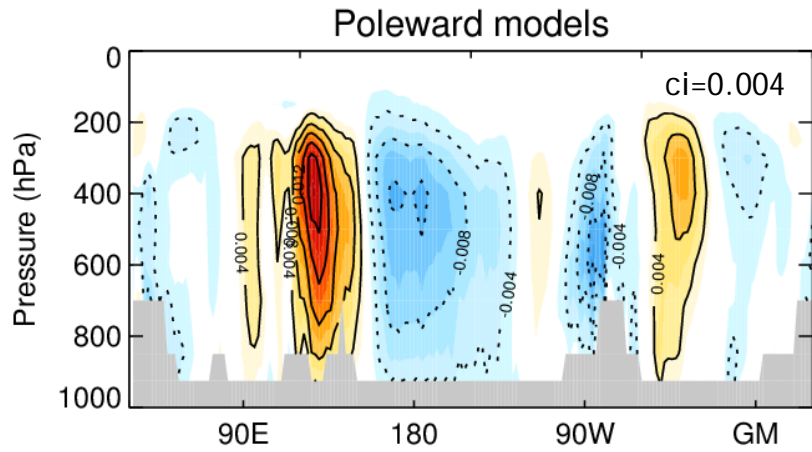


Why this difference?

$$Q = - \left(\frac{P}{P_o} \right)^{\kappa} \omega \left(\frac{\partial \theta}{\partial p} \right)$$

Diabatic Heating

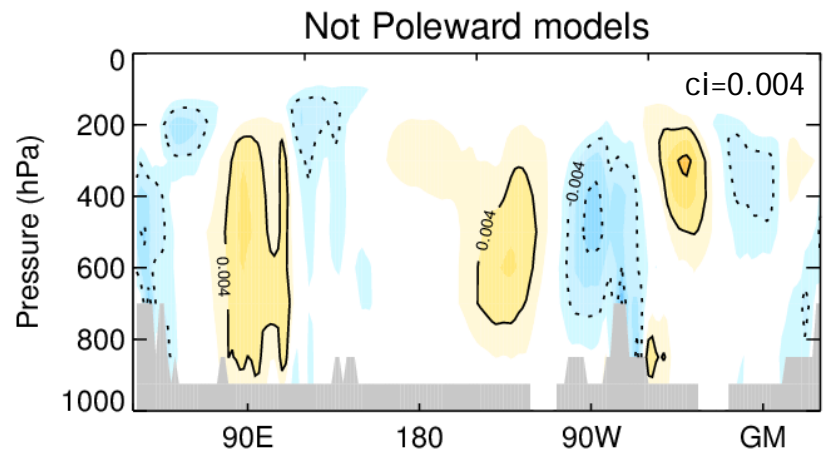
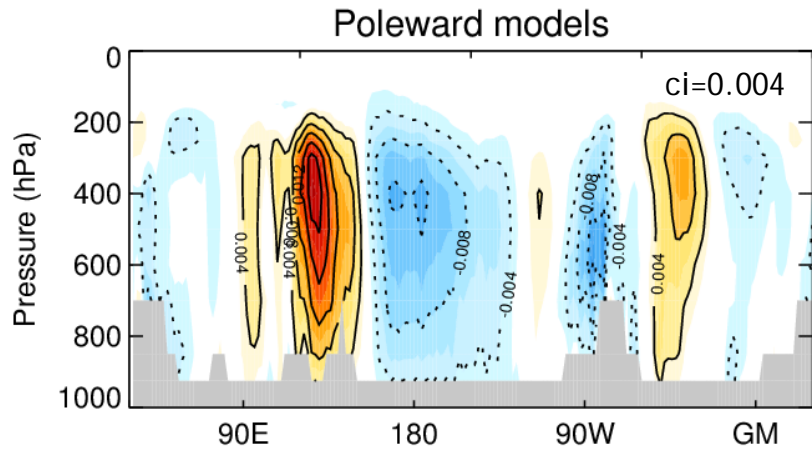
Vertical Advection



Why this difference?

Increasing θ

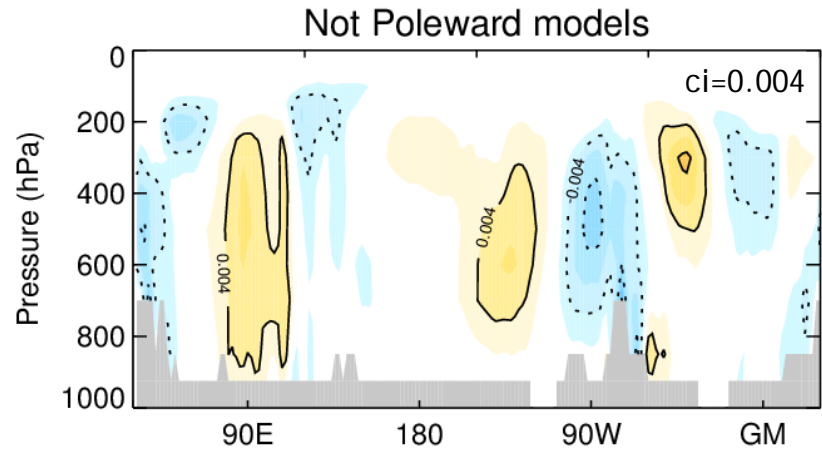
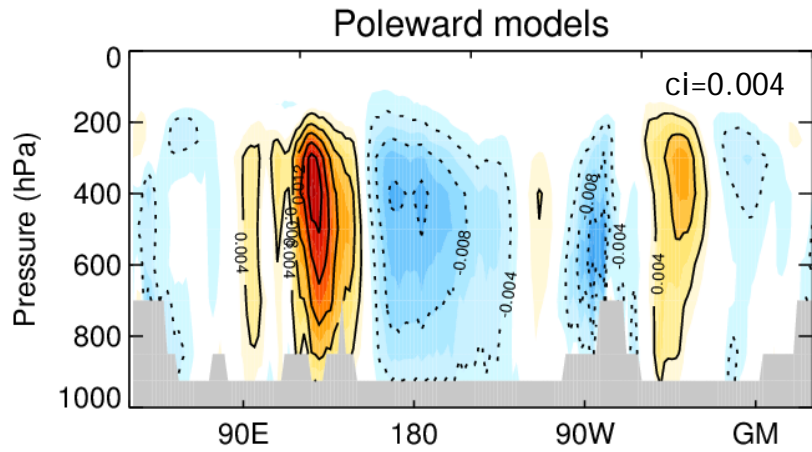




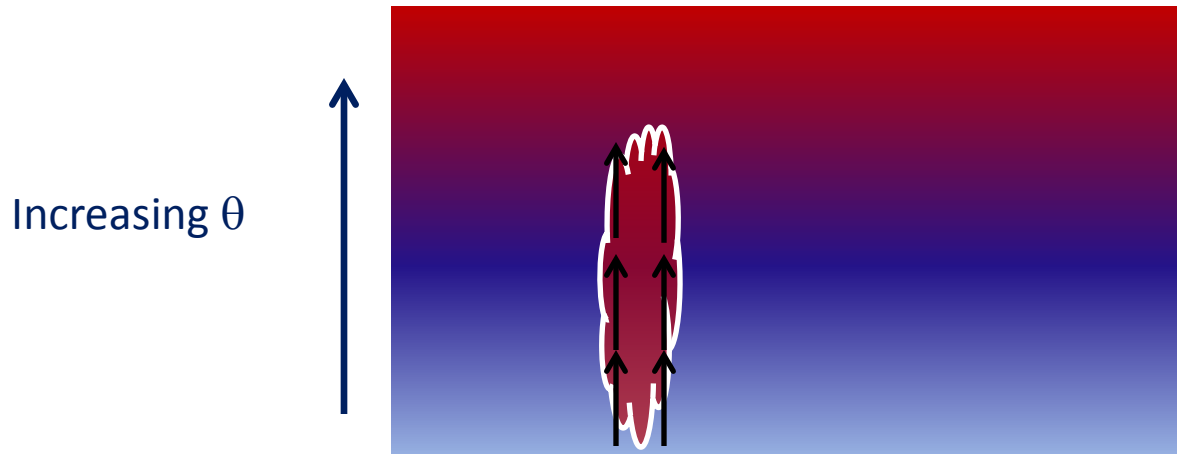
Why this difference?

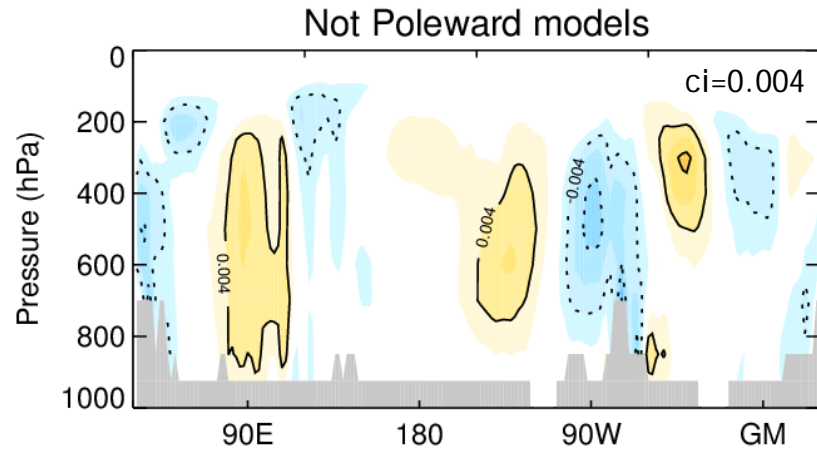
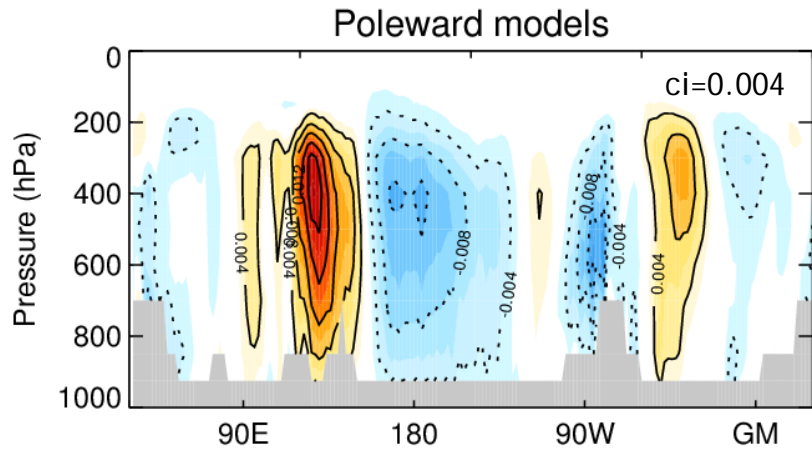
Increasing θ





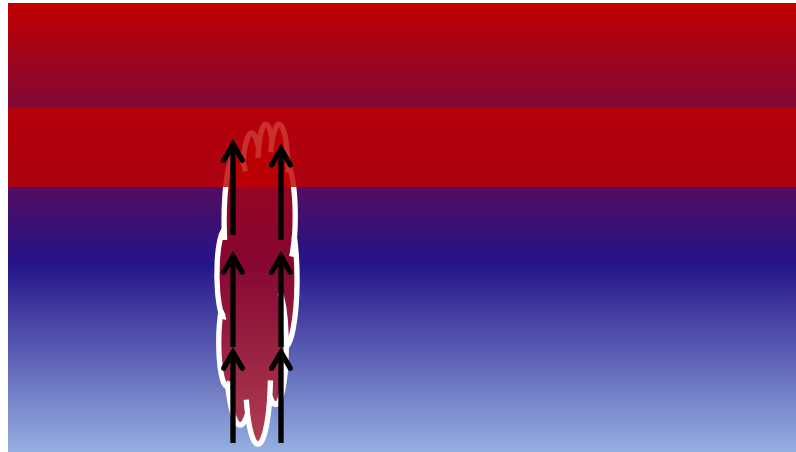
Why this difference?



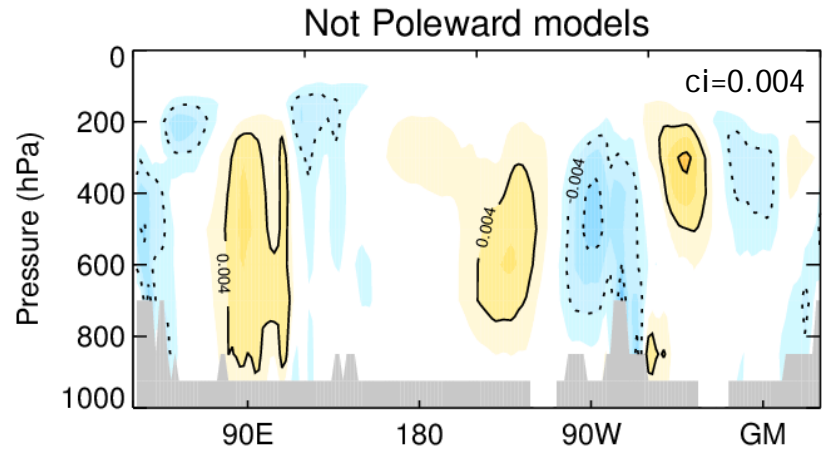
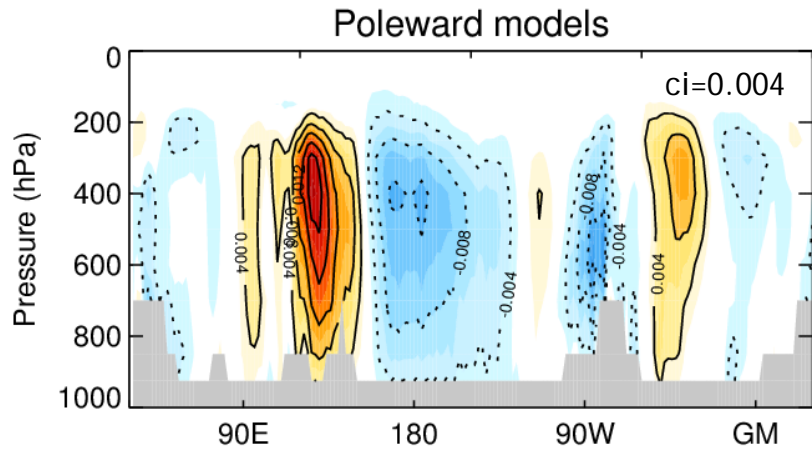


Why this difference?

Increasing θ

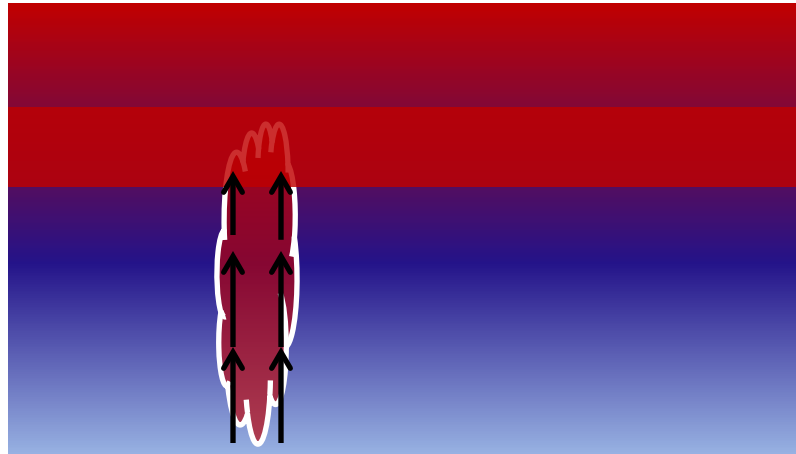


Stability Influence

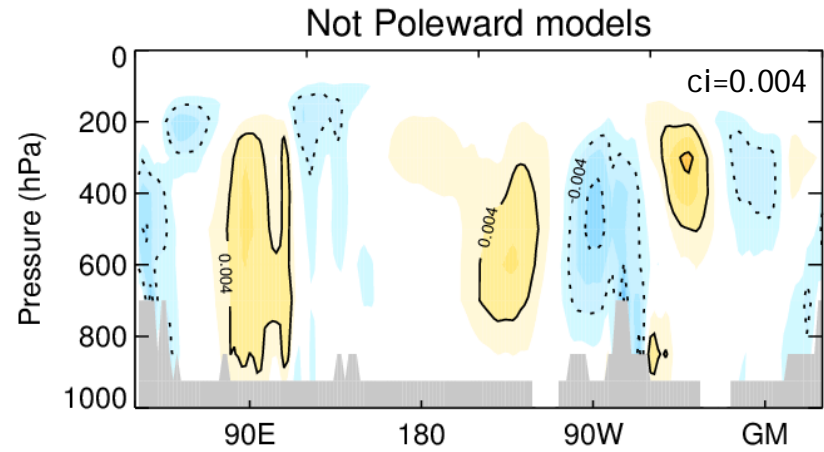
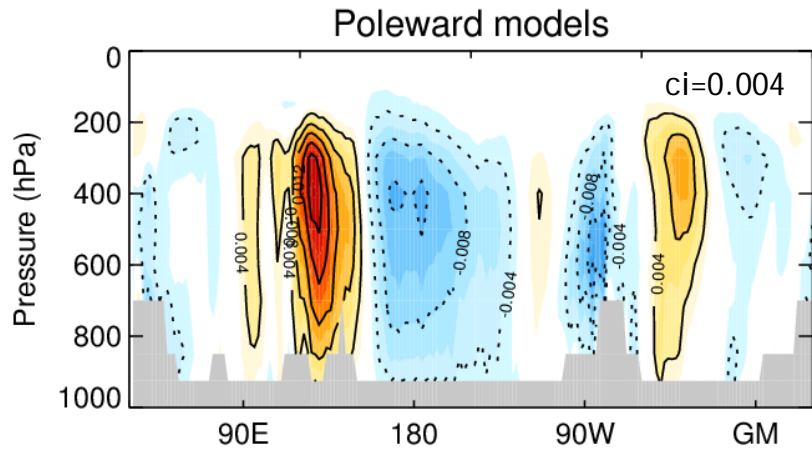


Why this difference?

Increasing θ

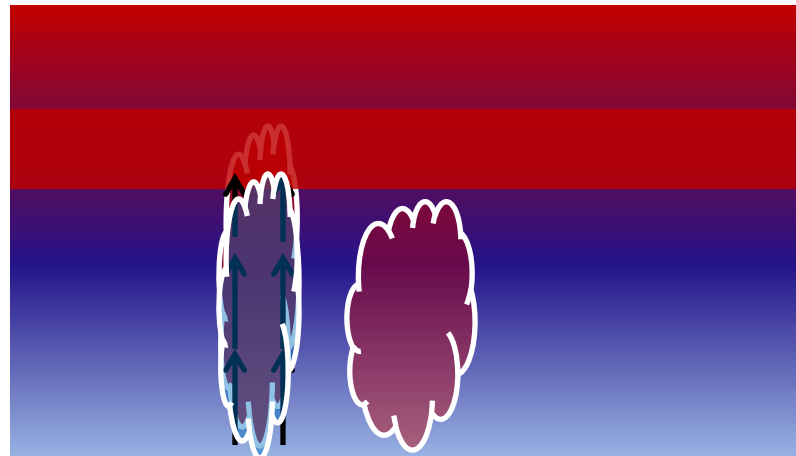


Stability Influence



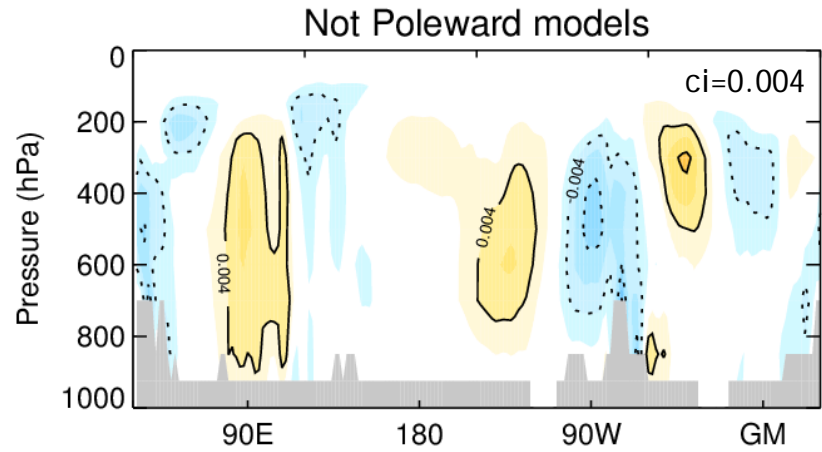
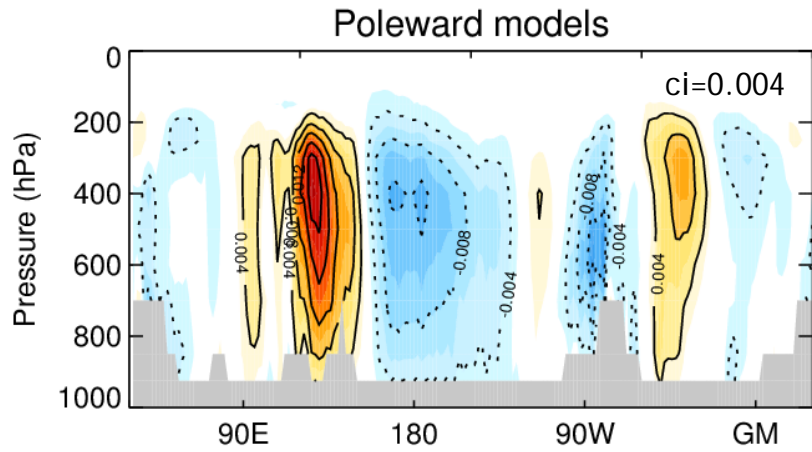
Why this difference?

Increasing θ



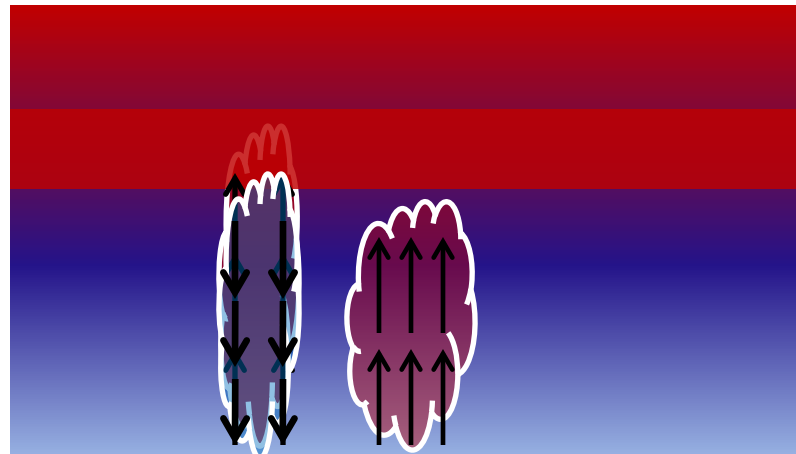
Stability Influence

Redistribution of Diabatic Heating (Q)



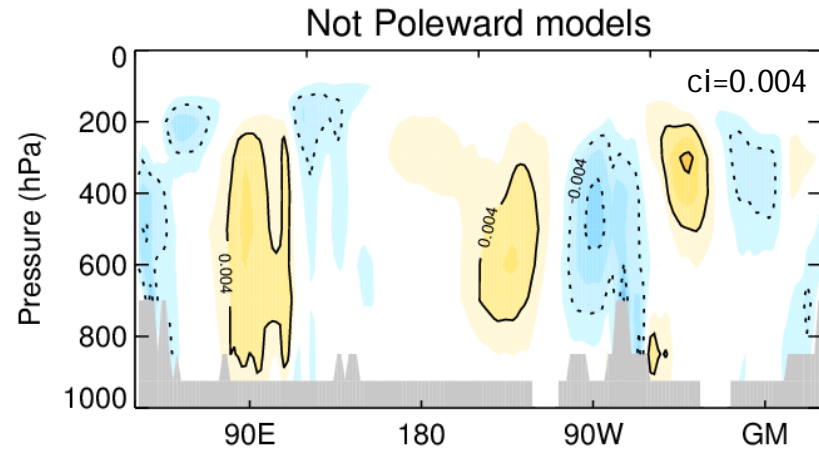
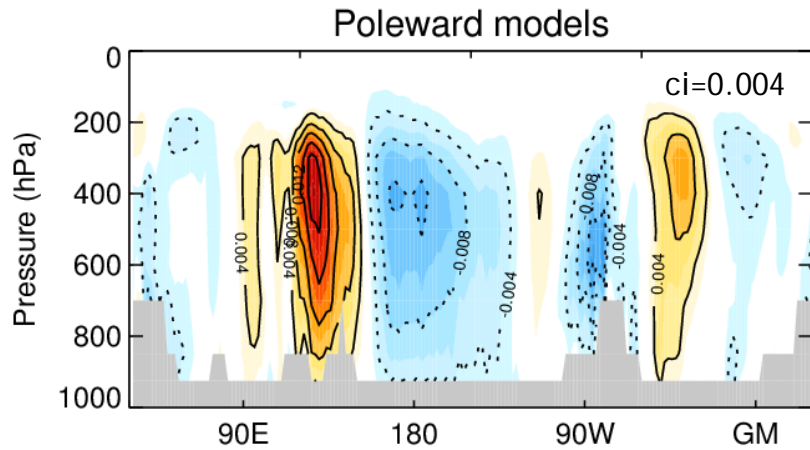
Why this difference?

Increasing θ



Stability Influence

Redistribution of Diabatic Heating (Q)



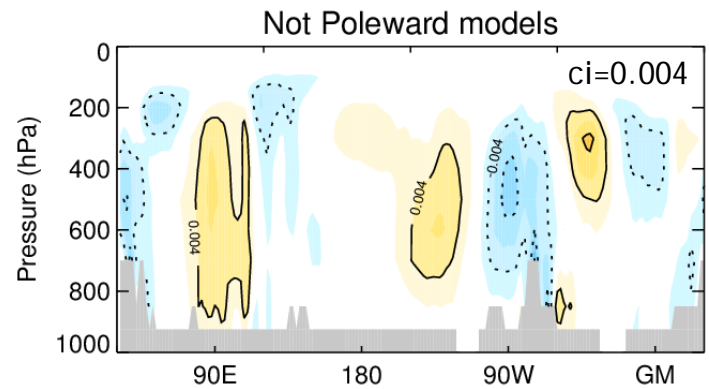
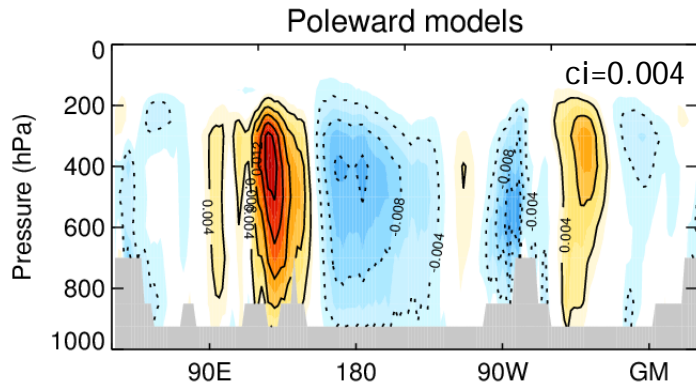
Why this difference?

$$\Delta\omega = - \left(\frac{P}{P_o} \right)^{-\kappa} \left(\frac{\partial\theta}{\partial p} \right)_p^{-1} \Delta Q - \left(\frac{\partial\theta}{\partial P} \right)_p^{-1} \omega_p \Delta \left(\frac{\partial\theta}{\partial P} \right) + \text{Nonlinear}$$

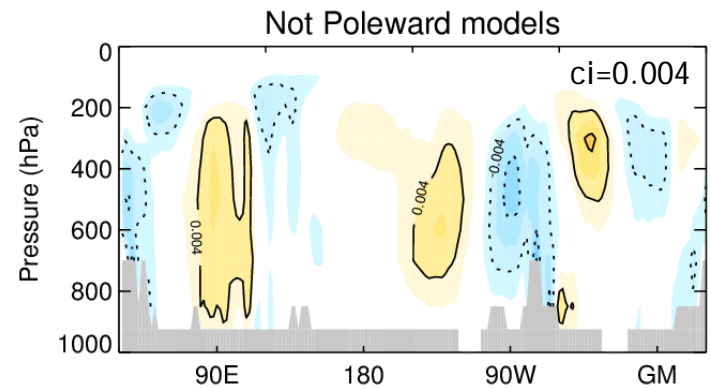
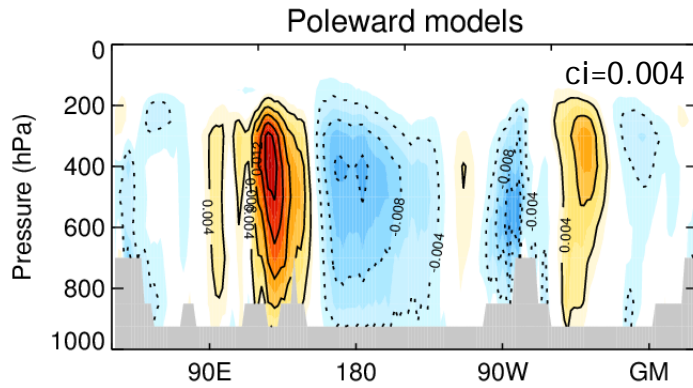
Change in Diabatic Heating

Change in Stability

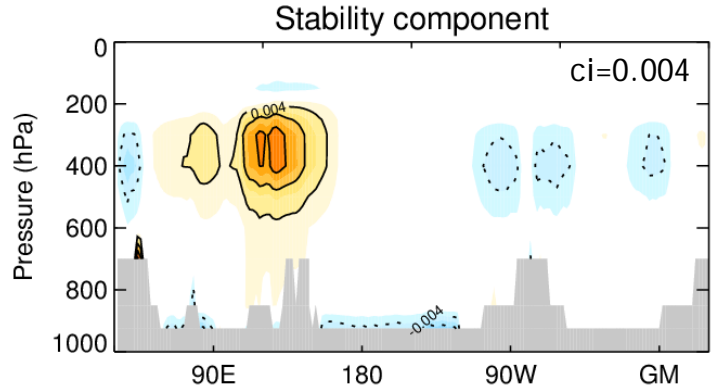
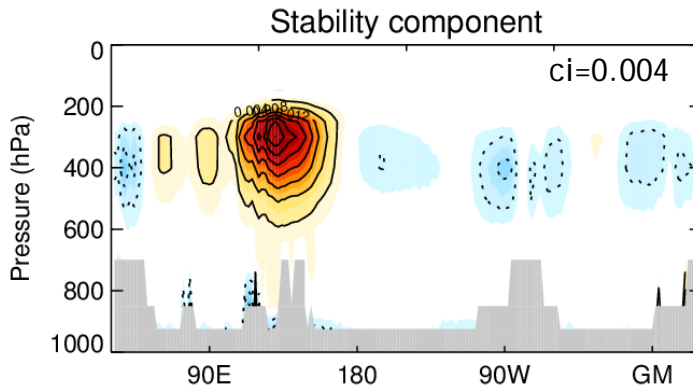
Full change
in ω



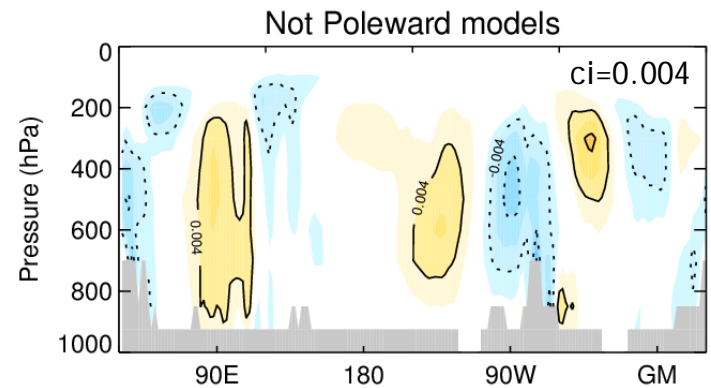
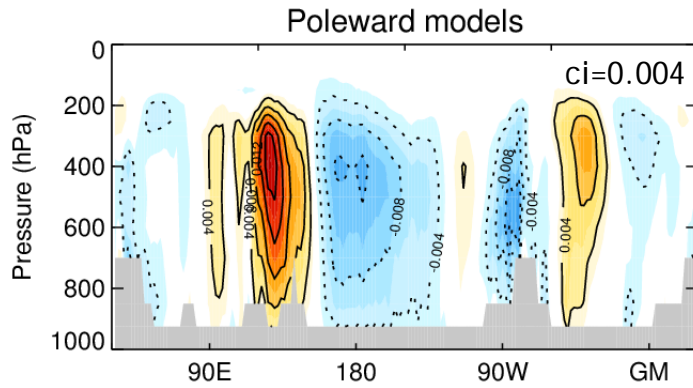
Full change
in ω



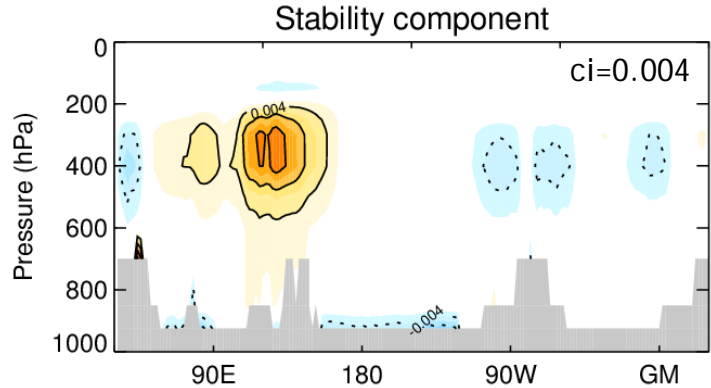
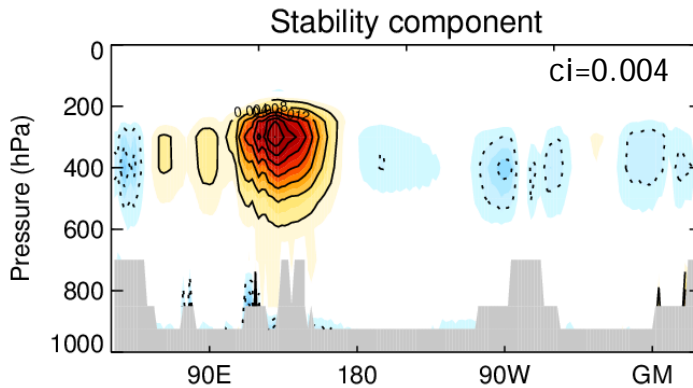
Component
due to
change in
stability



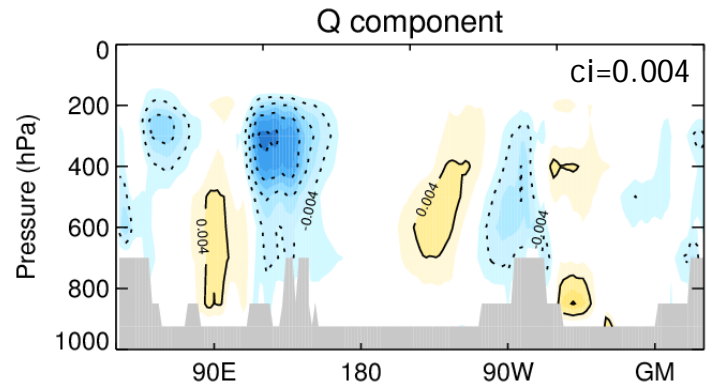
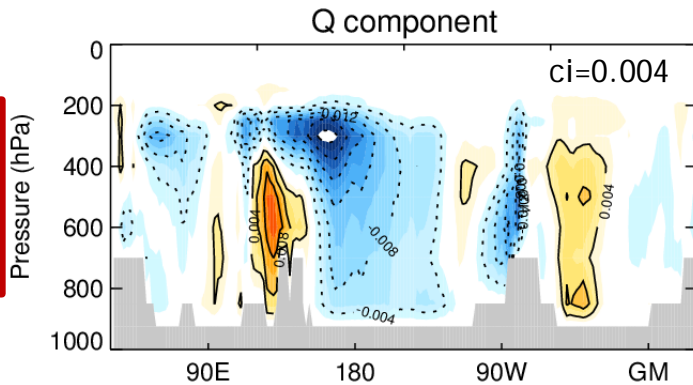
Full change
in ω



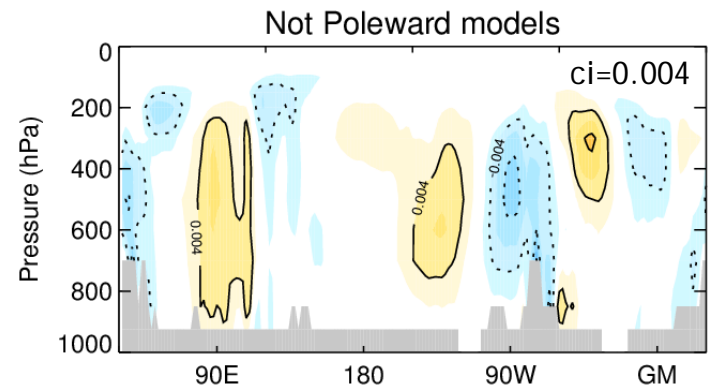
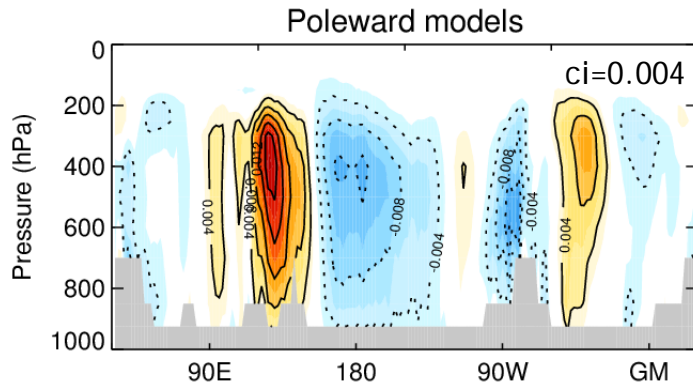
Component
due to
change in
stability



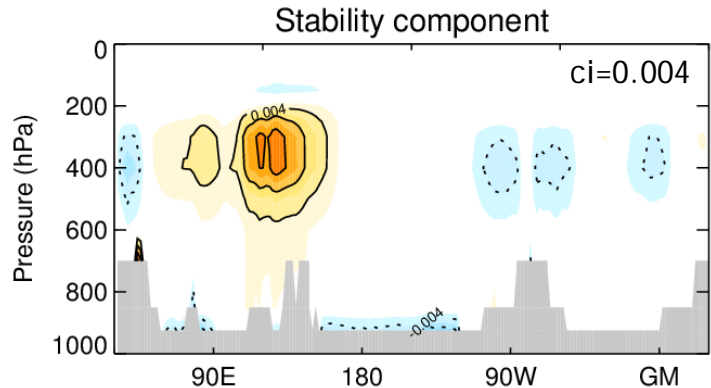
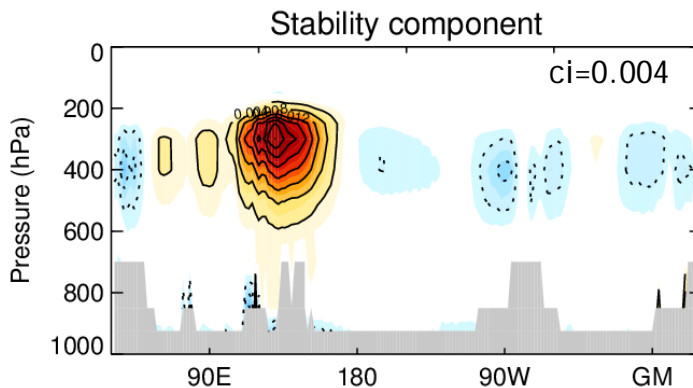
Component
due to
change in Q



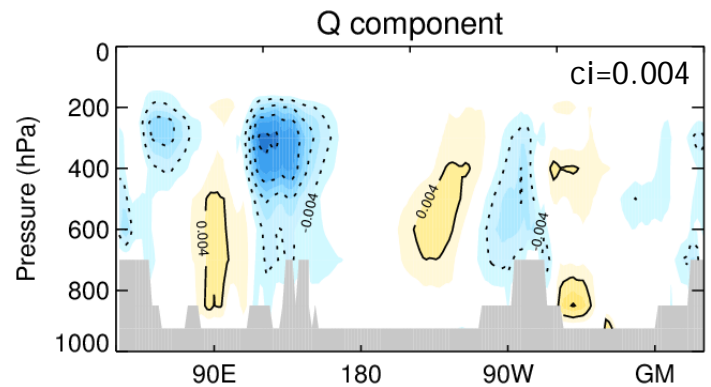
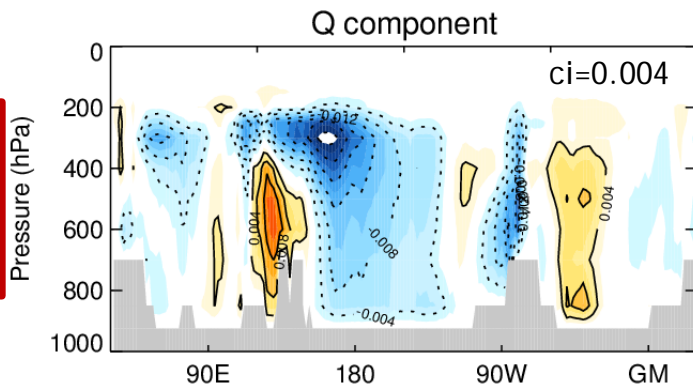
Full change
in ω



Component
due to
change in
stability



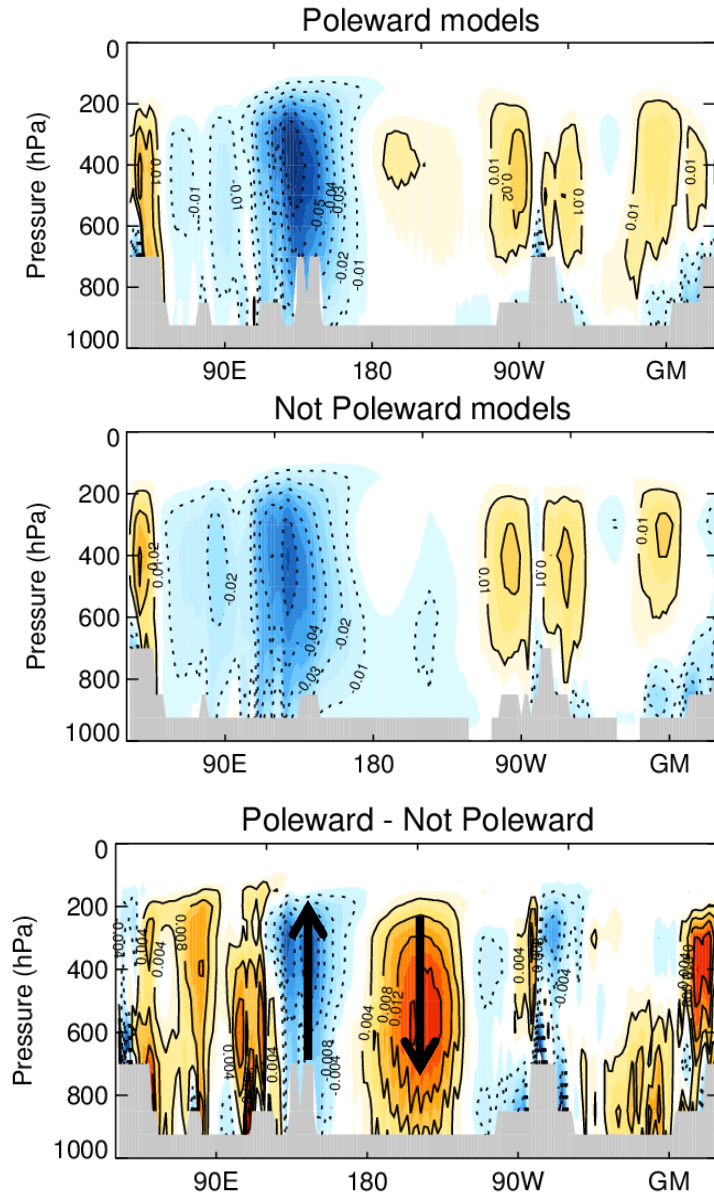
Component
due to
change in Q



Why this difference in the stability influence?

$$- \left(\frac{\partial \theta}{\partial P} \right)_p^{-1} \omega_p \Delta \left(\frac{\partial \theta}{\partial P} \right)$$

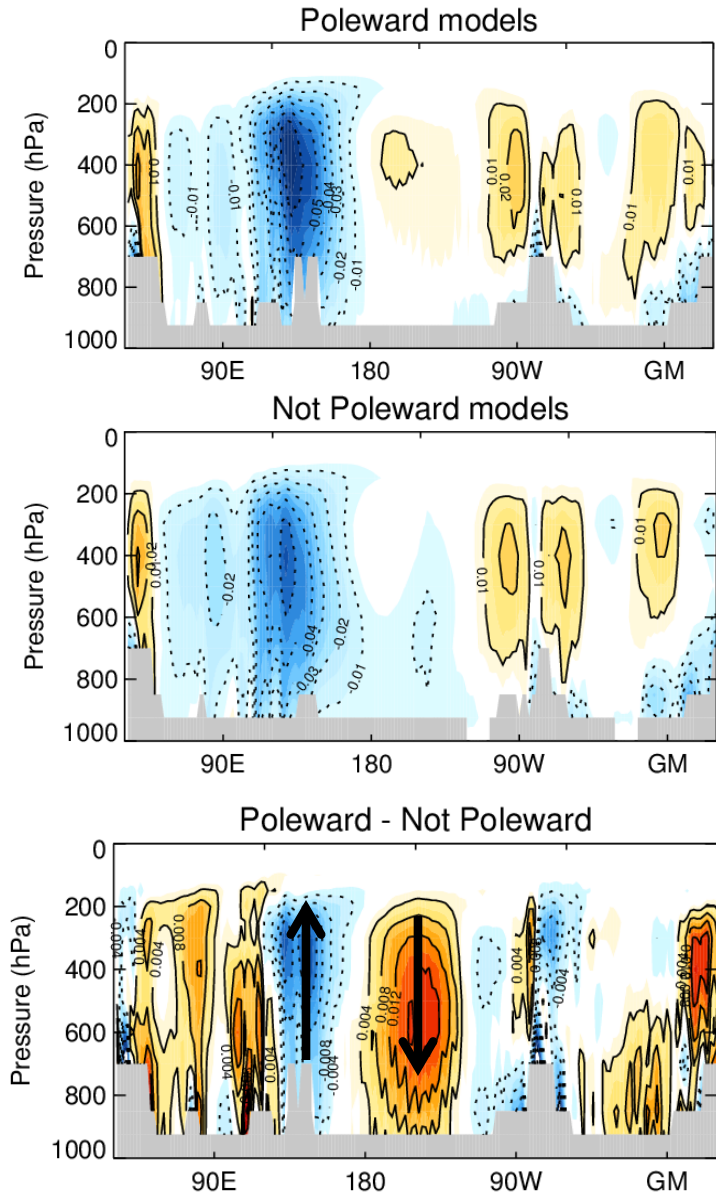
Past Climatological Vertical Velocity



Why this difference in the stability influence?

$$- \left(\frac{\partial \theta}{\partial P} \right)_p^{-1} \omega_p \Delta \left(\frac{\partial \theta}{\partial P} \right)$$

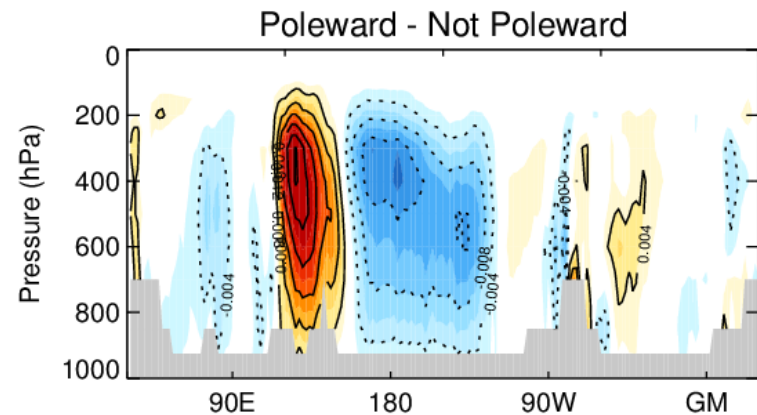
Past Climatological Vertical Velocity



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$$-\left(\frac{\partial \theta}{\partial P}\right)_p^{-1} \omega_p \Delta \left(\frac{\partial \theta}{\partial P}\right)$$

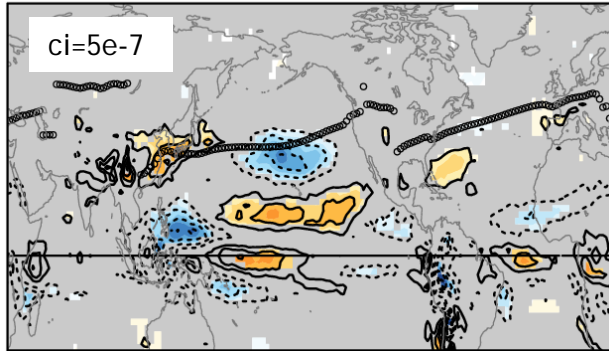
Future-Past Difference



Poleward - Not Poleward Models

Future-Past difference

Poleward - Not Poleward

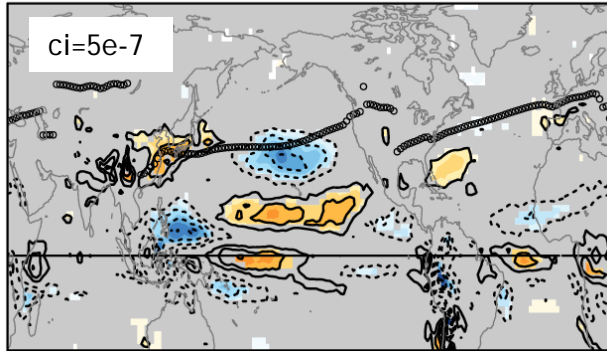


250hPa
Divergence

Poleward - Not Poleward Models

Future-Past difference

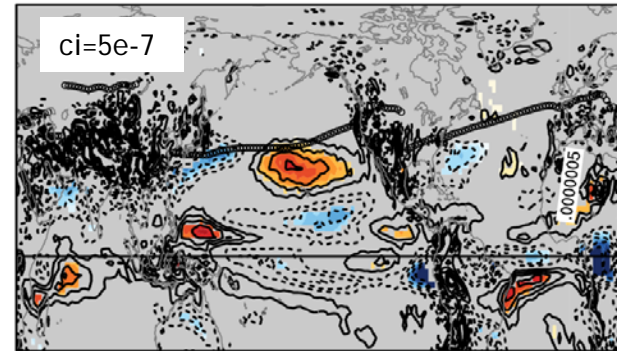
Poleward - Not Poleward



250hPa
Divergence

Past Climatology

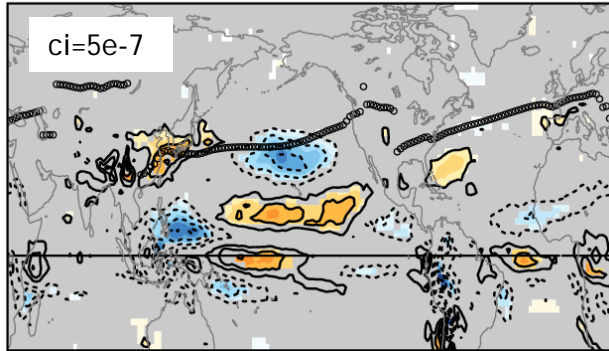
Poleward - Not Poleward



Poleward - Not Poleward Models

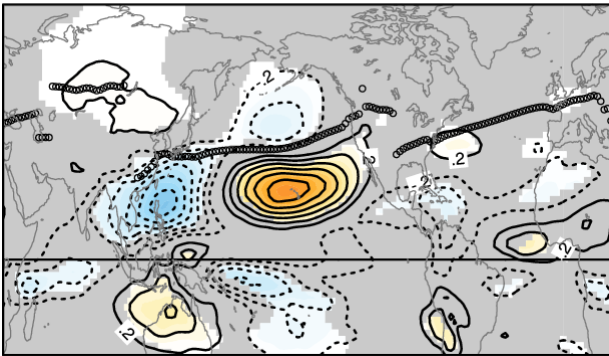
Future-Past difference

Poleward - Not Poleward



250hPa
Divergence

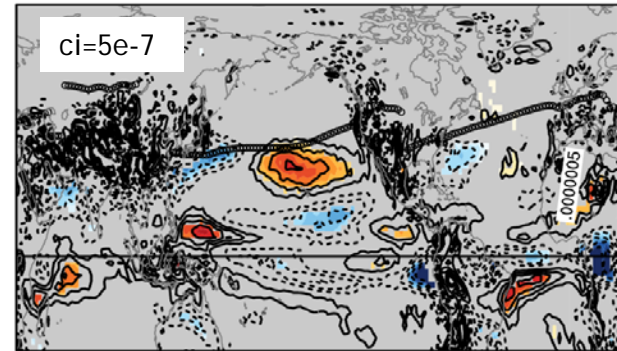
Poleward - Not Poleward



250hPa
Divergent v

Past Climatology

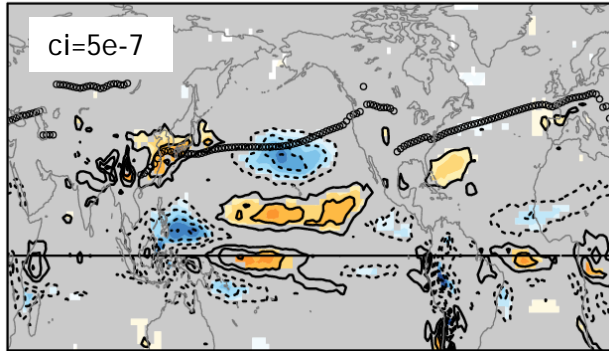
Poleward - Not Poleward



Poleward - Not Poleward Models

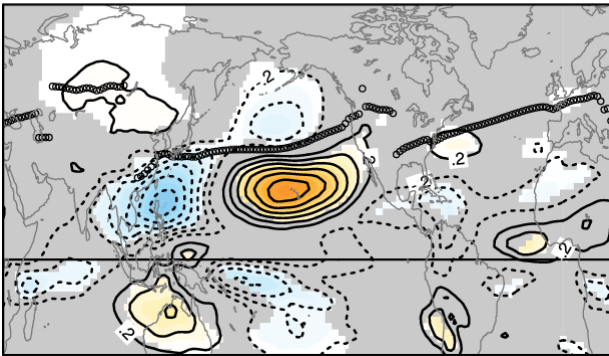
Future-Past difference

Poleward - Not Poleward



250hPa
Divergence

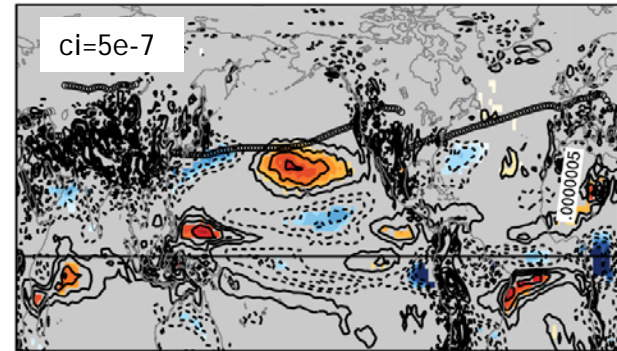
Poleward - Not Poleward



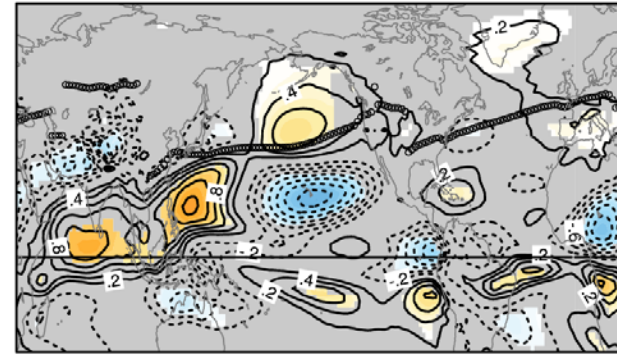
250hPa
Divergent v

Past Climatology

Poleward - Not Poleward



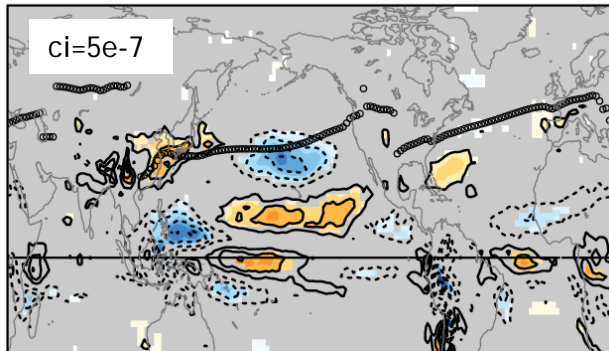
Poleward - Not Poleward



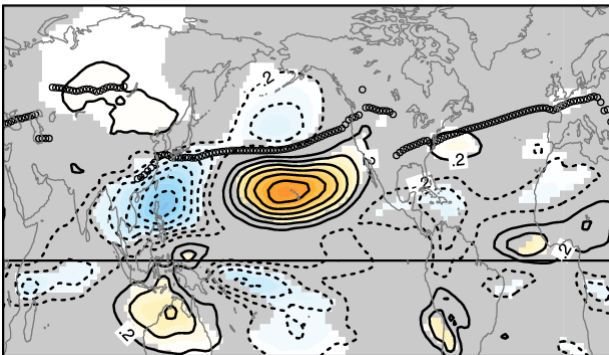
Poleward - Not Poleward Models

Future-Past difference

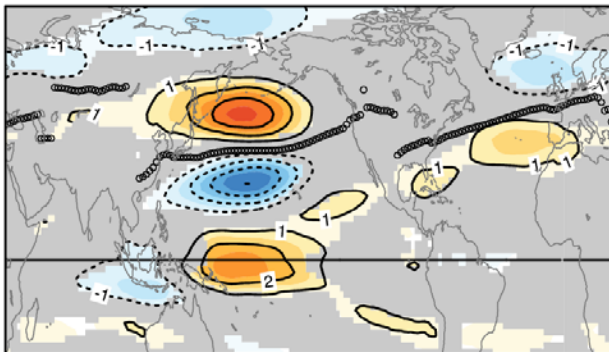
Poleward - Not Poleward



Poleward - Not Poleward

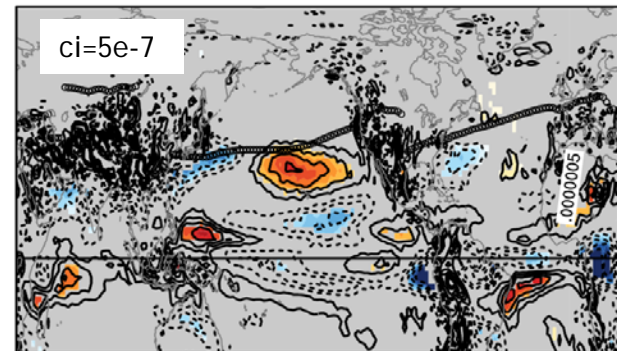


Poleward - Not Poleward

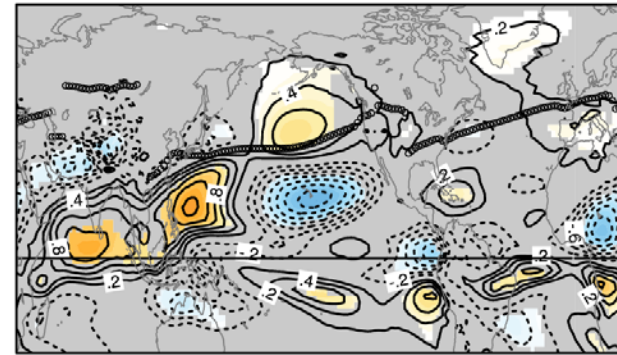


Past Climatology

Poleward - Not Poleward



Poleward - Not Poleward



250hPa
Divergence

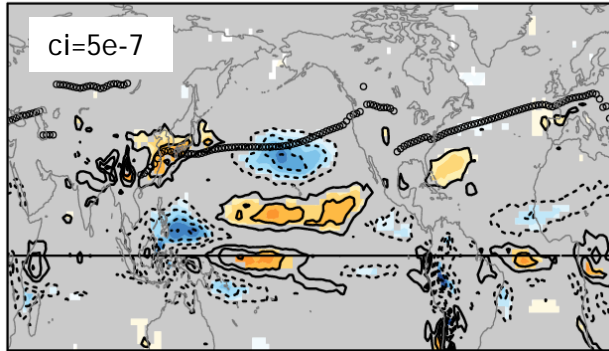
250hPa
Divergent v

700hPa
zonal wind

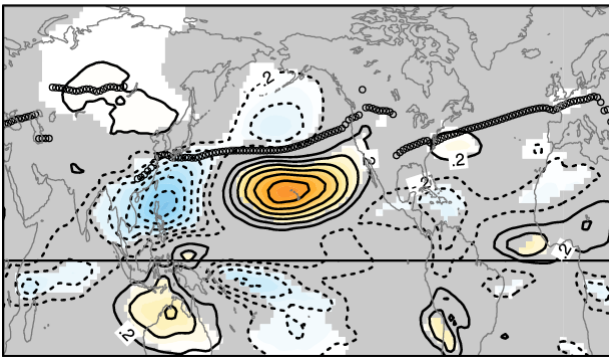
Poleward - Not Poleward Models

Future-Past difference

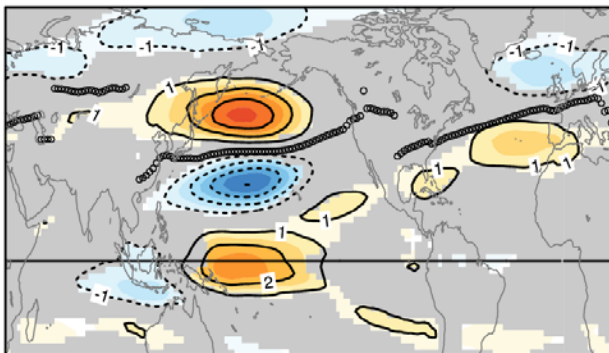
Poleward - Not Poleward



Poleward - Not Poleward

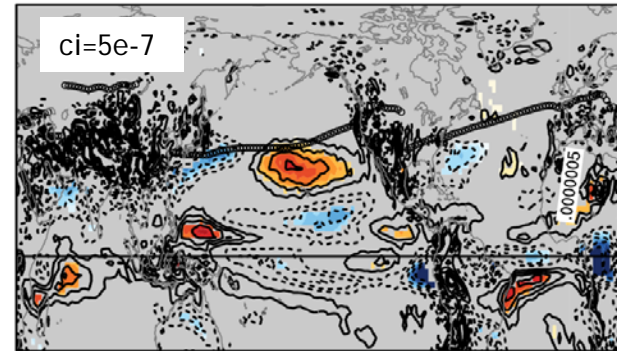


Poleward - Not Poleward

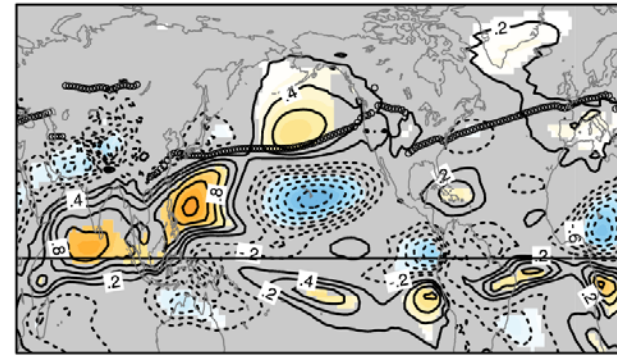


Past Climatology

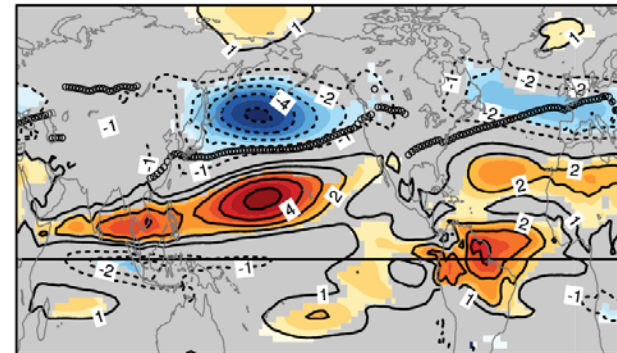
Poleward - Not Poleward



Poleward - Not Poleward



Poleward - Not Poleward (Past)



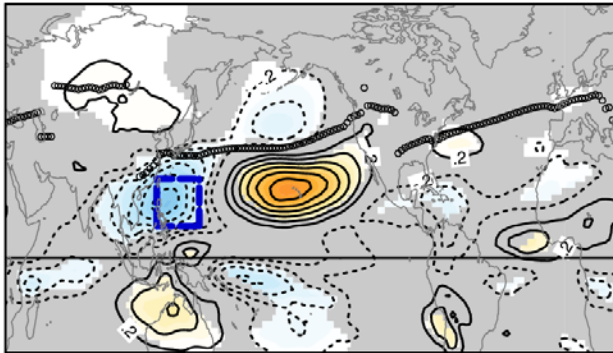
250hPa
Divergence

250hPa
Divergent v

700hPa
zonal wind

Future-Past difference in divergent v

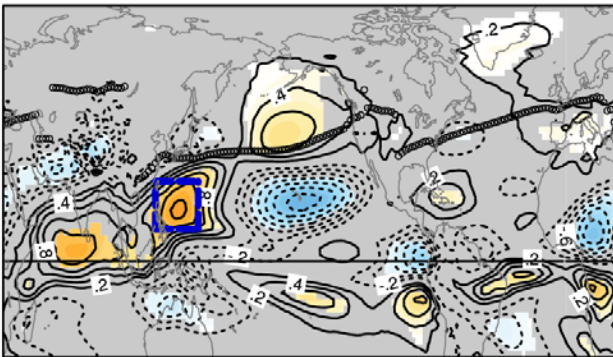
Poleward - Not Poleward



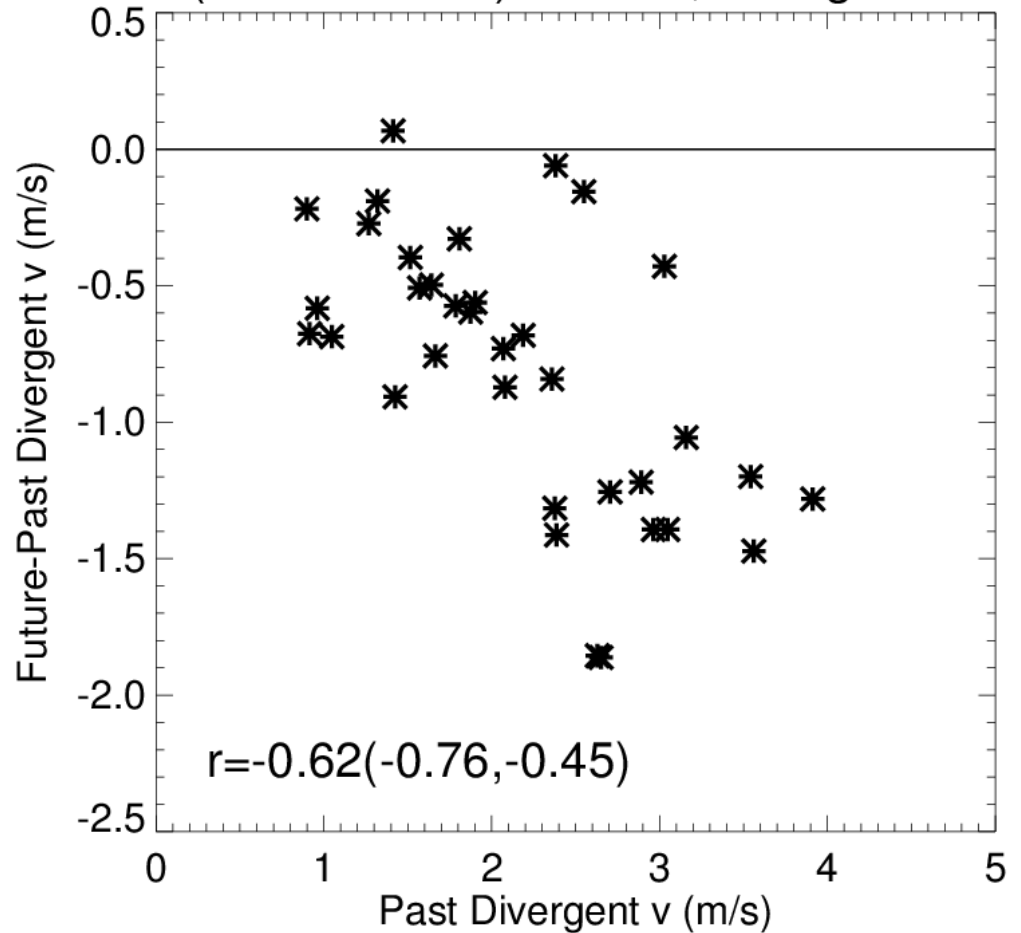
VS

Past divergent v

Poleward - Not Poleward



(Future - Past) vs Past, divergent v



Summary

- Models exhibit considerable diversity in their Future North Pacific circulation changes.
- This appears to be related to a difference in their response in the tropical Pacific.
- A model's tropical circulation response seems to be related to its present day climatology.
- A model with greater climatological divergence in the western Pacific in the present day, exhibits a greater weakening of that divergence in the future and an associated poleward shifting of the westerlies.
- The "Not Poleward" Models are much more realistic when compared with ERA-Interim in quantities such as west pacific divergent v , location of the climatological jet

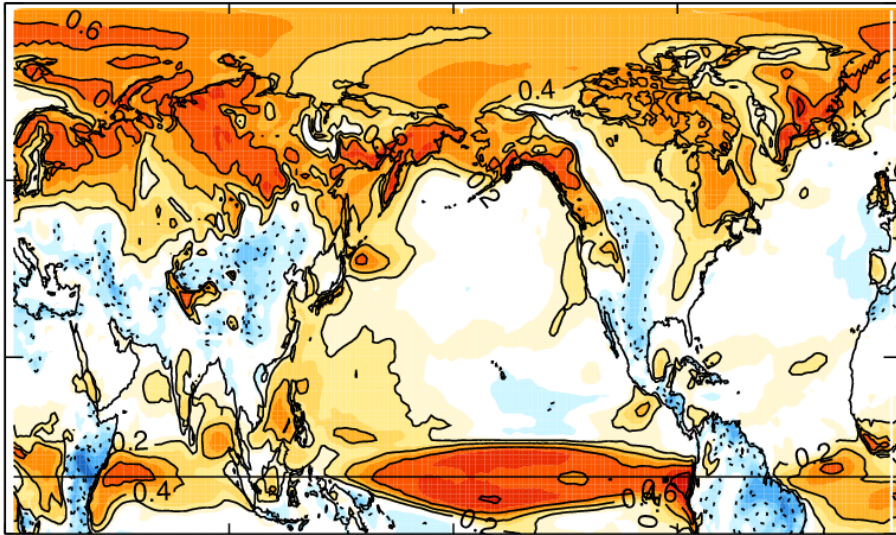
Unanswered Questions

- What chain of events leads to such differences in the tropical circulation response? e.g. feedbacks with reorganization of diabatic heating, SST's, clouds?
- What gives rise to these differences between the model climatologies? Looks likely to be associated with SST's (magnitude of cold tongue bias)
- What is the relative importance of Rossby wave propagation and feedbacks involving transient eddies in giving rise to the extra-tropical circulation changes.

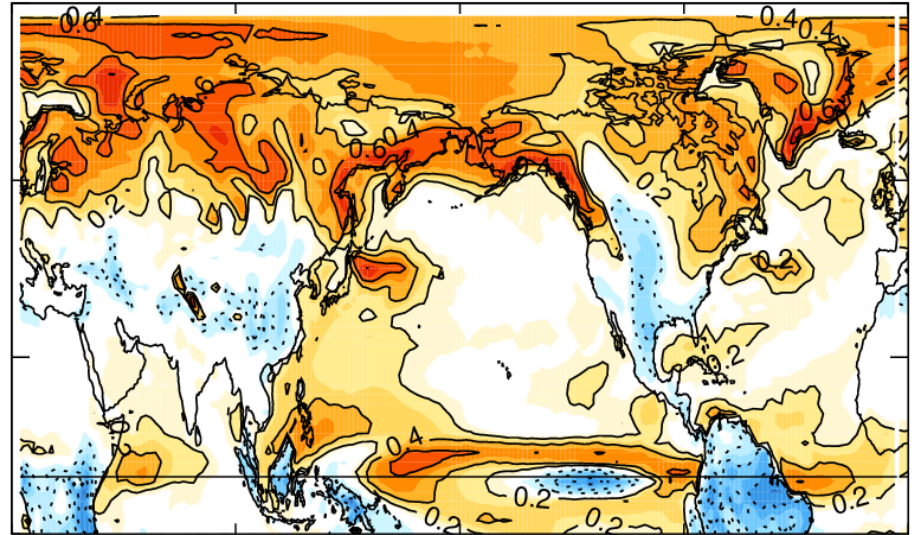
Extra Slides

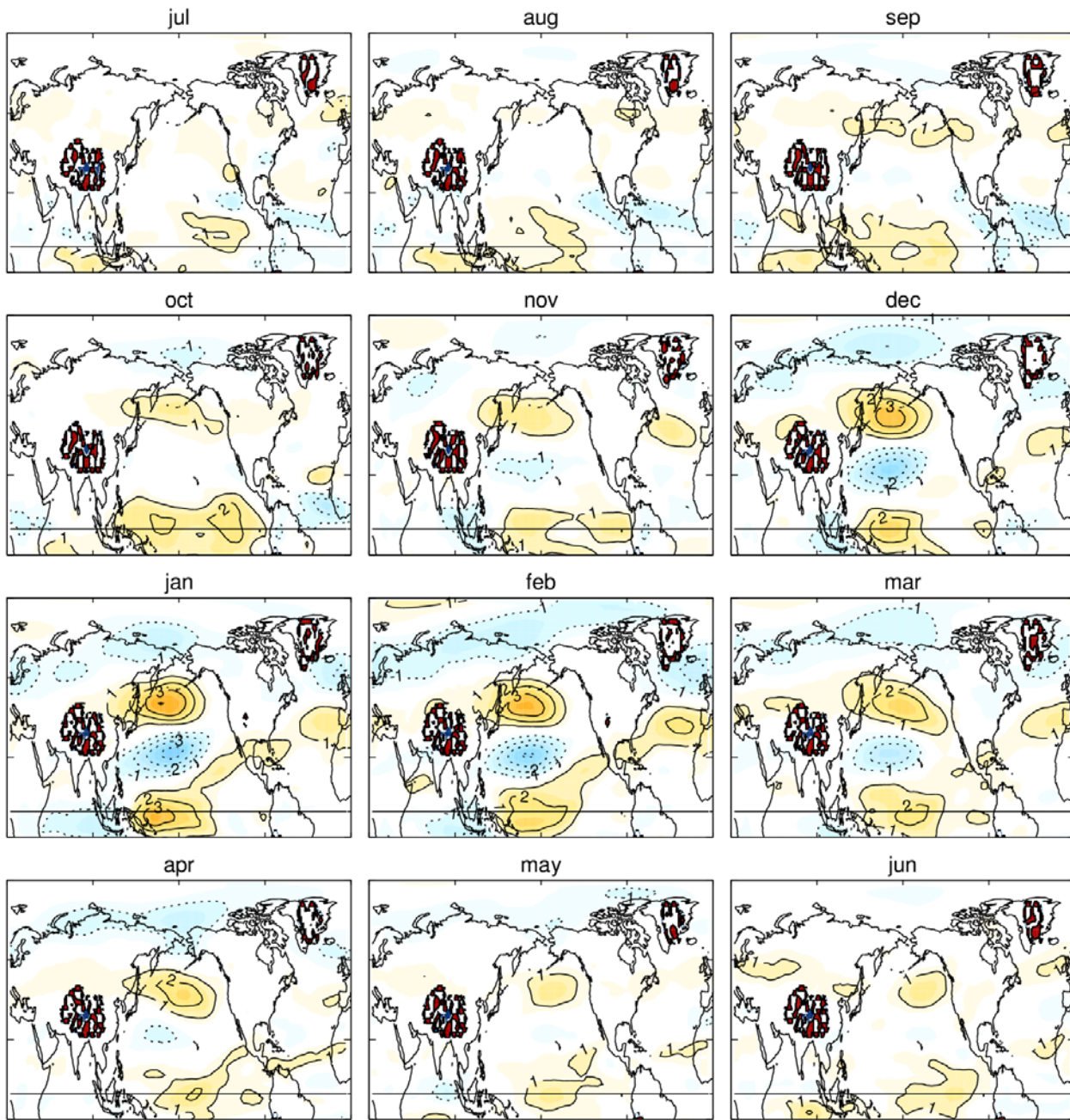
Cor(TS, Precip)

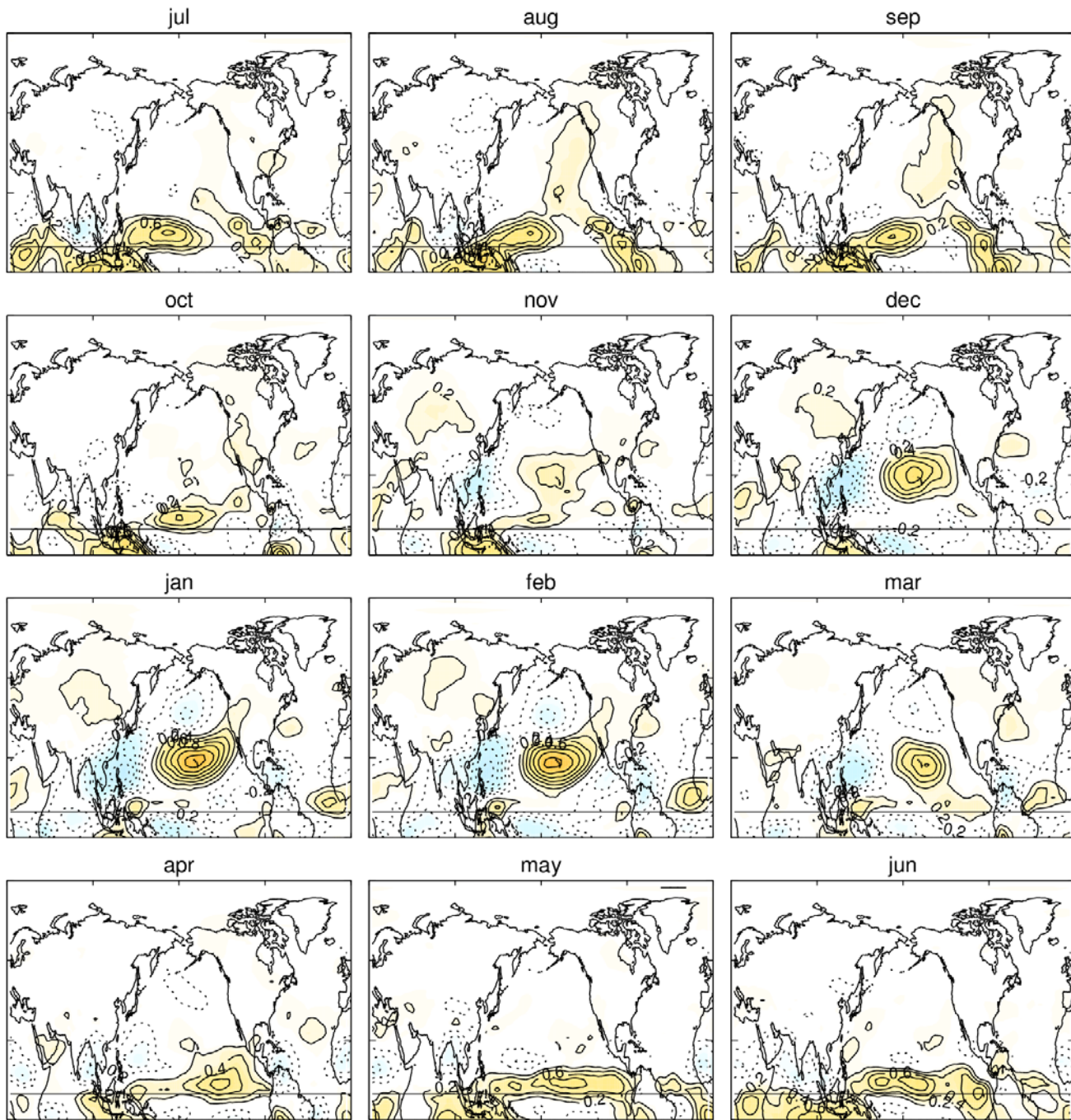
Cor(TS, PR), CCSM4



Cor(TS, PR), MPI-ESM-LR

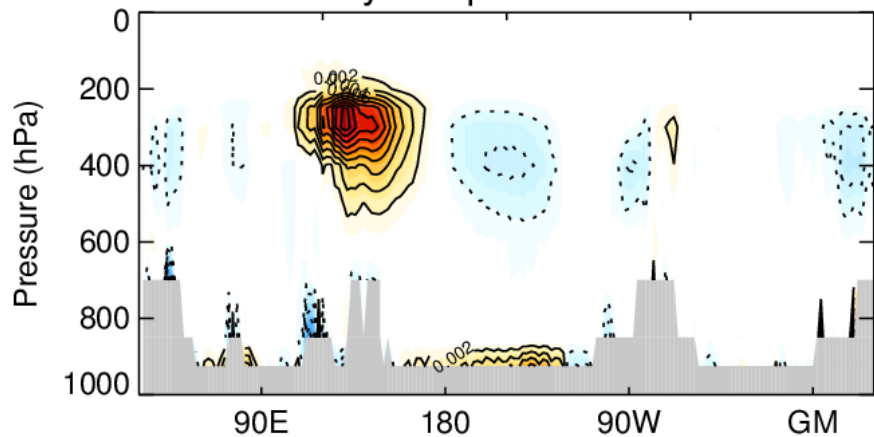




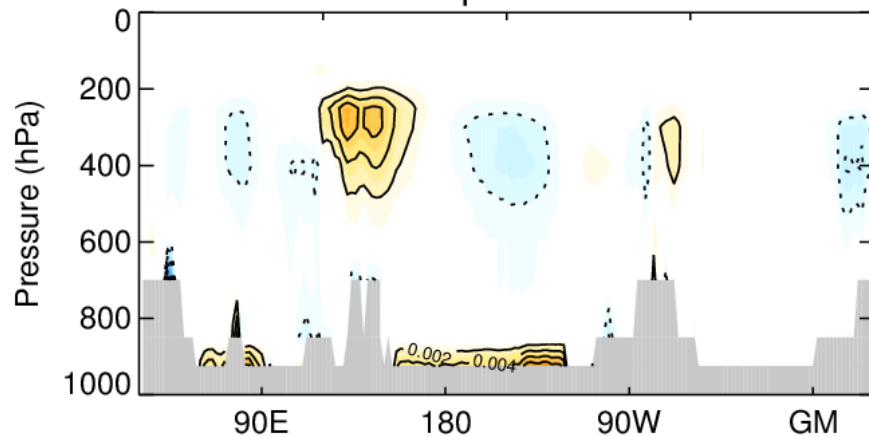


$$-\left(\frac{\partial\theta}{\partial P}\right)_p^{-1}\omega_p\Delta\left(\frac{\partial\theta}{\partial P}\right)$$

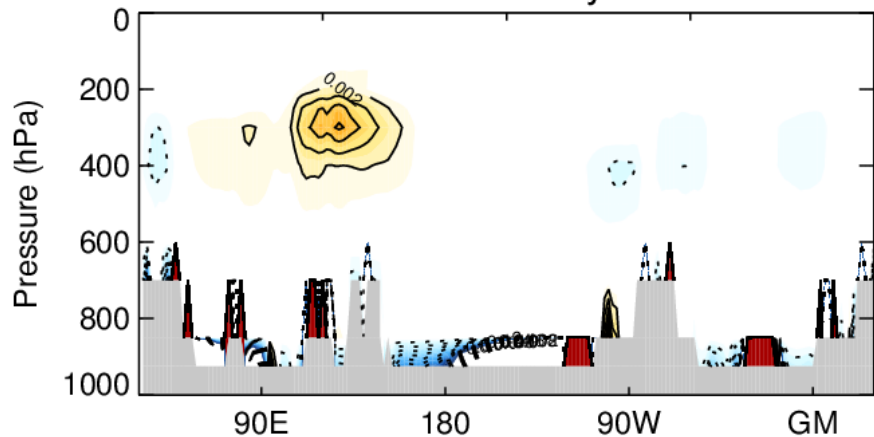
Stability component difference



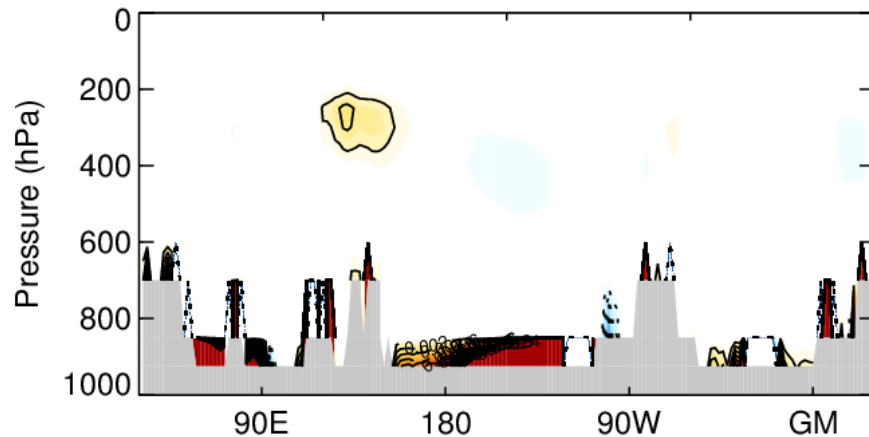
Difference in past clim influence



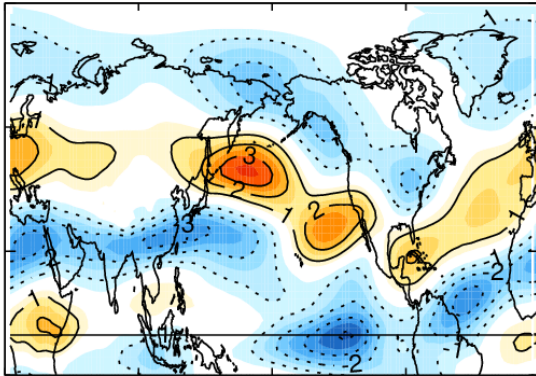
Difference in Stability influence



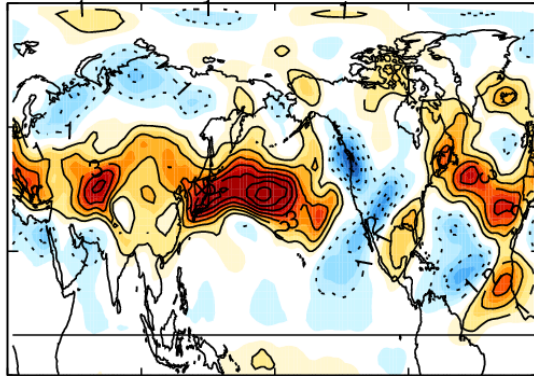
Nonlin



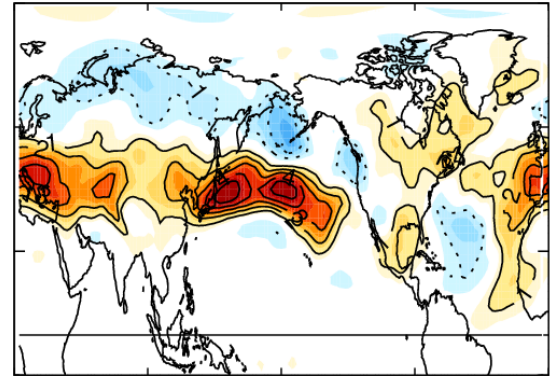
U, Poleward



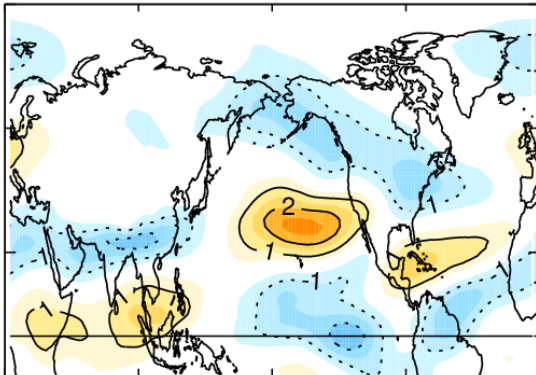
UV, poleward



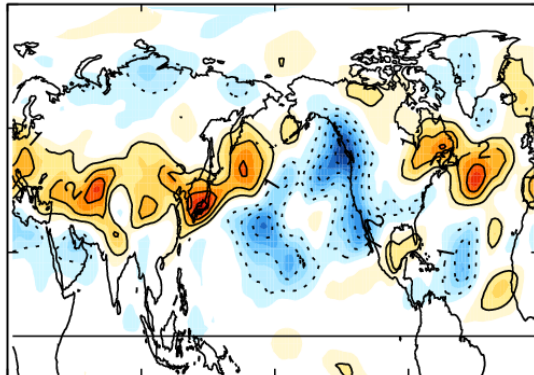
UhVh, poleward



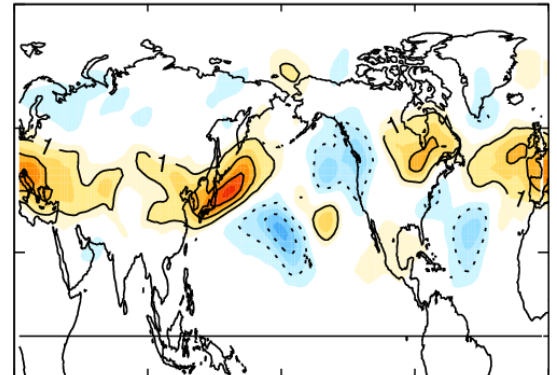
U, Not Poleward



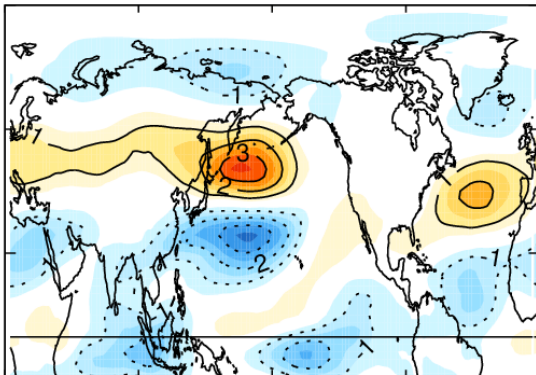
UV, Not Poleward



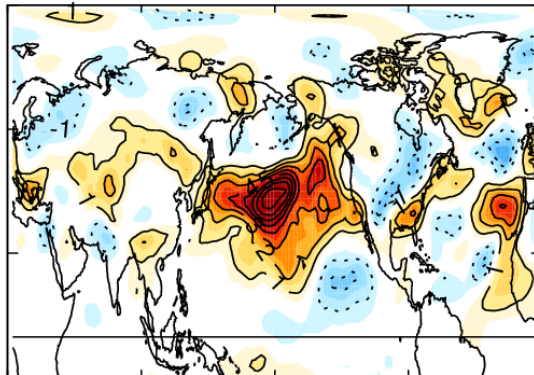
UhVh, Not Poleward



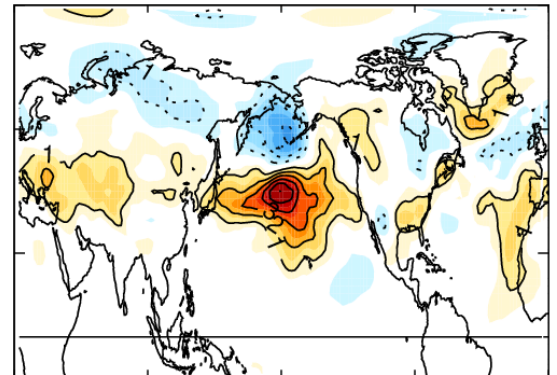
U, Poleward - Not Poleward



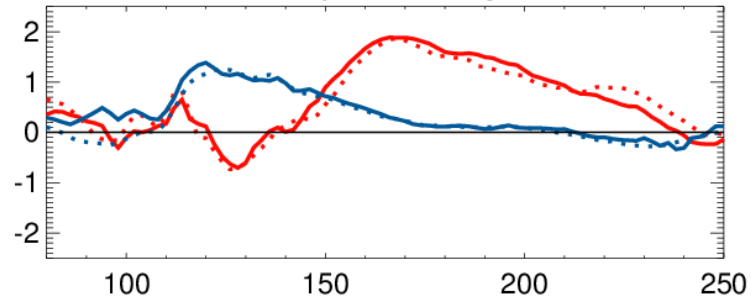
UV, Poleward - Not Poleward



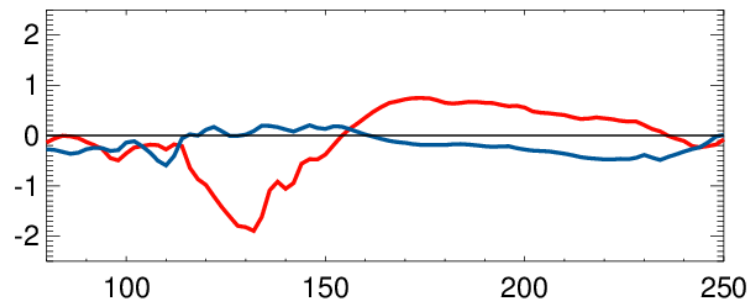
UhVh, Poleward - Not Poleward



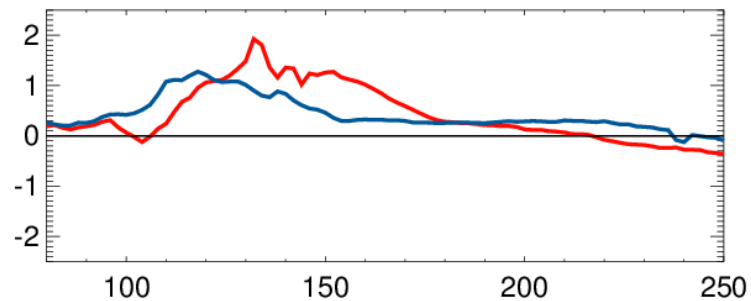
Precip and budget



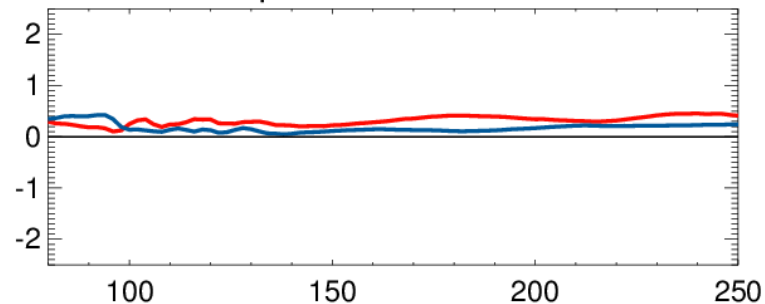
Anomalous circulation contribution



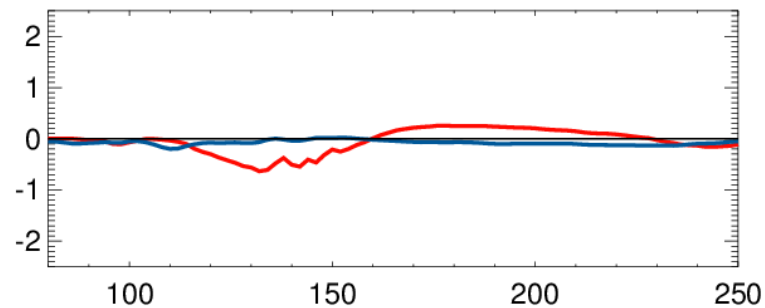
Anomalous moisture contribution



Evaporation contribution

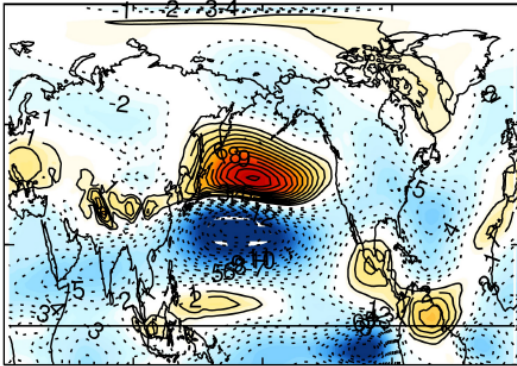


Non-linear contribution

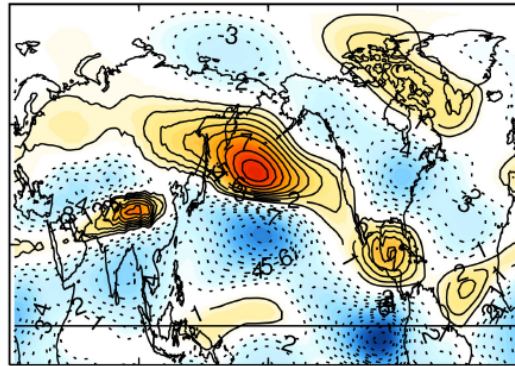


Past, u 250, not poleward - poleward

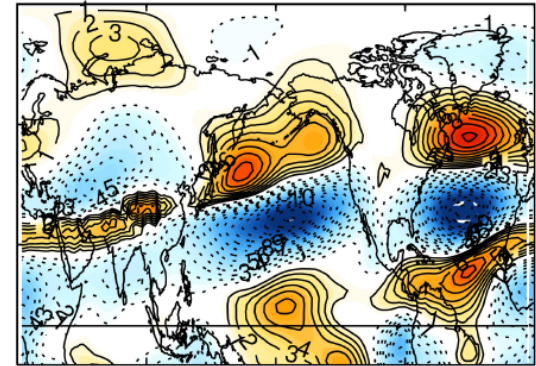
inmcm4



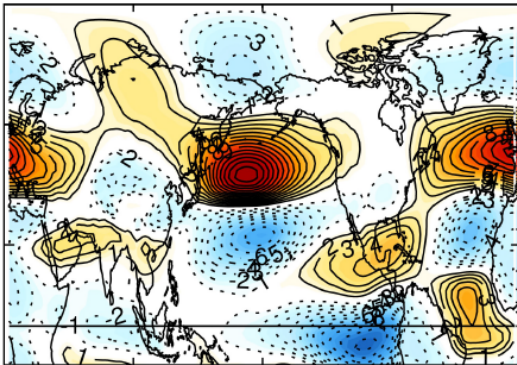
GFDL-ESM2M



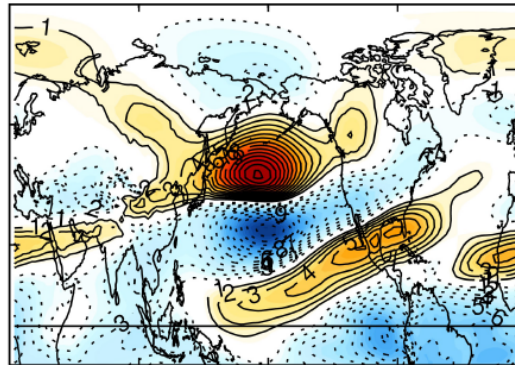
NorESM1-ME



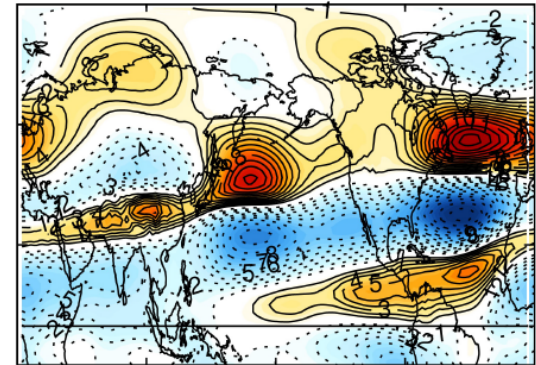
BNU-ESM



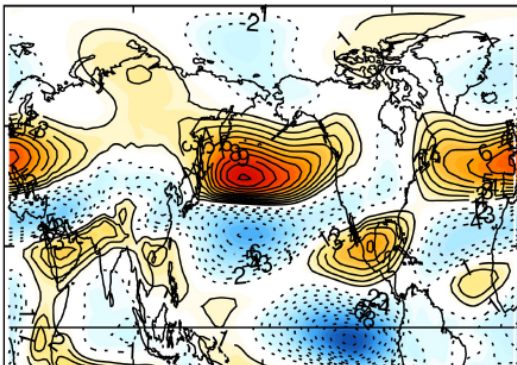
CNRM-CM5



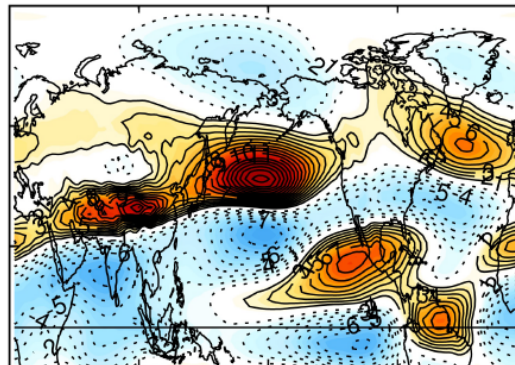
CCSM4



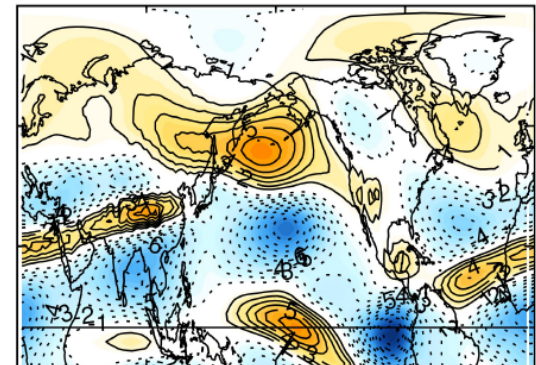
FIO-ESM



CanESM2

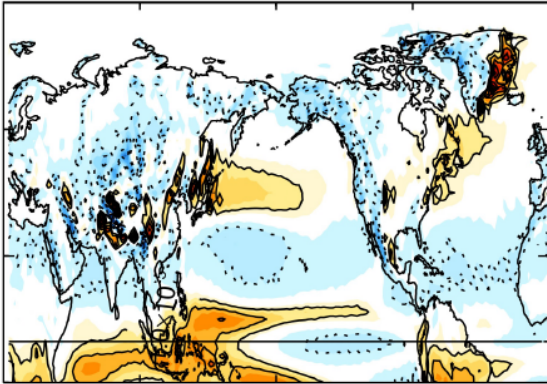


GFDL-ESM2G

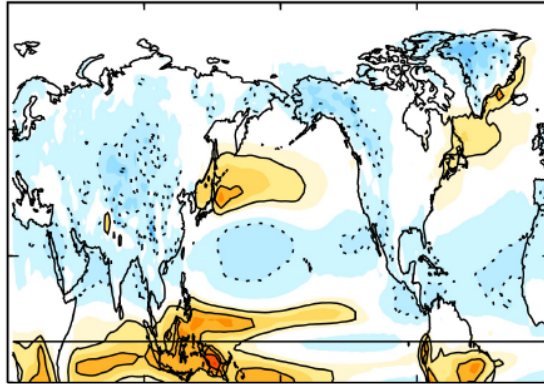


Vertically integrated diabatic heating
(top) past, (bottom) future-past

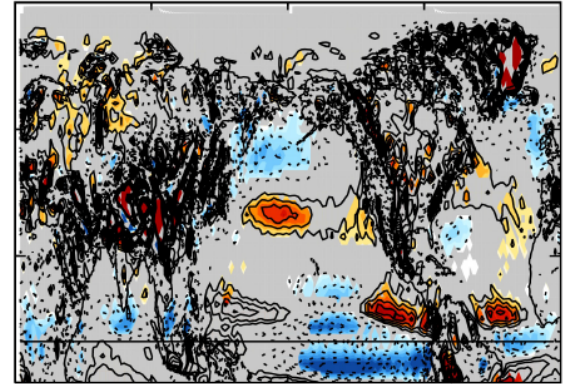
Positive, past



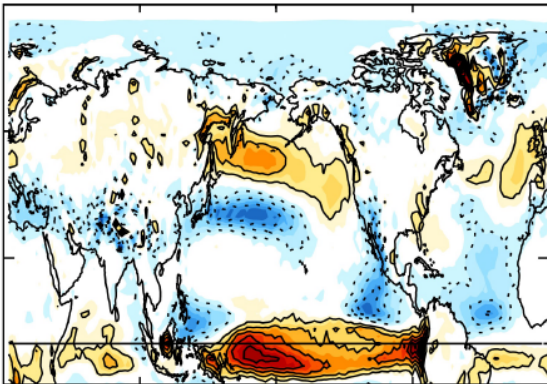
Negative, past



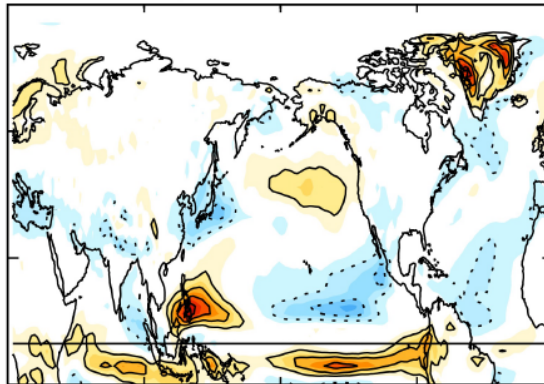
Positive-Negative, past



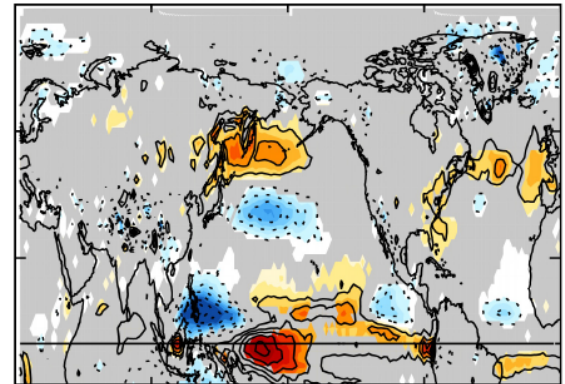
Positive, difference



Negative, difference

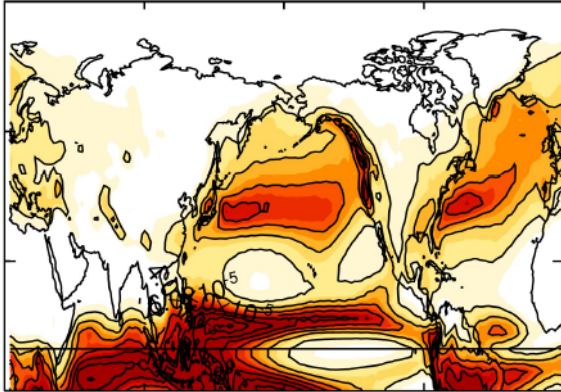


Positive-Negative, difference

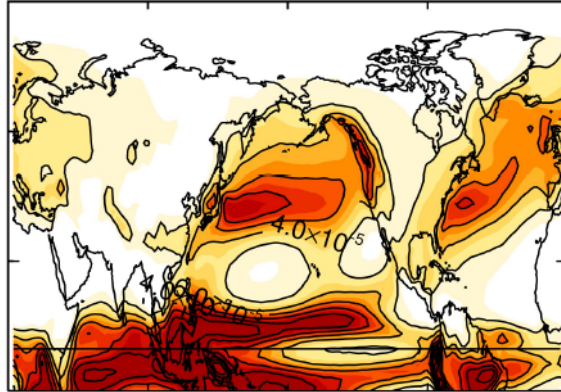


Precipitation (top) past, (bottom) future-past

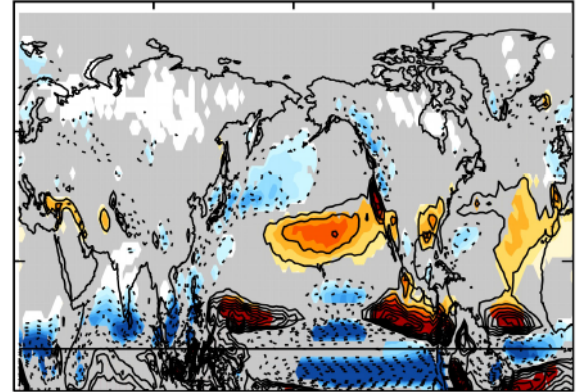
Positive EOF1, past



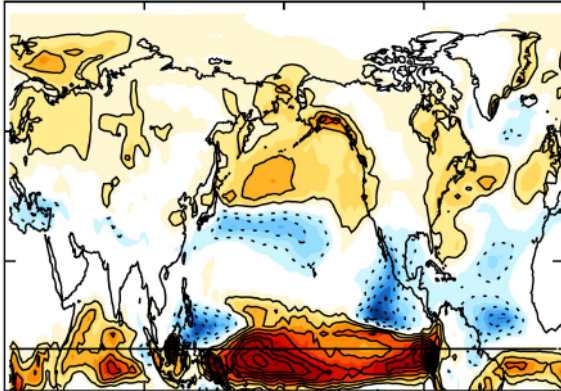
Negative EOF1, past



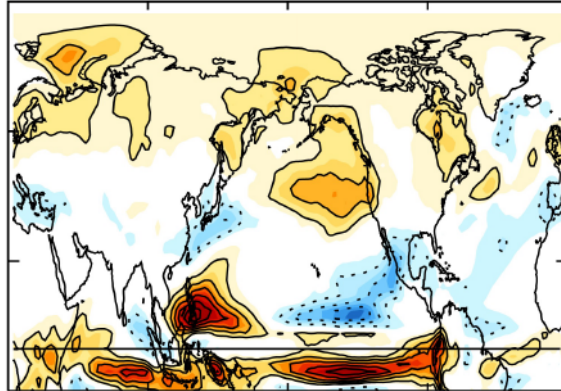
Positive-Negative EOF1, past



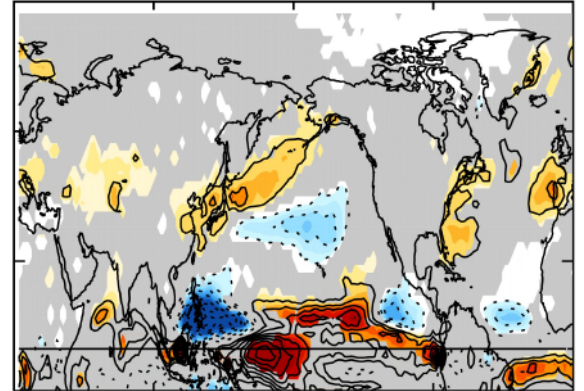
Positive EOF1, difference



Negative EOF1, difference

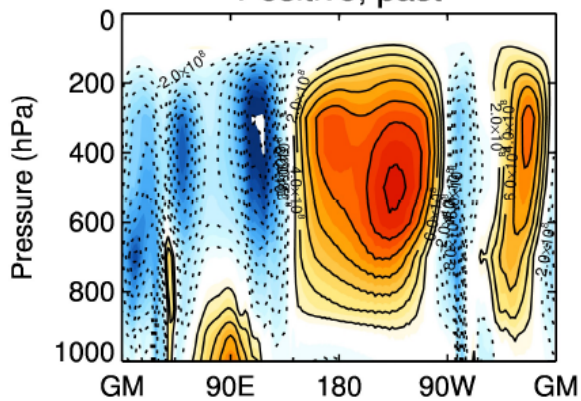


Positive-Negative EOF1, difference

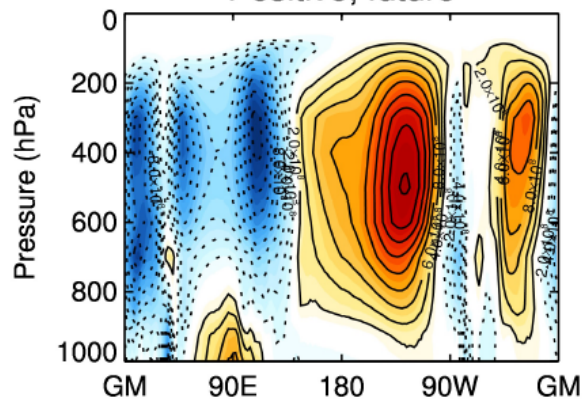


Stream function (top) Past, (bottom) Future-Past

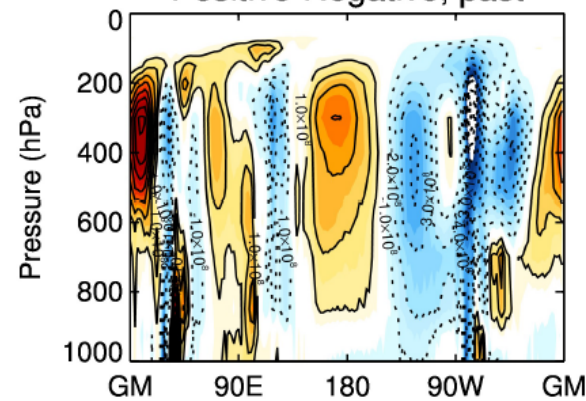
Positive, past



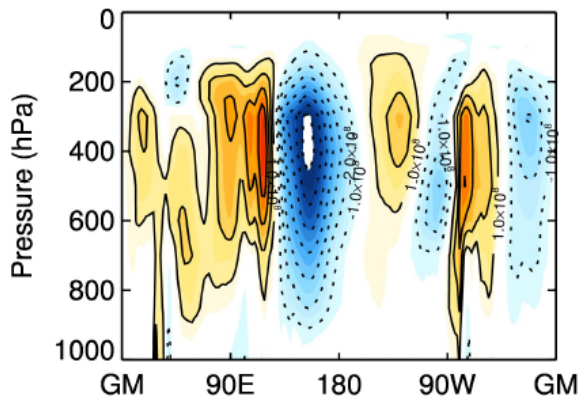
Positive, future



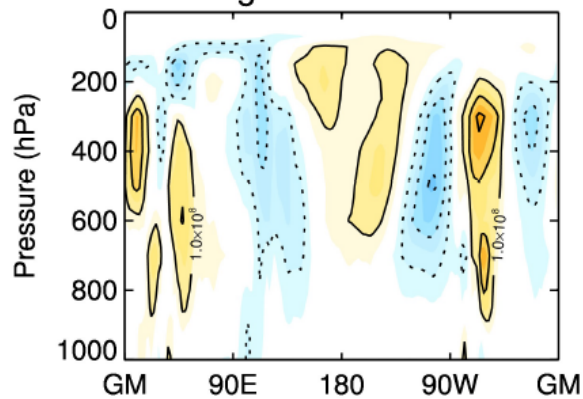
Positive-Negative, past



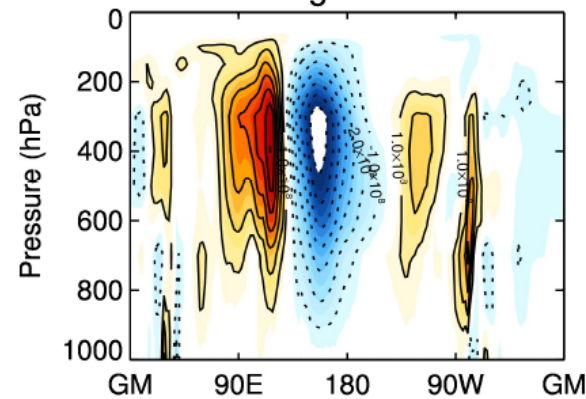
Positive difference



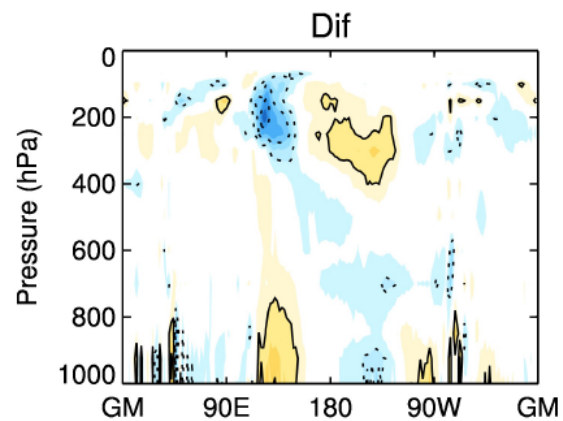
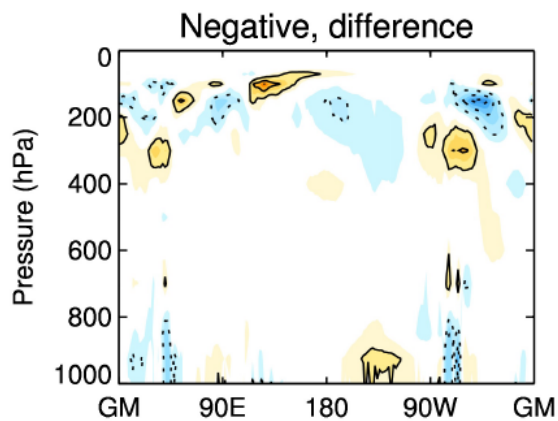
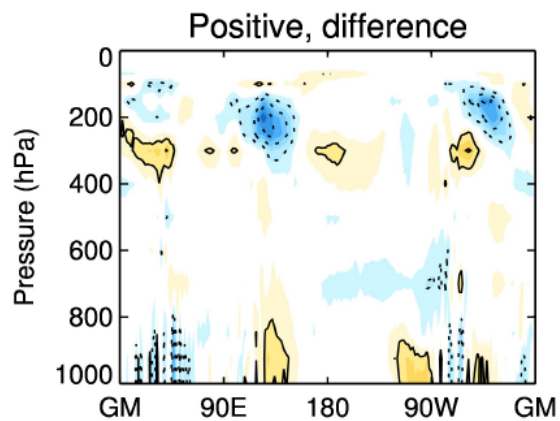
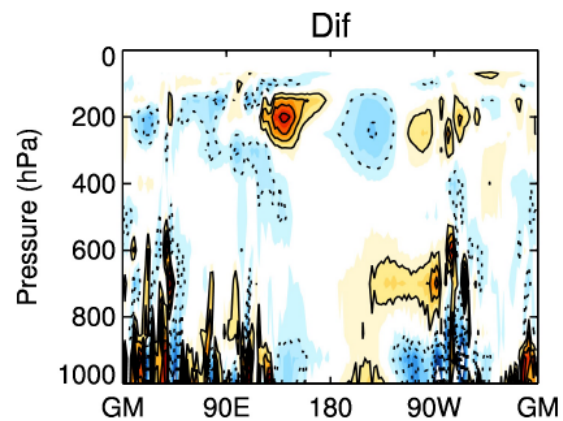
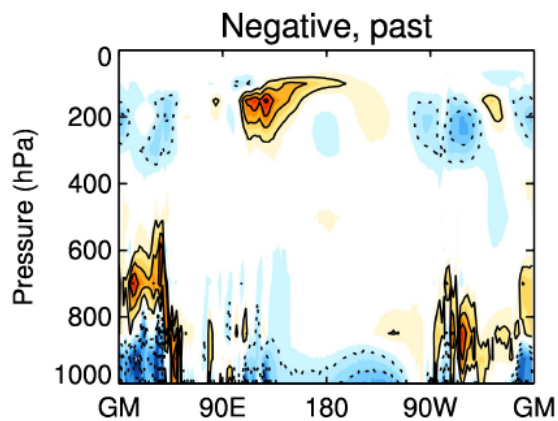
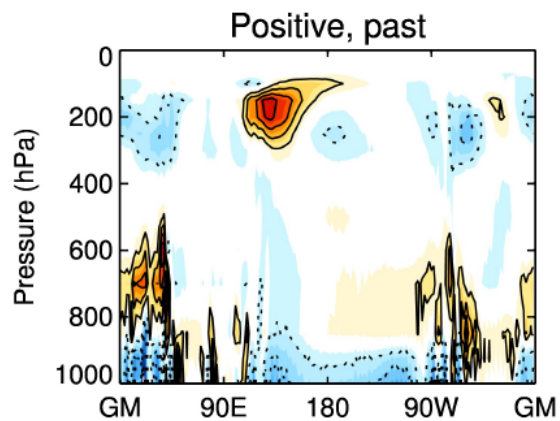
Negative difference



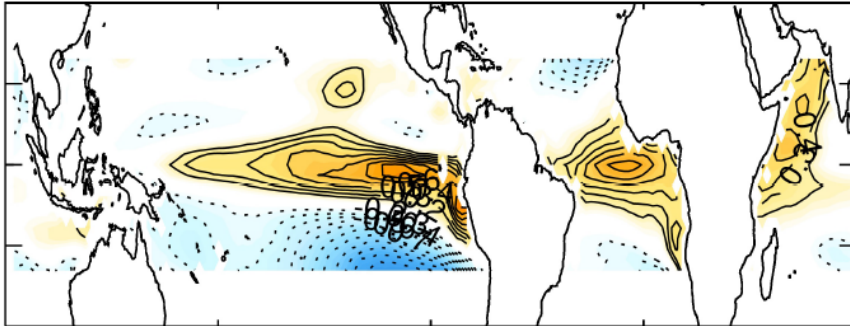
Positive-Negative difference



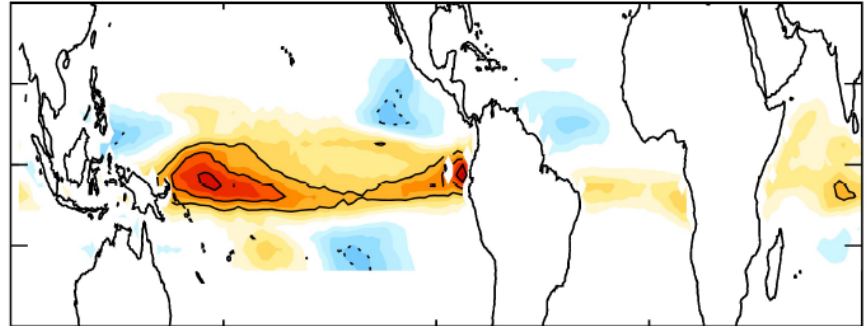
Divergence (top) Past, (bottom) Future-past



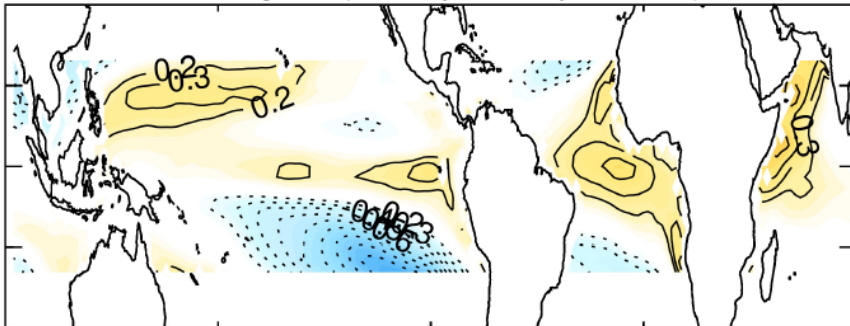
SST, positive (anomaly from tropical mean)



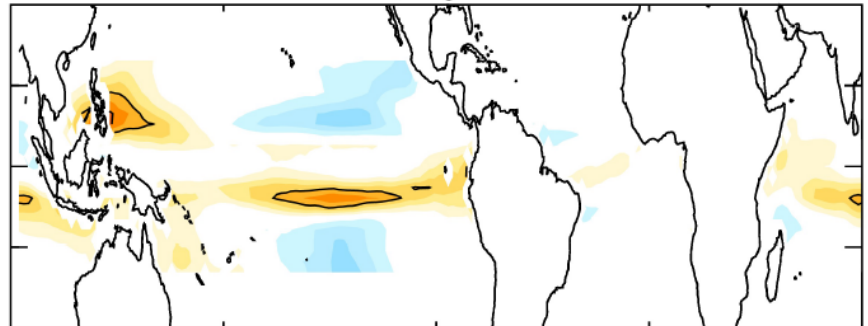
PR, Positive



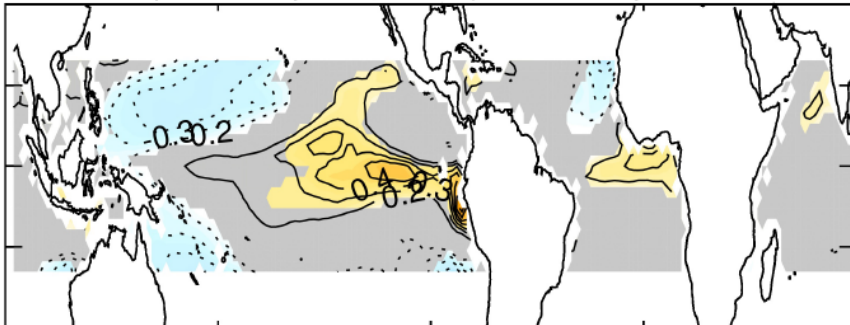
SST, negative (anomaly from tropical mean)



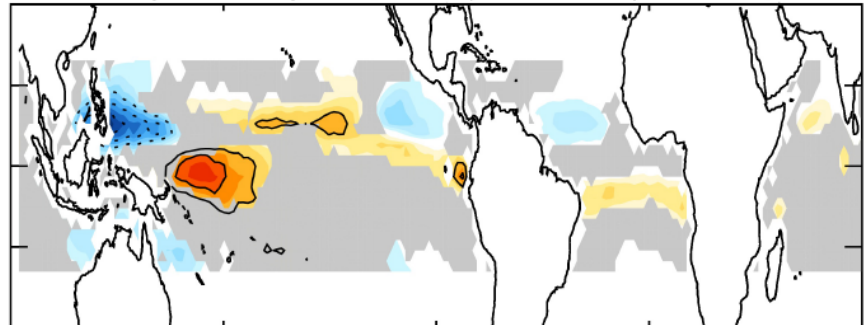
PR, negative



SST, positive-negative (anomaly from the tropical mean)

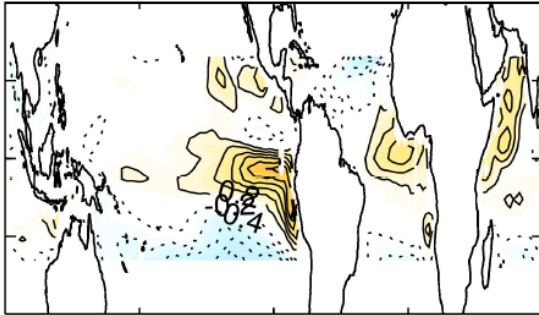


PR, positive-negative (anomaly from the tropical mean)

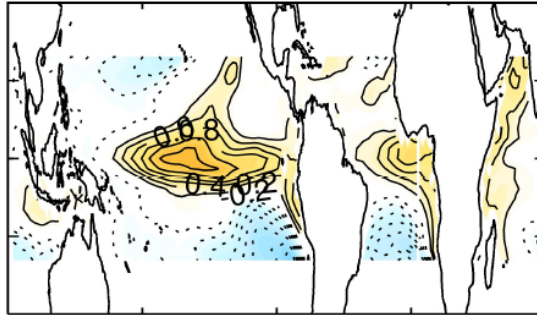


SST response, anomalies from the tropical mean, Poleward models.

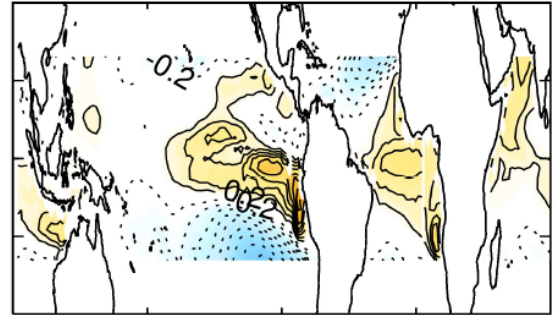
SST, MPI-ESM-LR



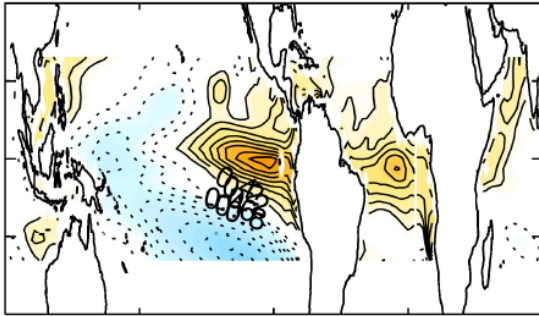
SST, MRI-CGCM3



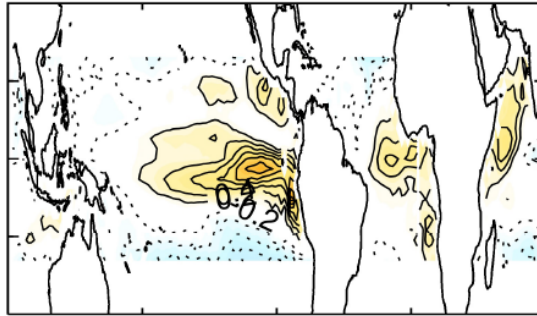
SST, CMCC-CMS



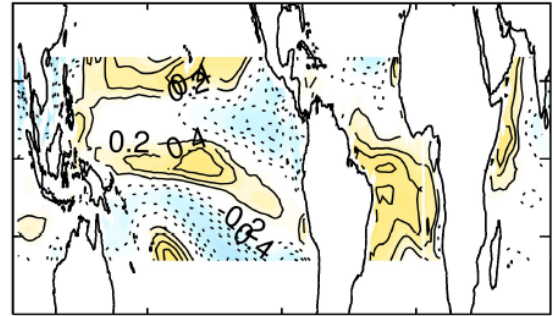
SST, MIROC5



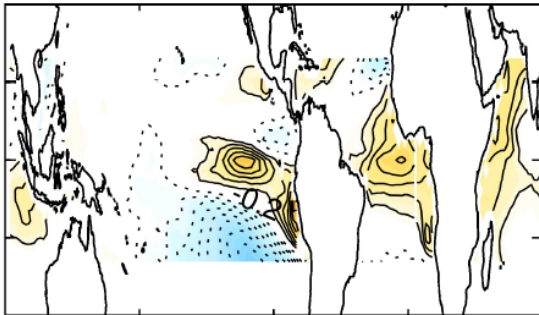
SST, MPI-ESM-MR



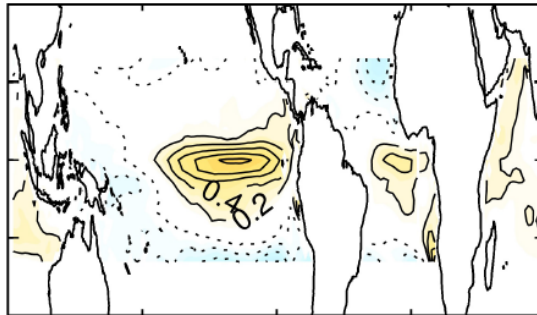
SST, IPSL-CM5A-MR



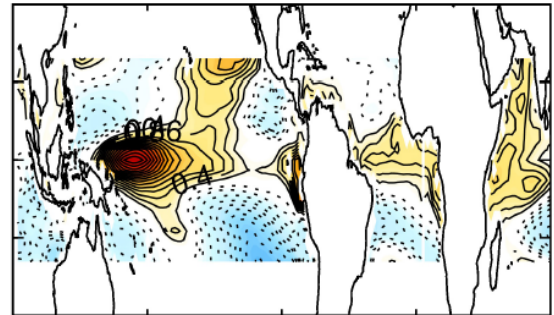
SST, CMCC-CM



SST, GISS-E2-R

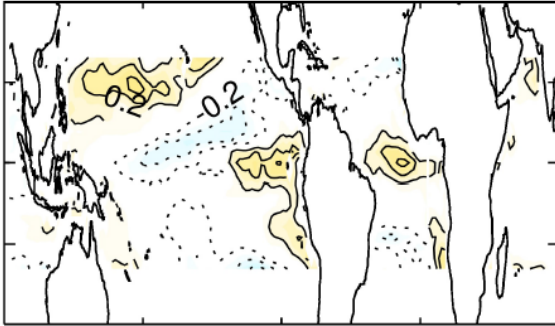


SST, CSIRO-Mk3-6-0

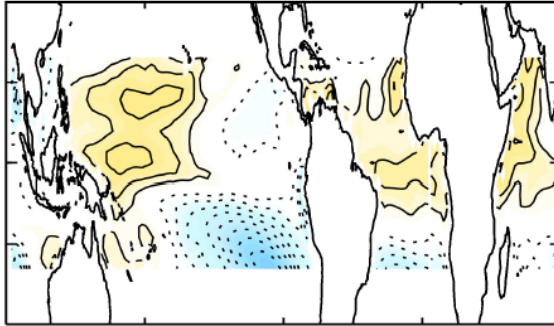


SST response, anomalies from the tropical mean, Poleward models.

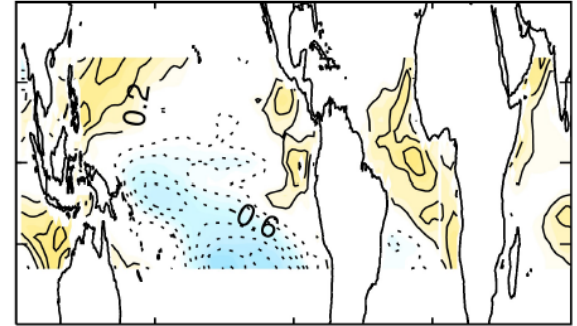
SST, Inmcm4



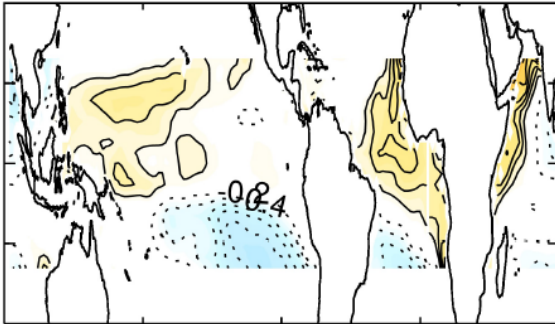
SST, GFDL-ESM2M



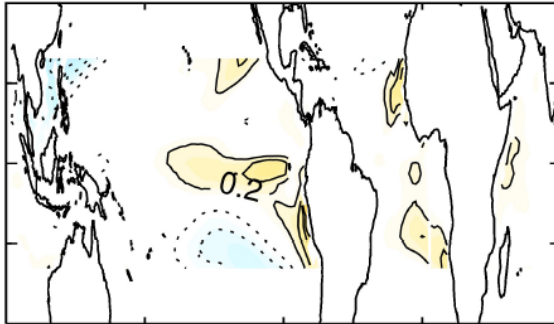
SST, NorESM1-ME



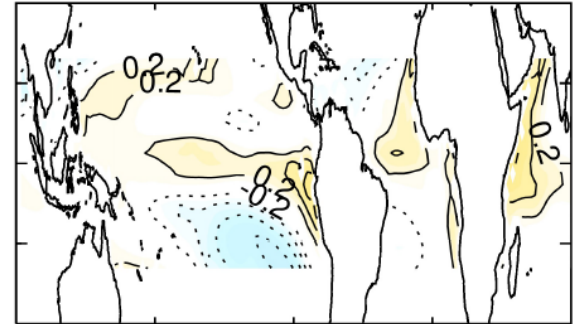
SST, BNU-ESM



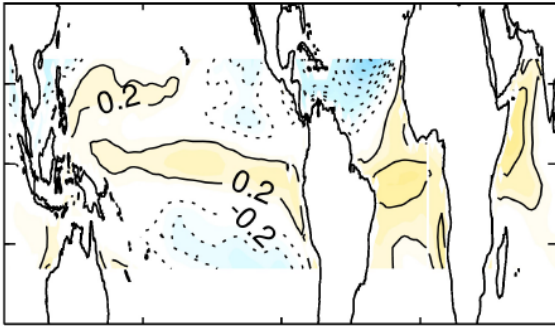
SST, CNRM-CM5



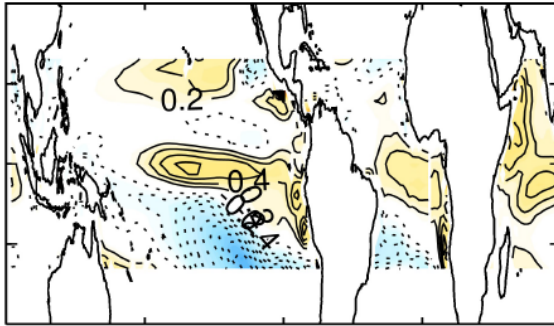
SST, CCSM4



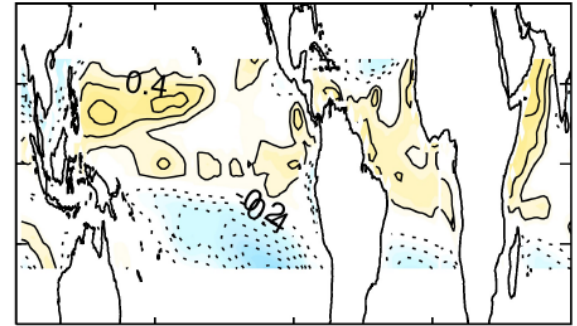
SST, FIO-ESM



SST, CanESM2

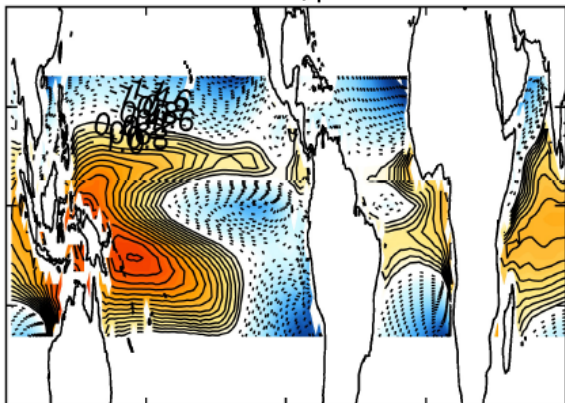


SST, GFDL-ESM2G

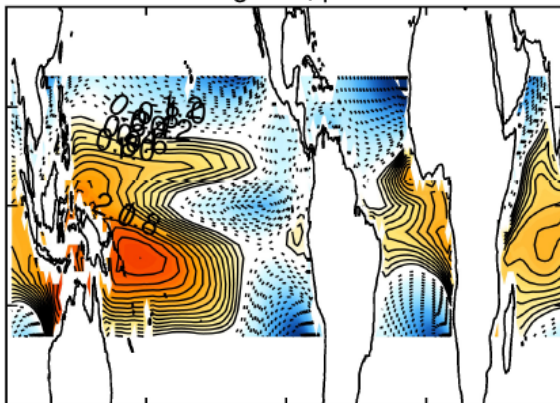


SST anomalies from the tropical mean

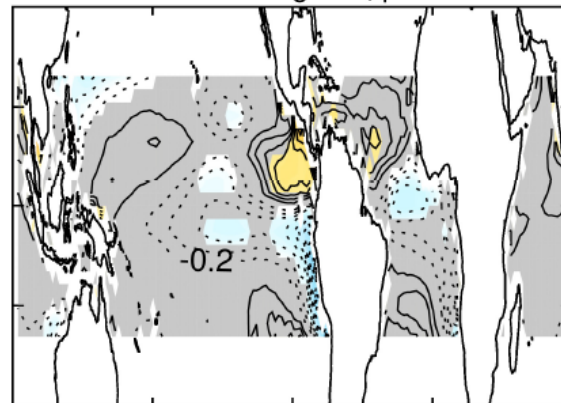
Positive, past



Negative, past



Positive-Negative, past



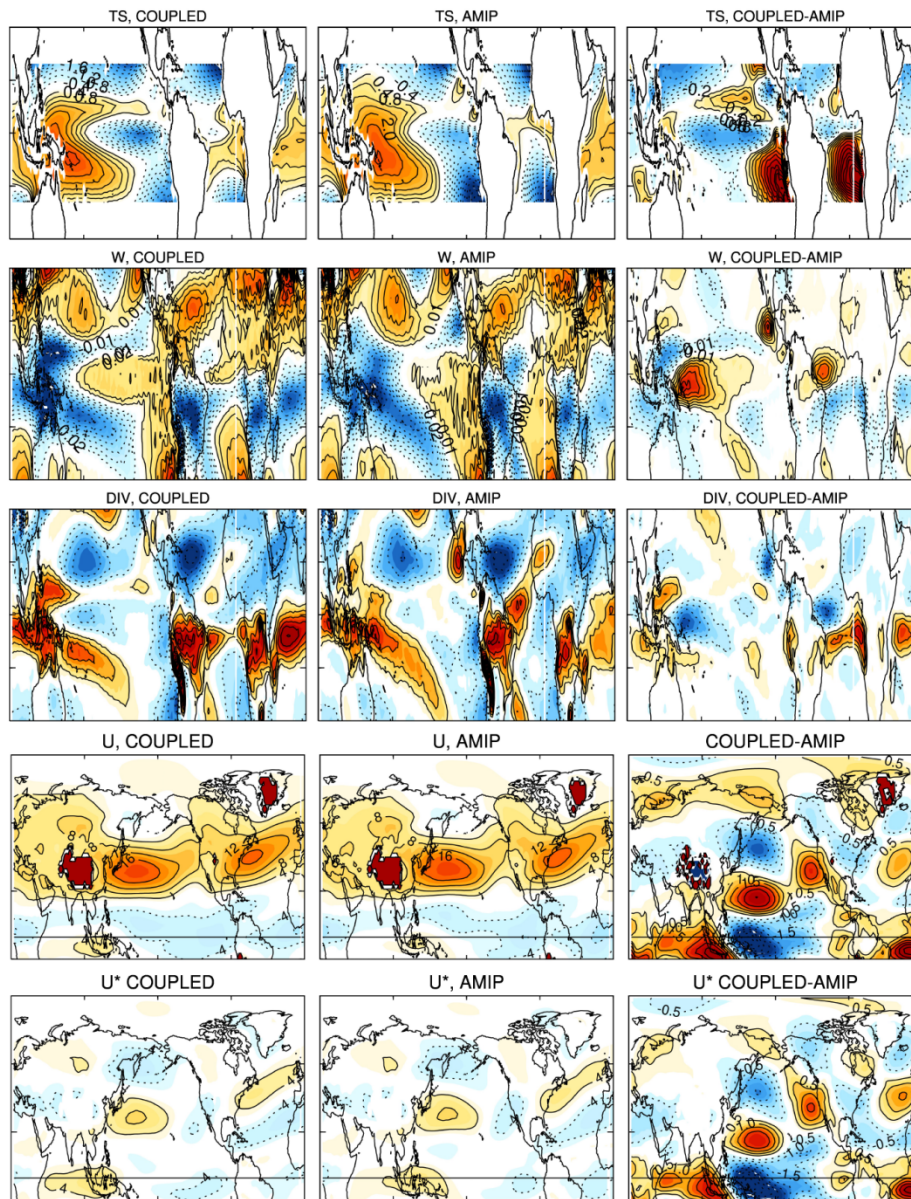


Figure 40: For the average of four models positive models (MPI-ESM-LR, MPI-ESM-MR, MIROC5, MRI-CGCM3) comparing the AMIP climatology with the coupled climatology (top) sst anomaly from the tropical mean, (2nd) 500hPa omega, (3rd) 250hPa divergence, (4th) 700hPa zonal wind, (5th) 700hPa eddy zonal wind.

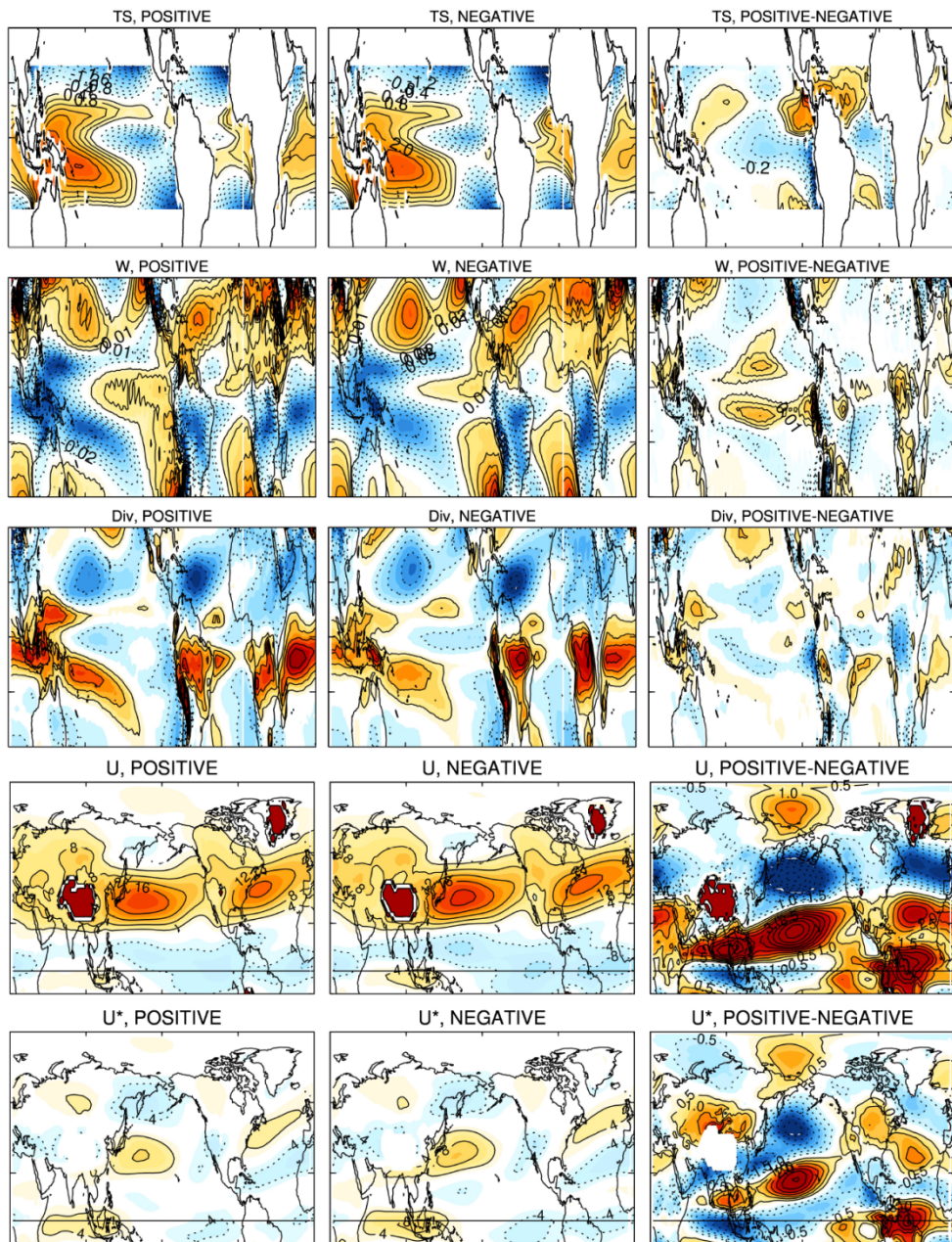
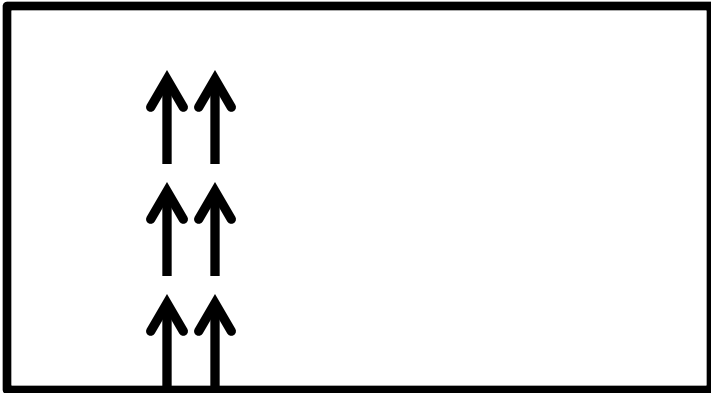
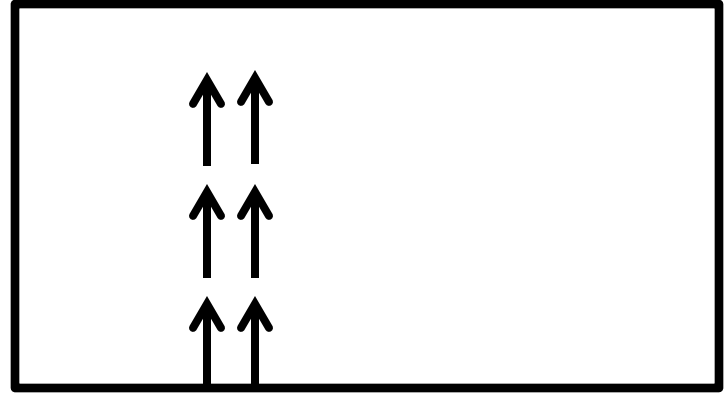


Figure 41: As Fig. 40 but for the positive and negative model composites (for comparison with Fig. 40)

Poleward

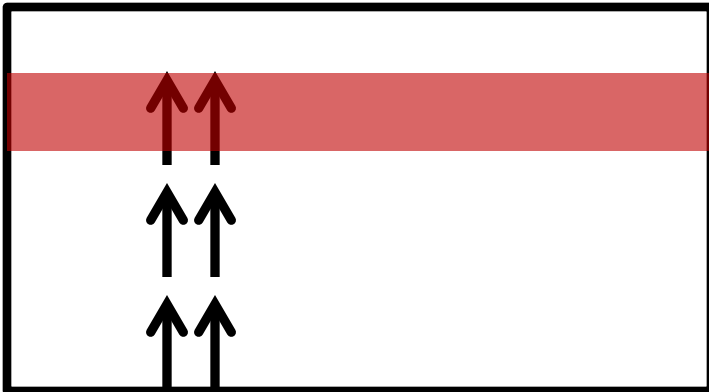


Not Poleward

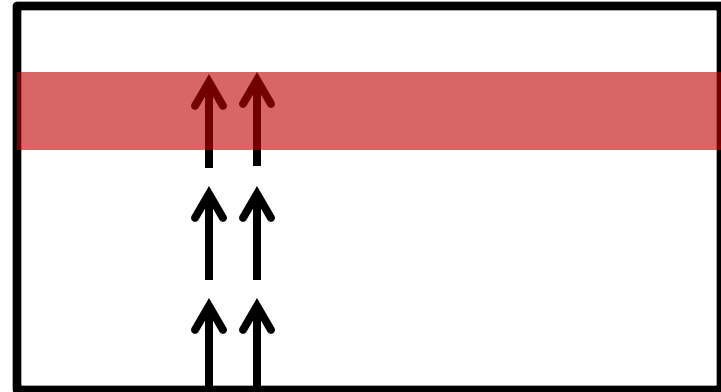


Increase Static Stability

Poleward

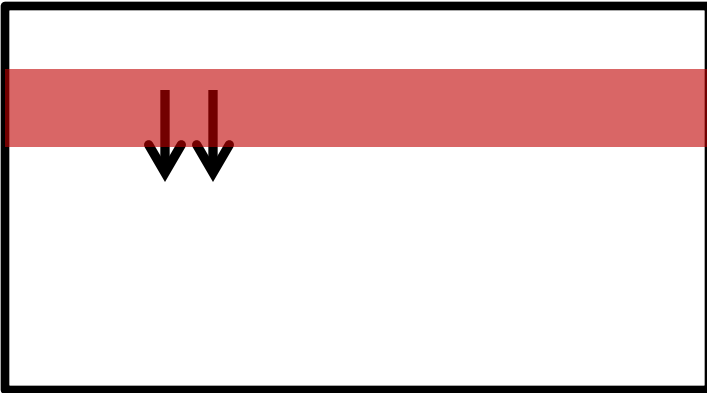


Not Poleward

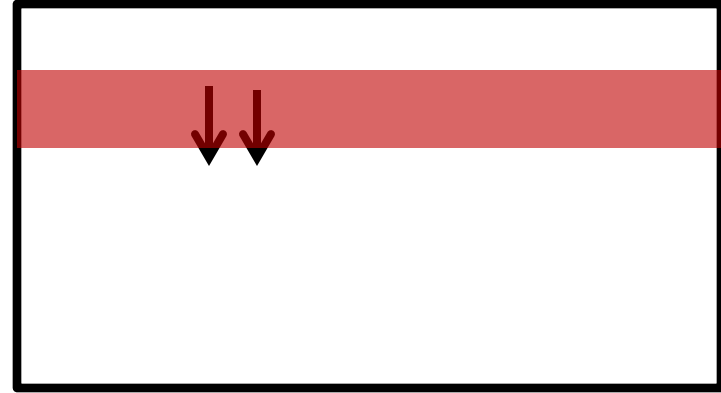


Increase Static Stability

Poleward



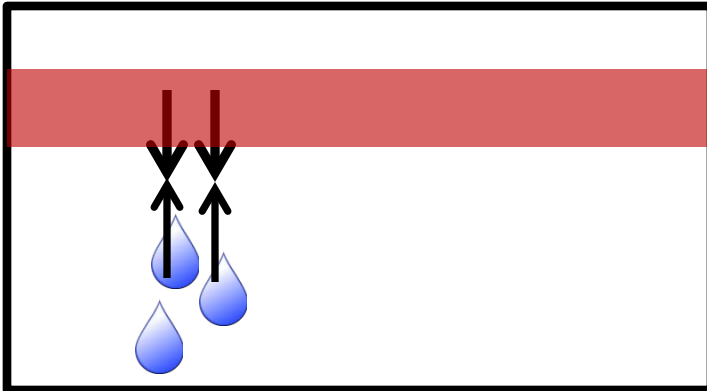
Not Poleward



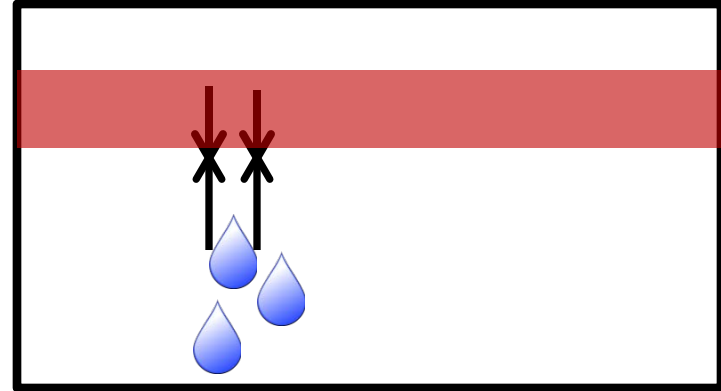
Increase Static Stability

Increase Specific Humidity

Poleward



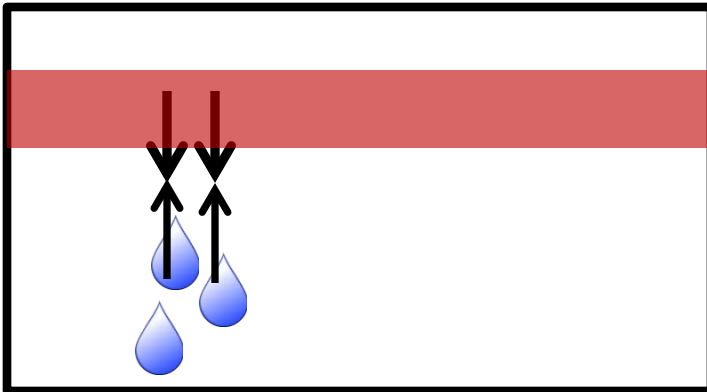
Not Poleward



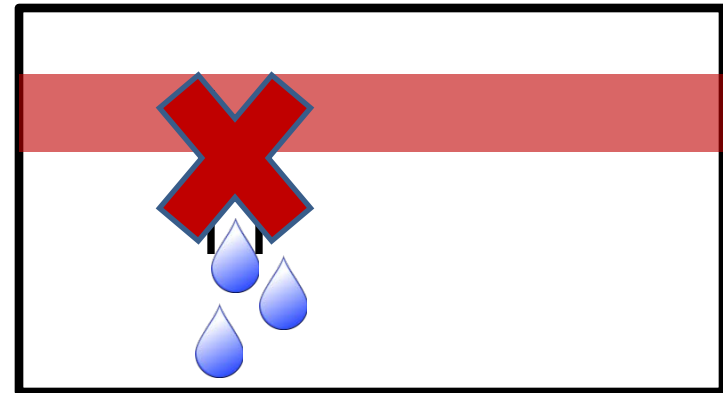
Increase Static Stability

Increase Specific Humidity

Poleward



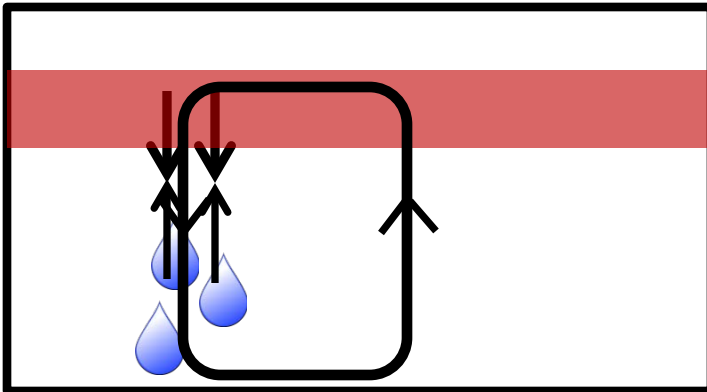
Not Poleward



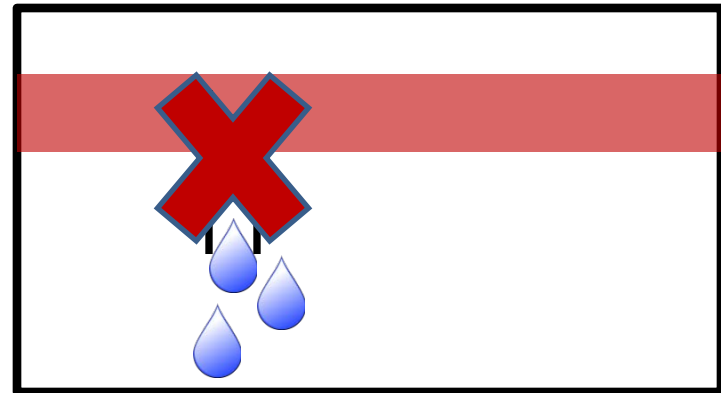
Increase Static Stability

Increase Specific Humidity

Poleward



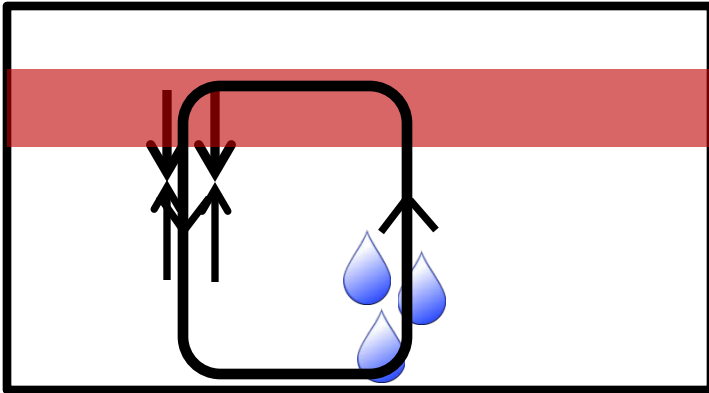
Not Poleward



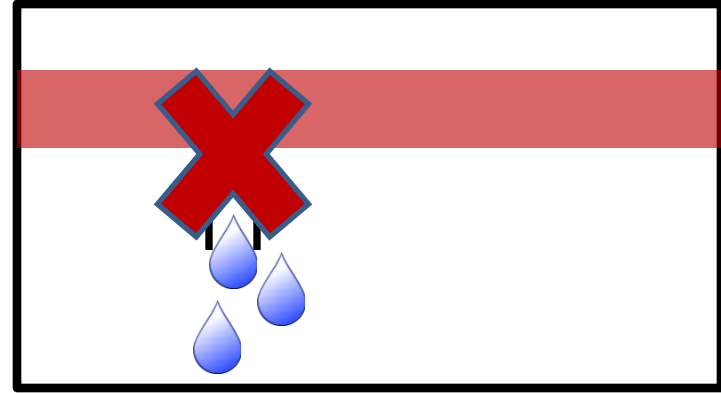
Increase Static Stability

Increase Specific Humidity

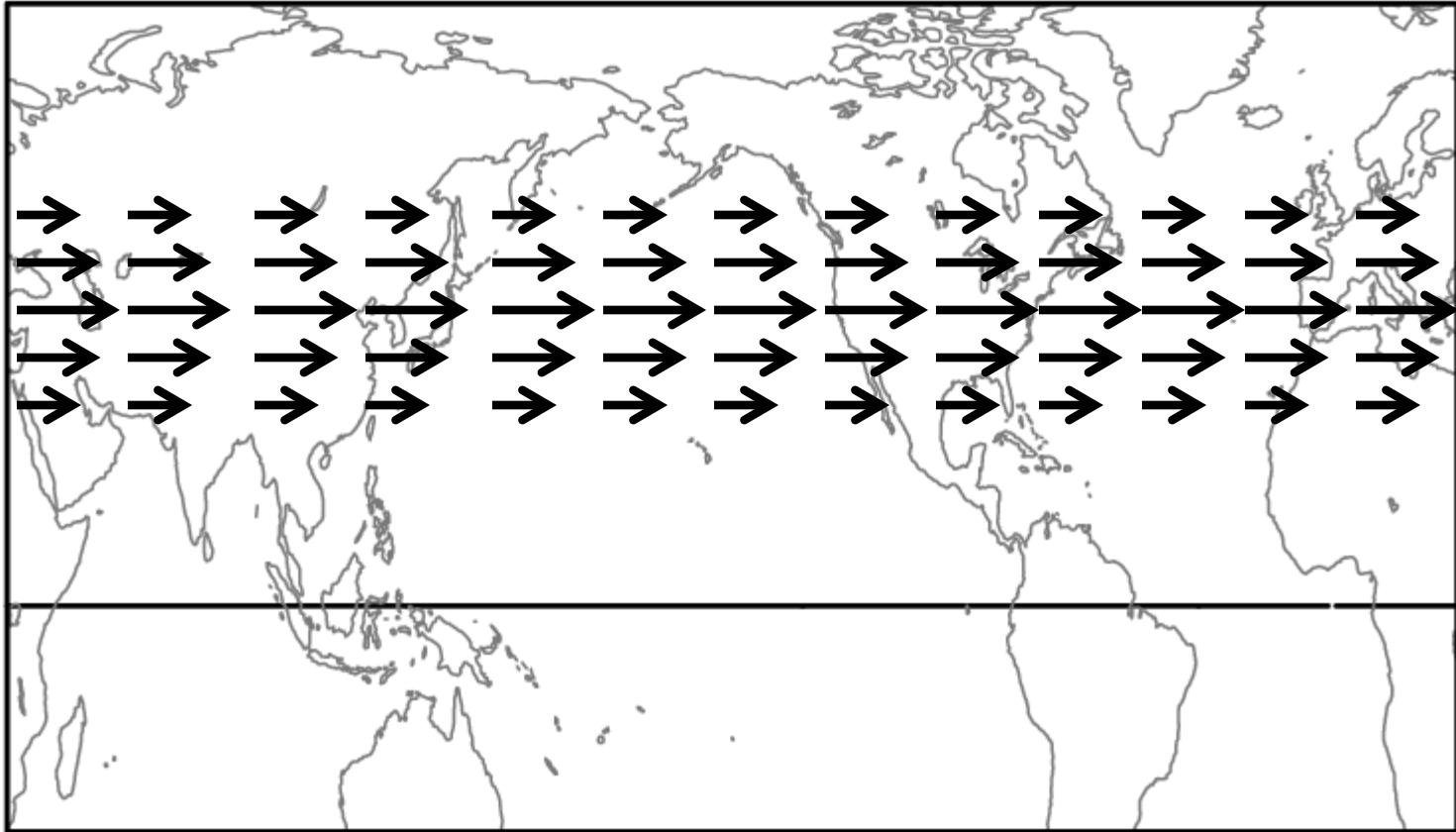
Poleward



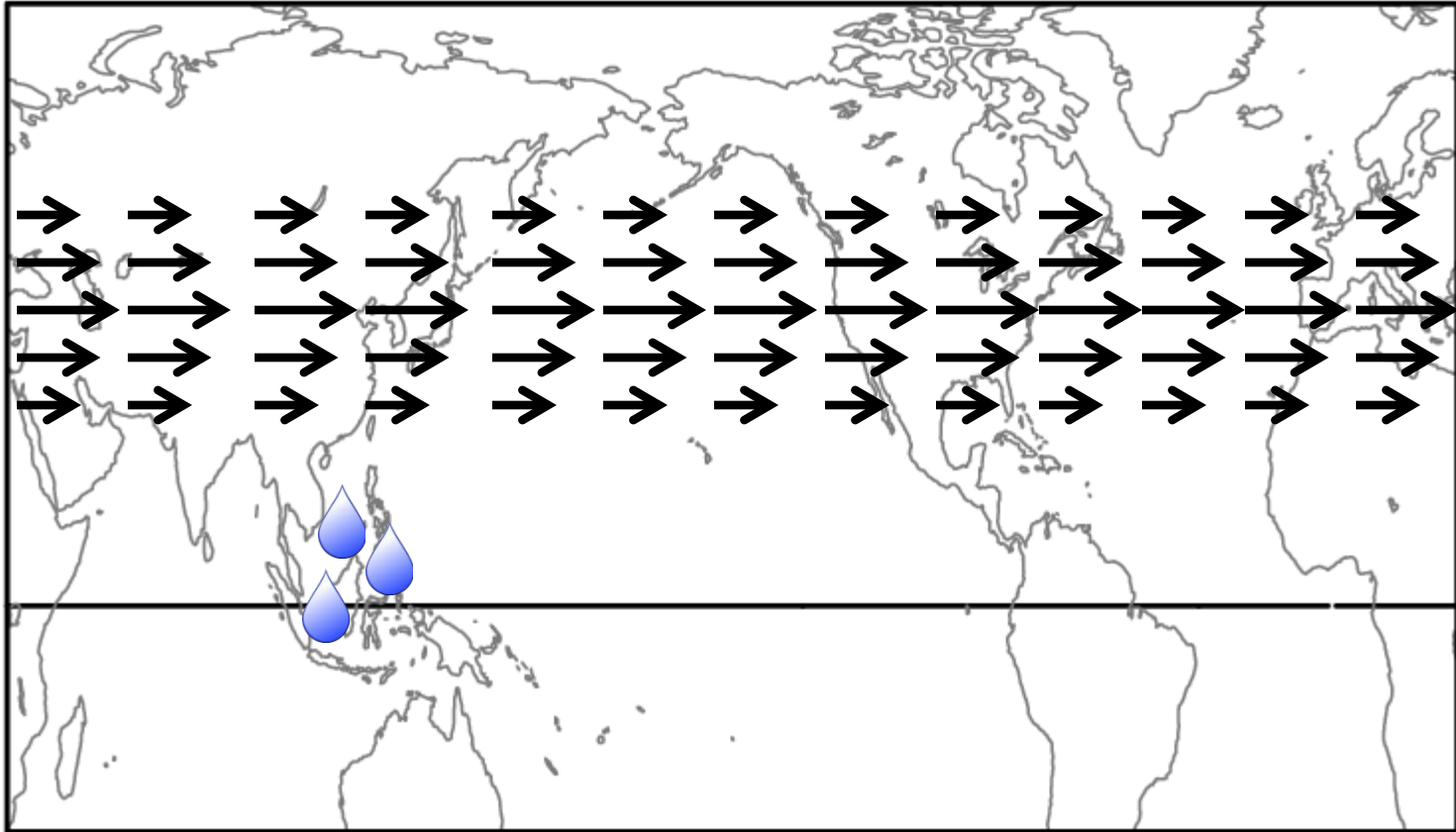
Not Poleward



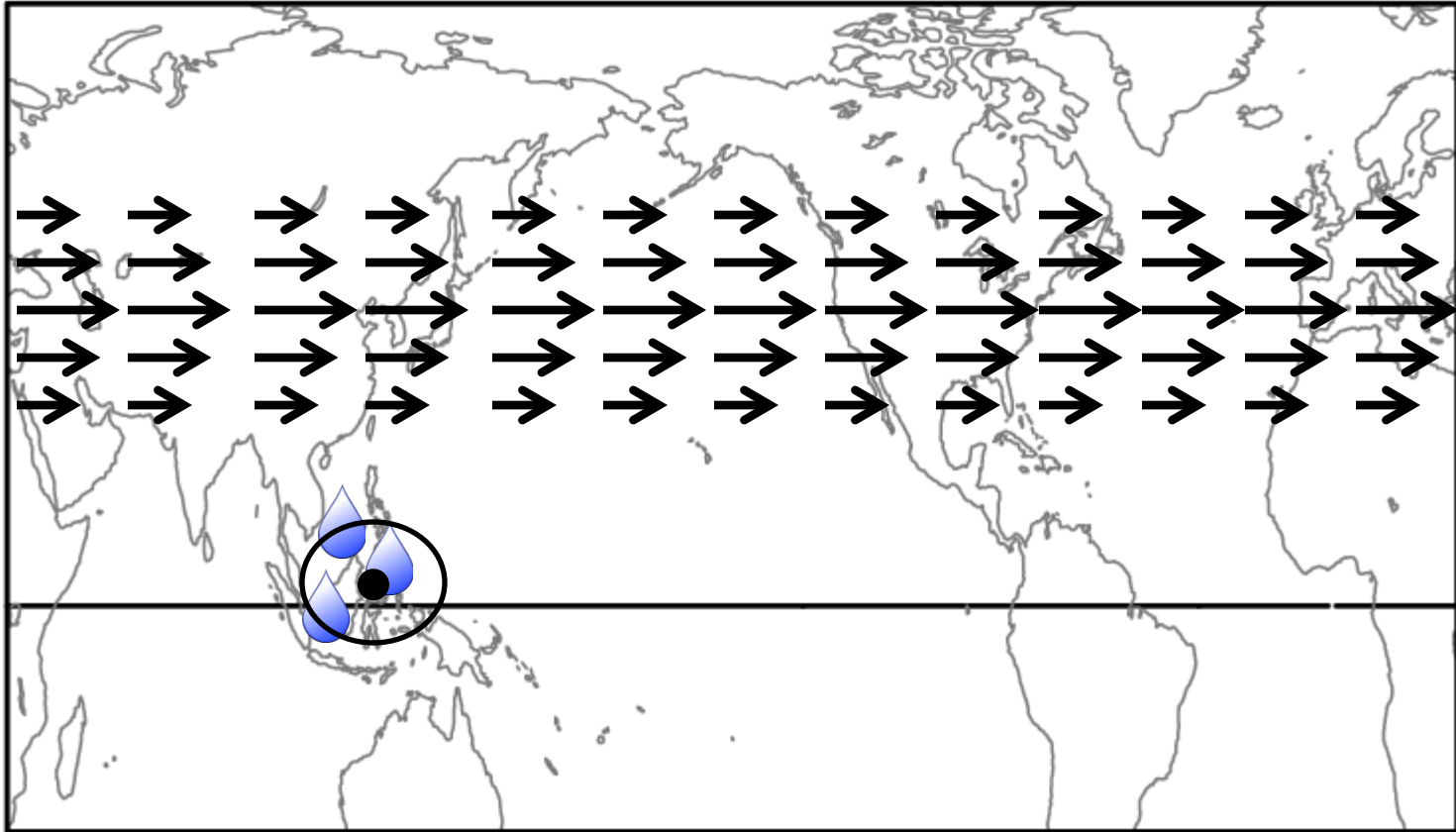
Tropical divergence impacts on extra-tropical circulation in the present-day climate



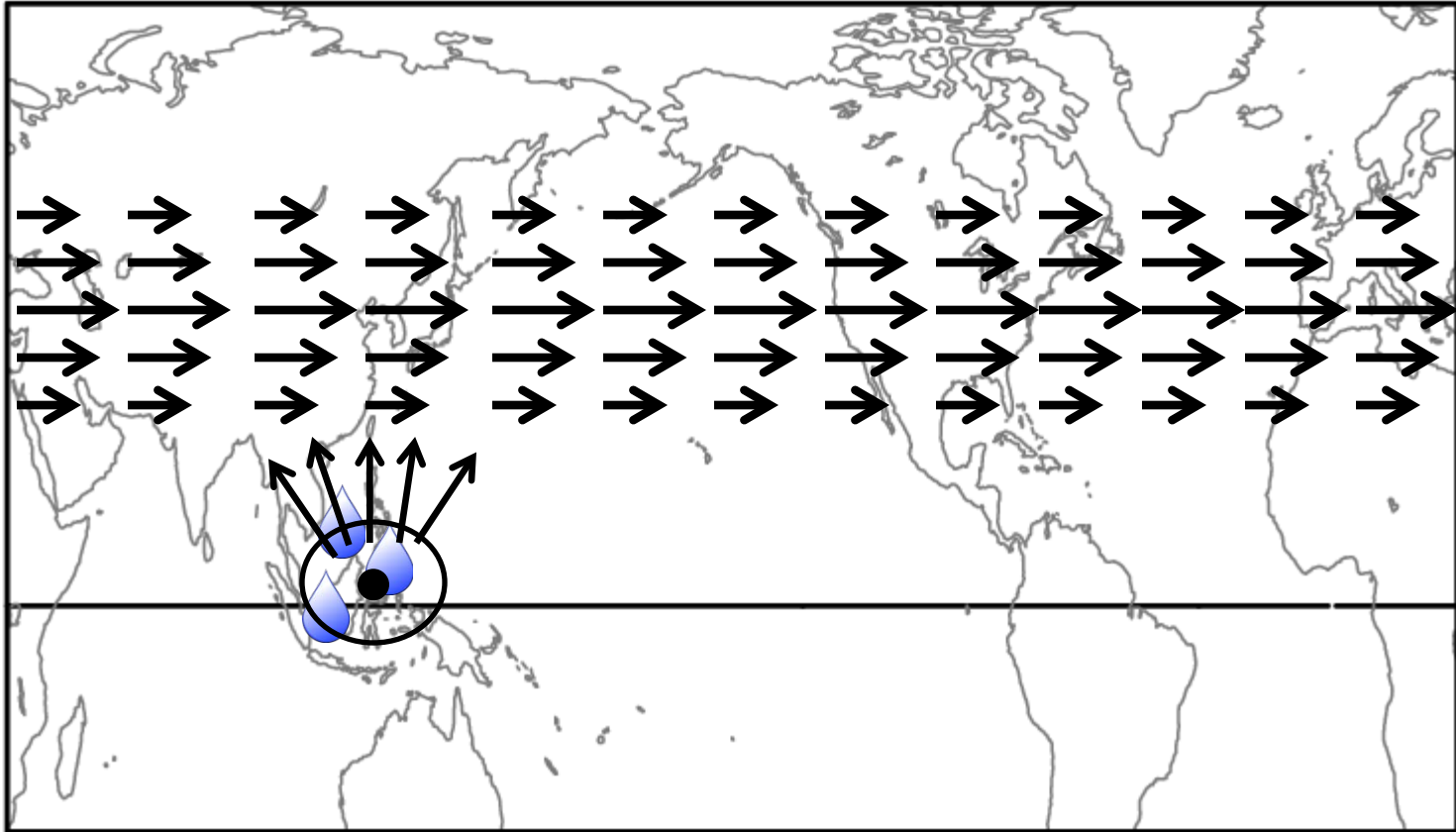
Tropical divergence impacts on extra-tropical circulation in the present-day climate



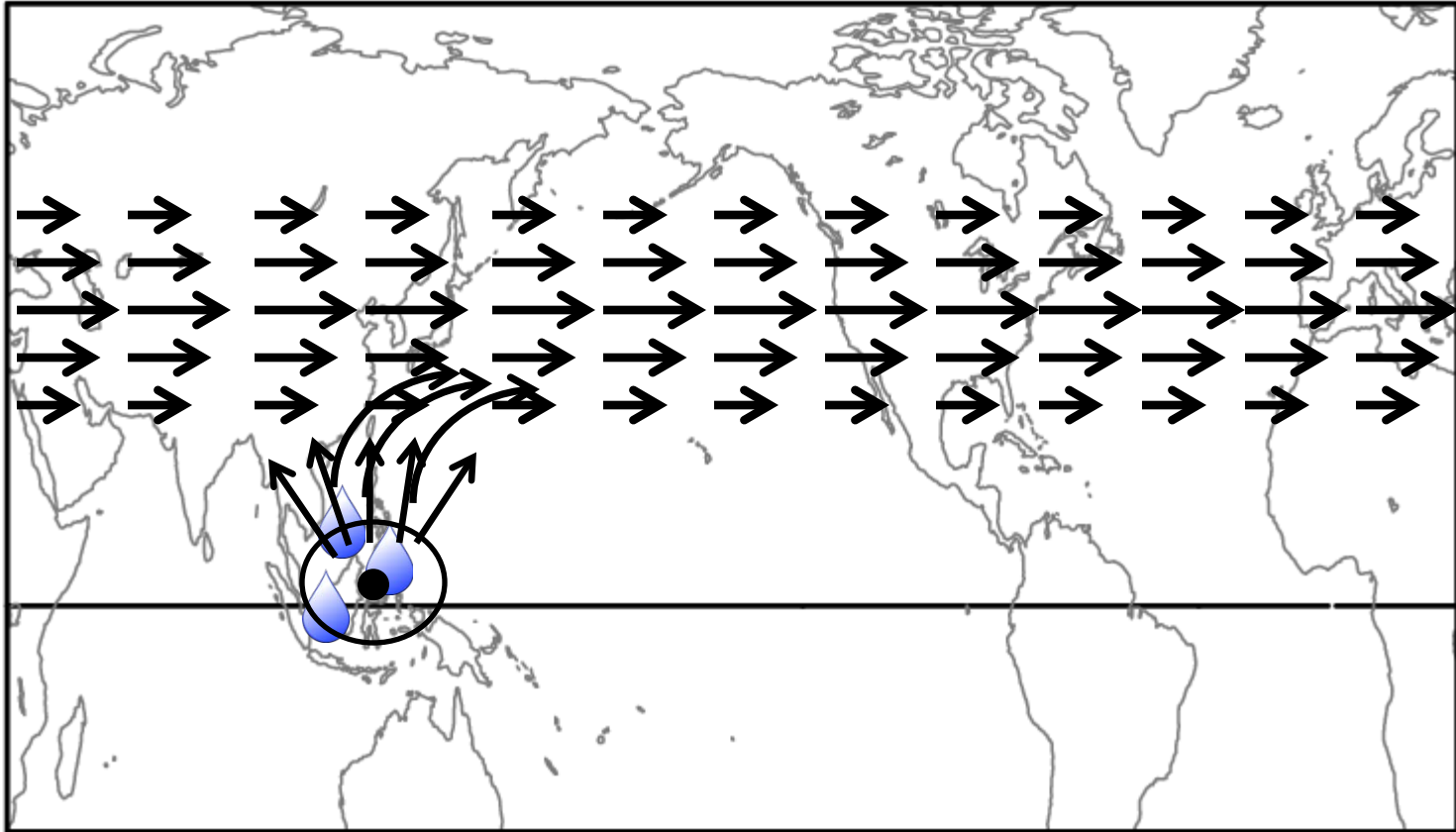
Tropical divergence impacts on extra-tropical circulation in the present-day climate



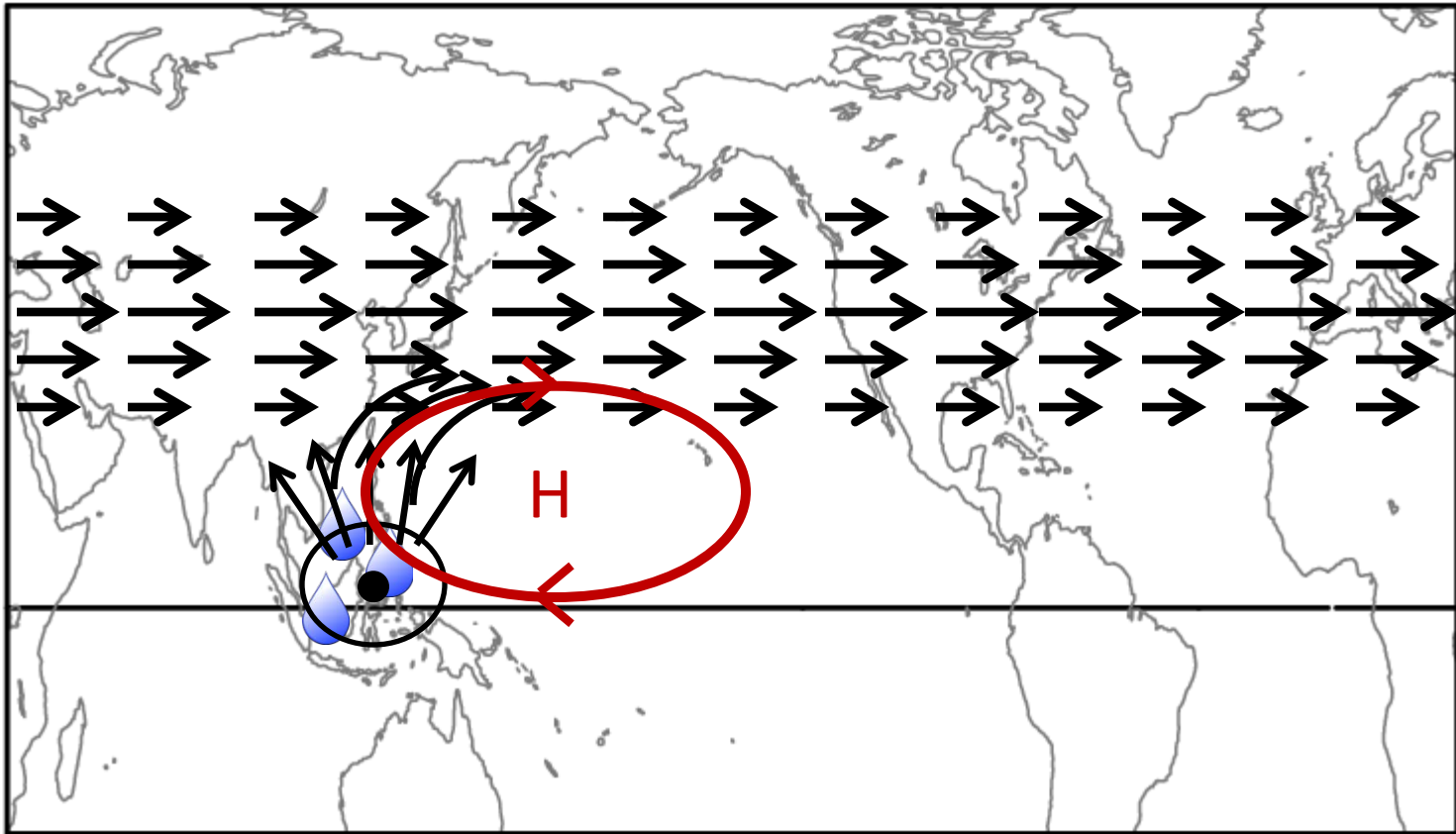
Tropical divergence impacts on extra-tropical circulation in the present-day climate



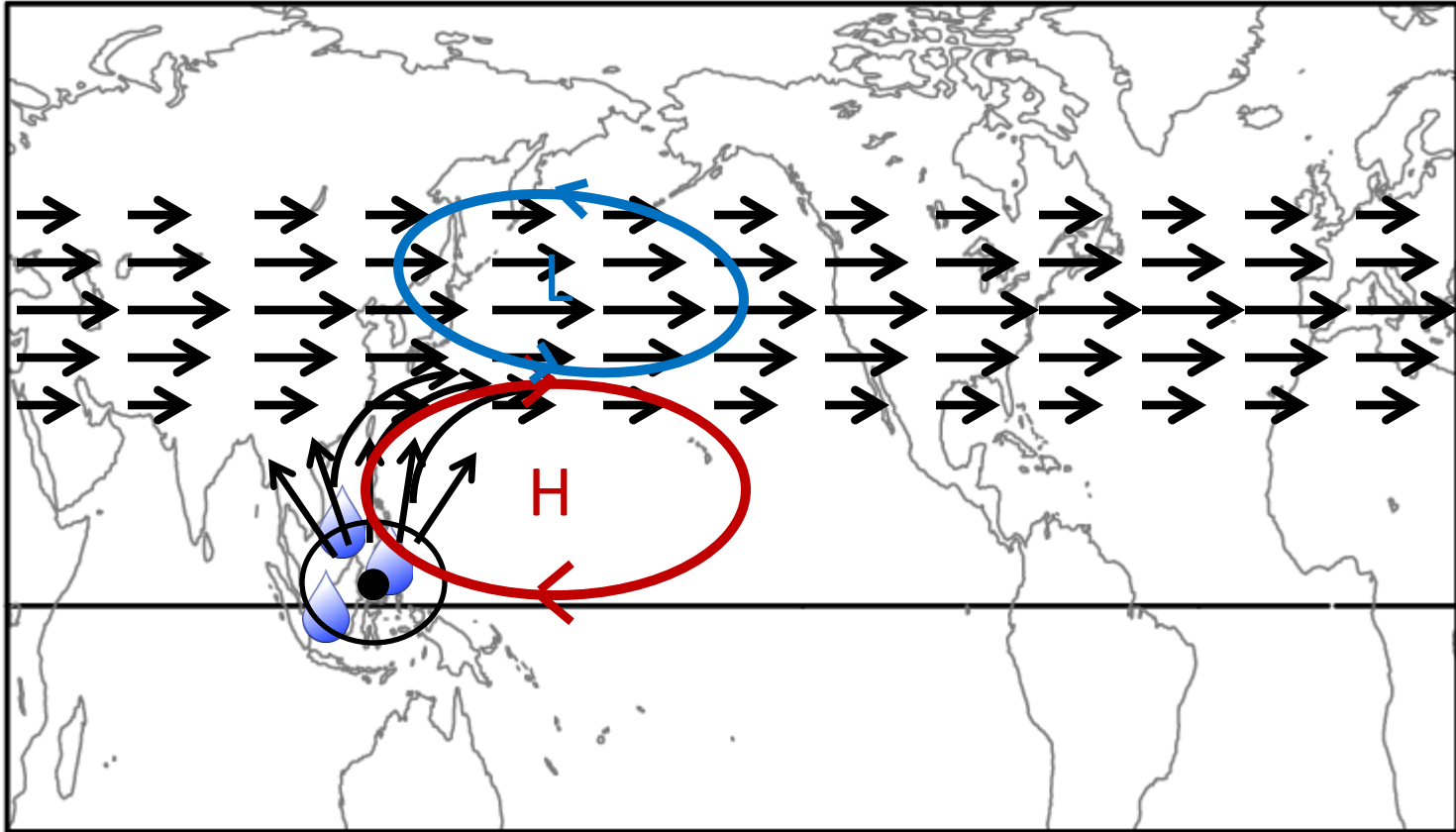
Tropical divergence impacts on extra-tropical circulation in the present-day climate



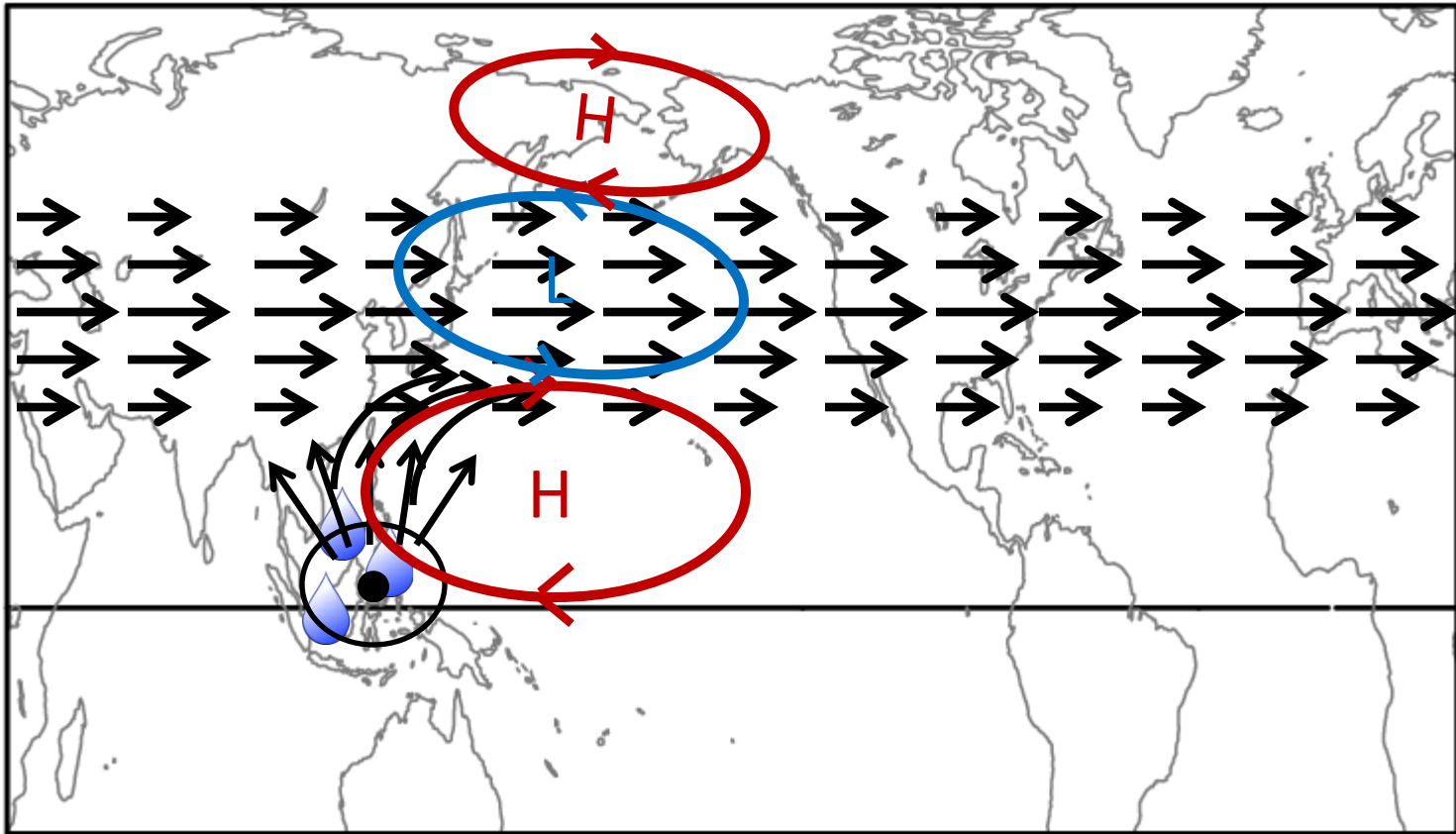
Tropical divergence impacts on extra-tropical circulation in the present-day climate



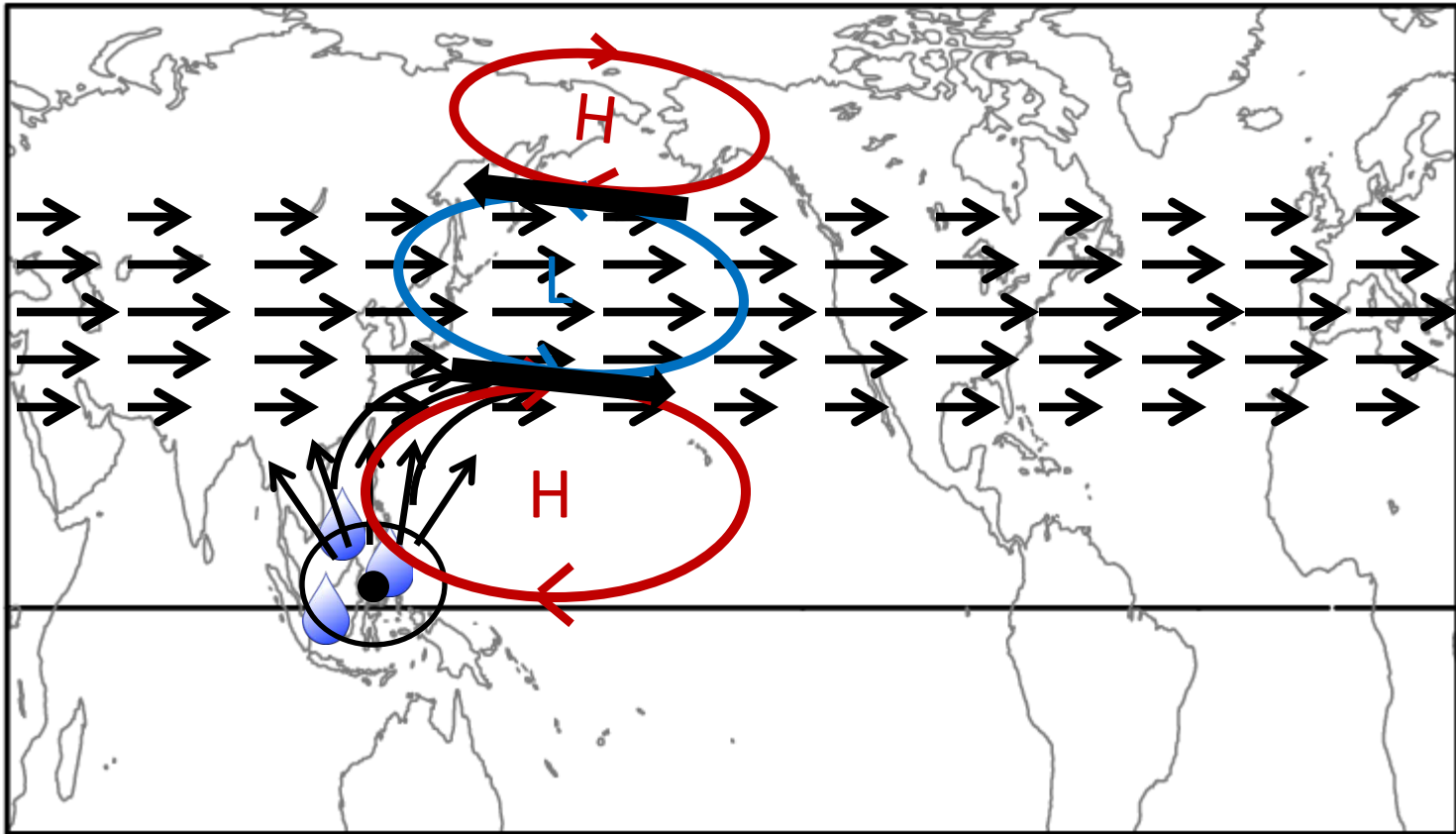
Tropical divergence impacts on extra-tropical circulation in the present-day climate



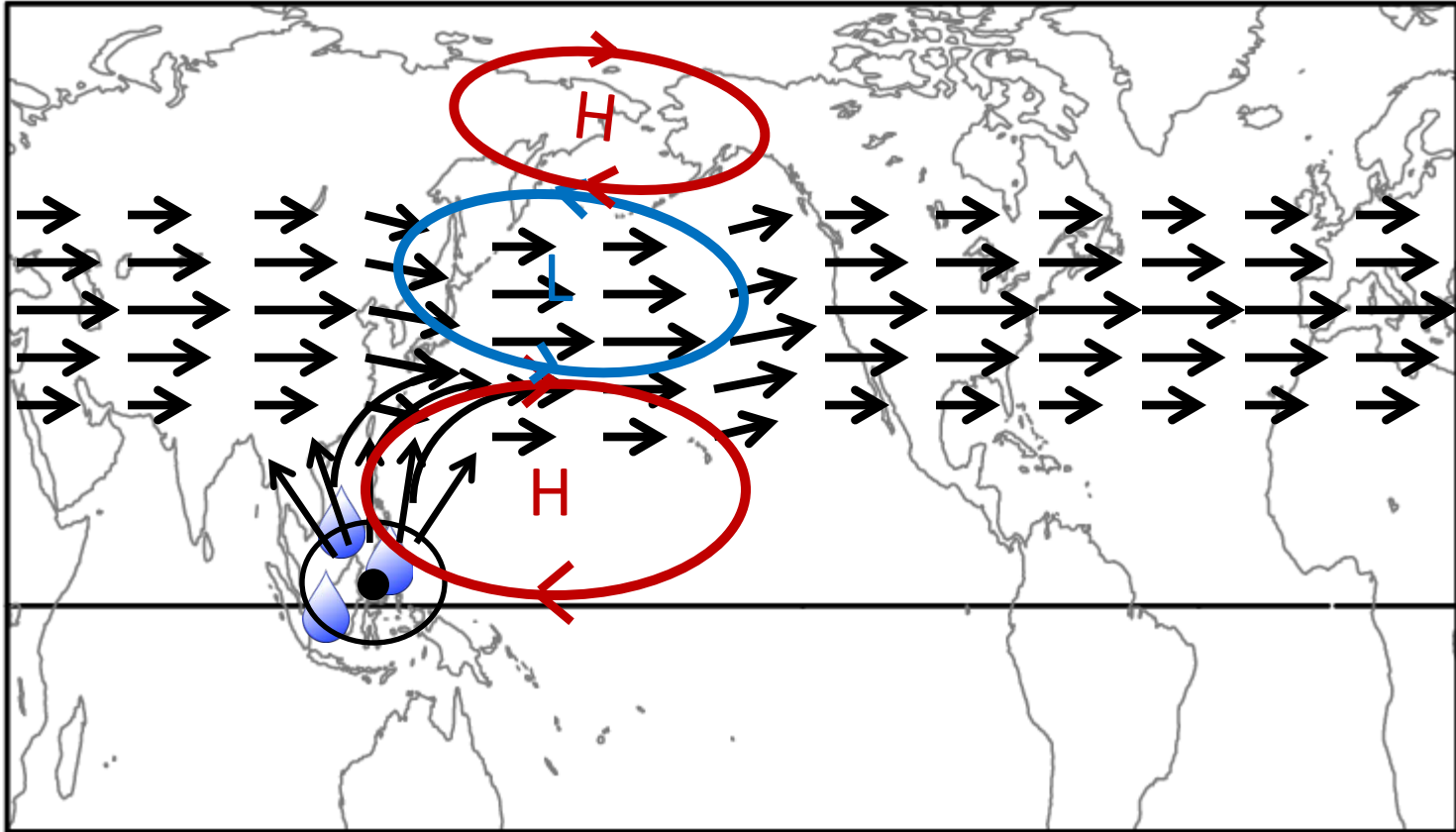
Tropical divergence impacts on extra-tropical circulation in the present-day climate



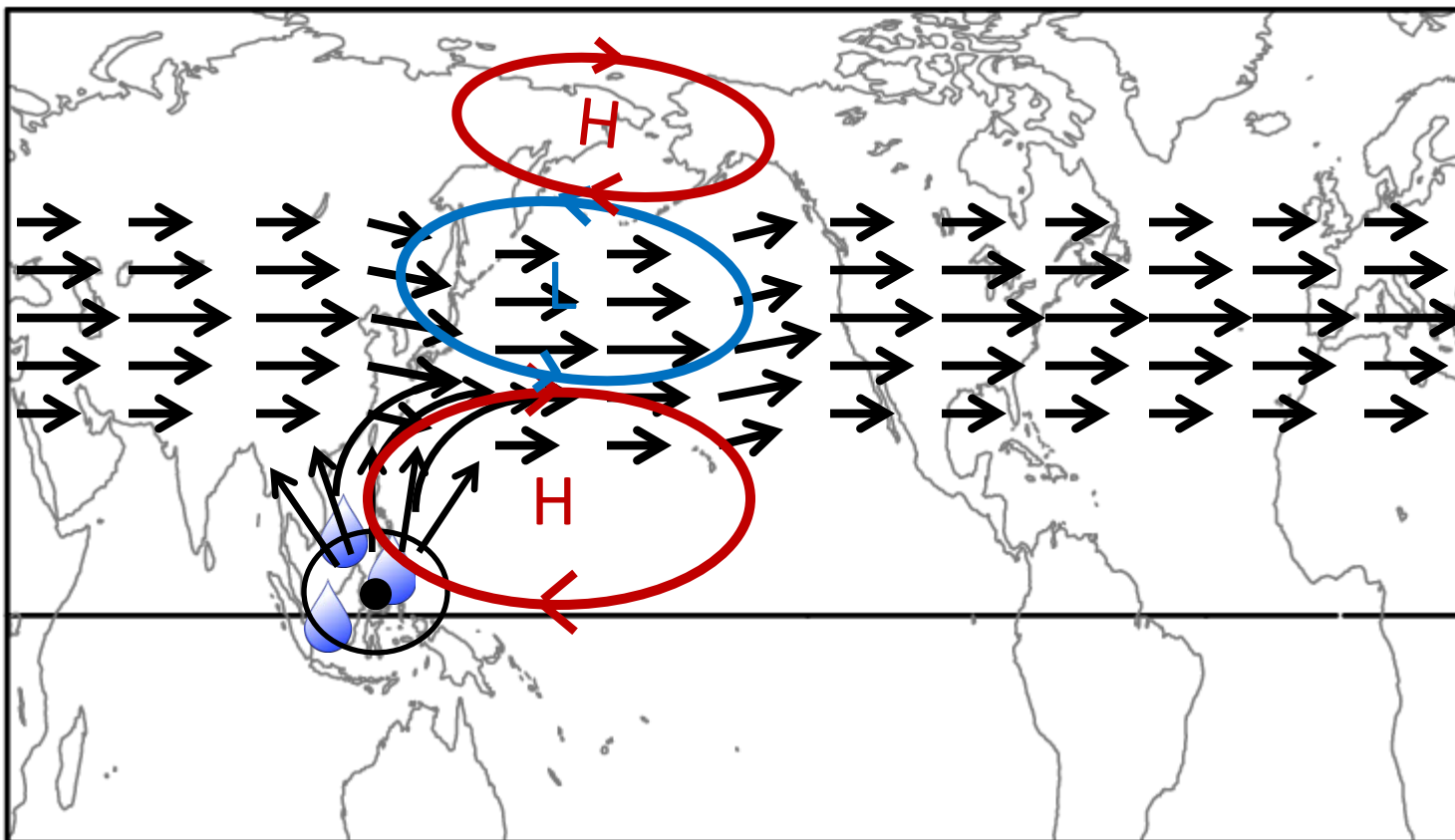
Tropical divergence impacts on extra-tropical circulation in the present-day climate



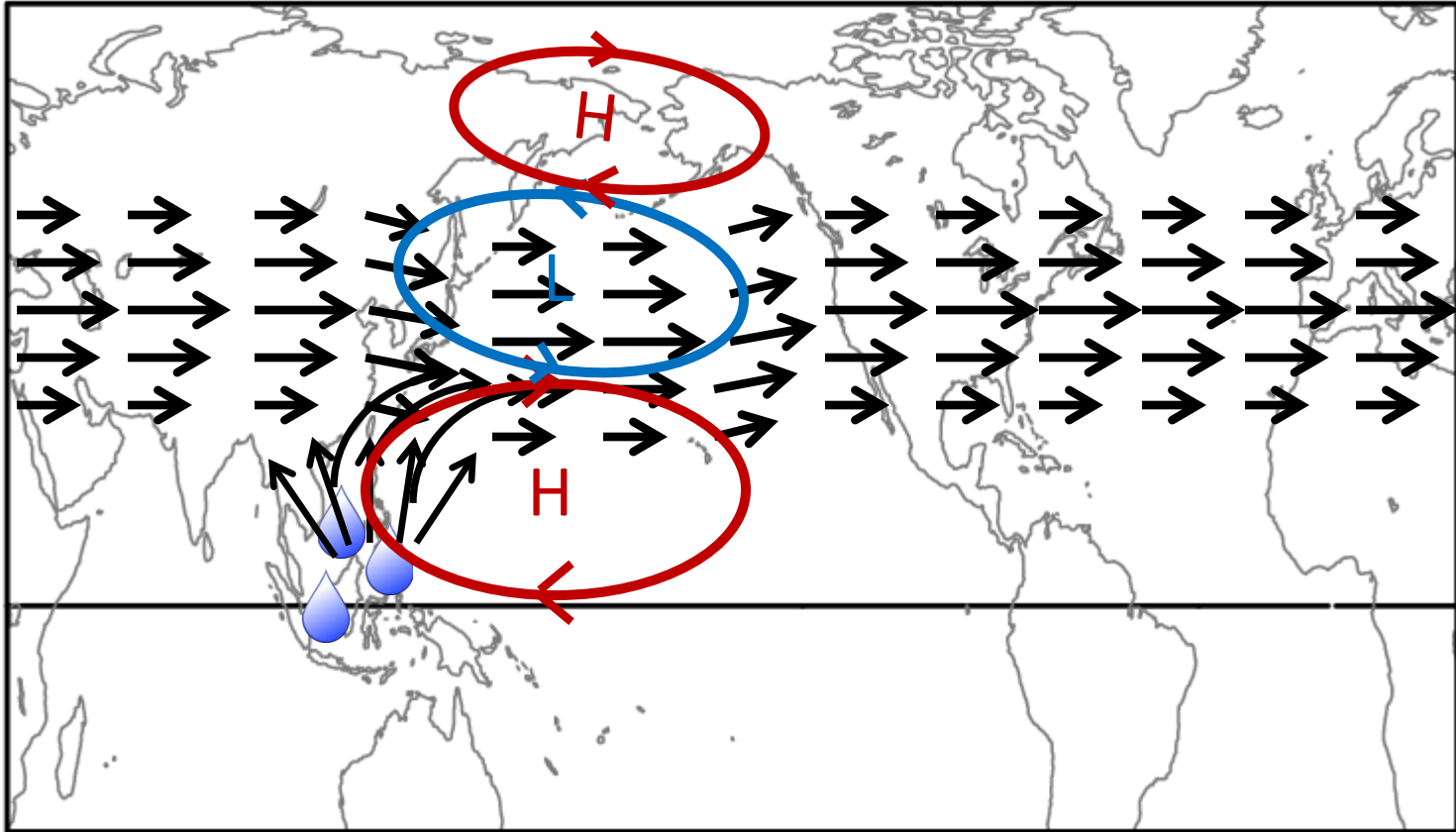
Tropical divergence impacts on extra-tropical circulation in the present-day climate



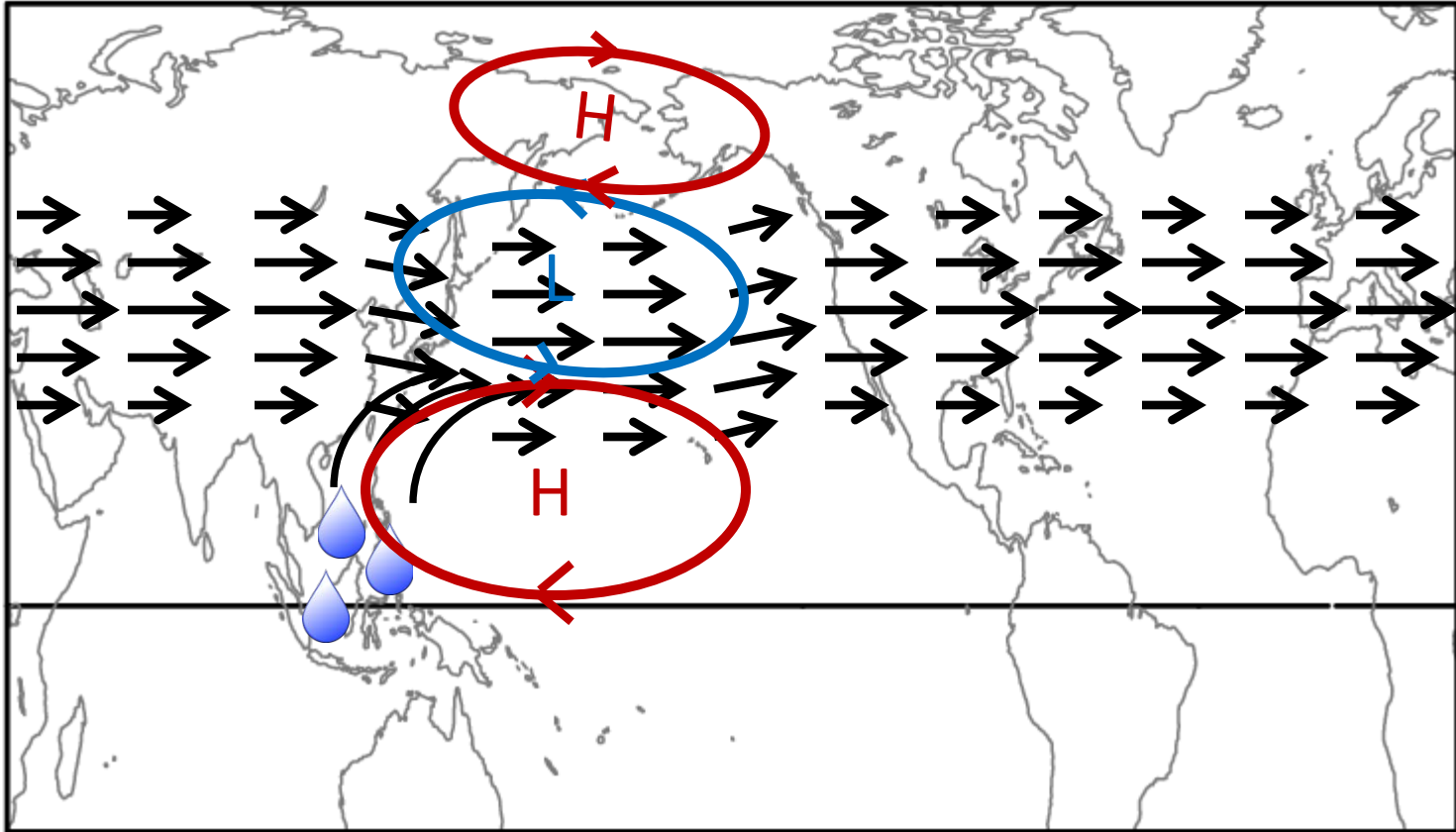
Future Changes - Poleward Models



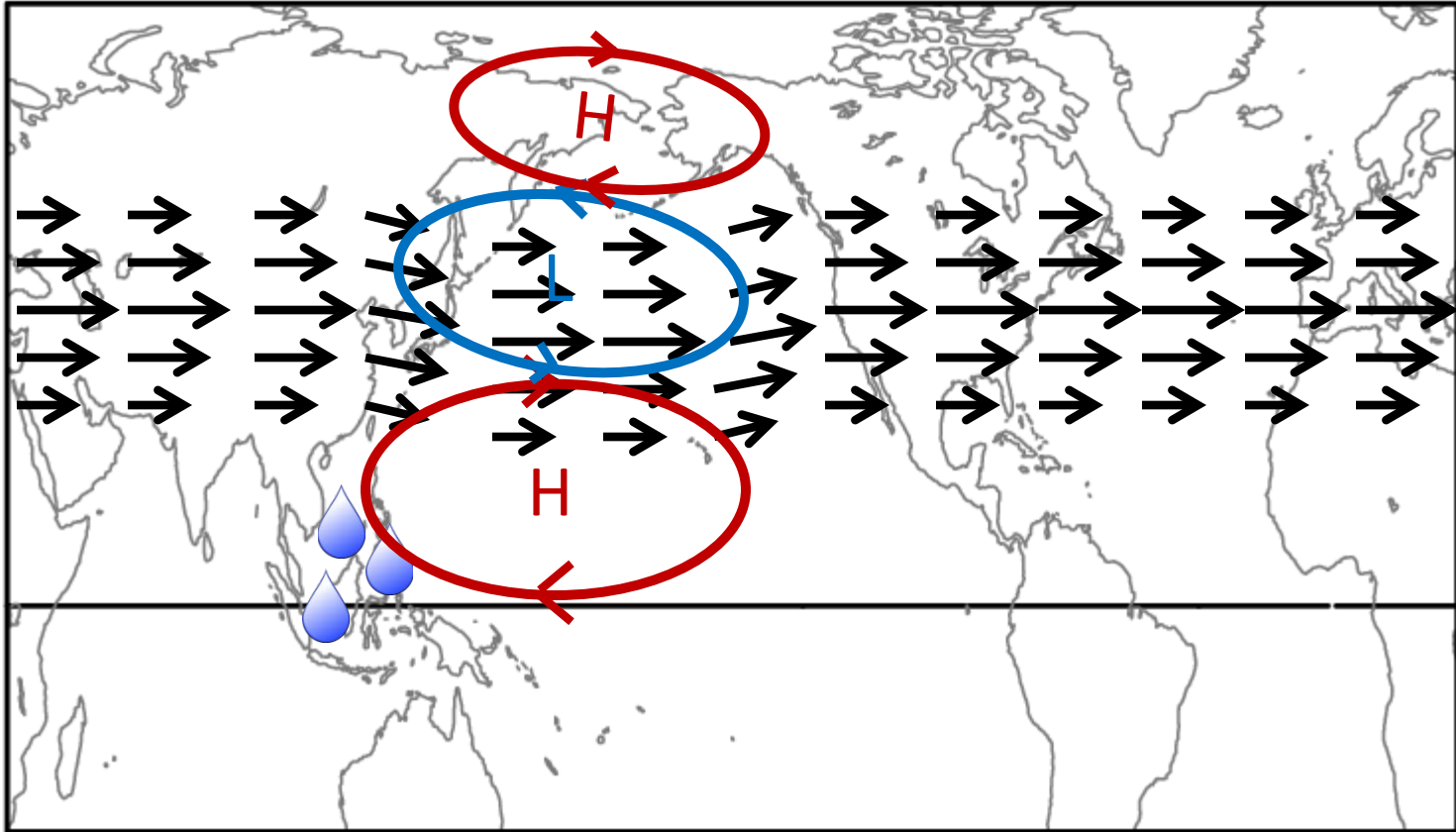
Future Changes - Poleward Models



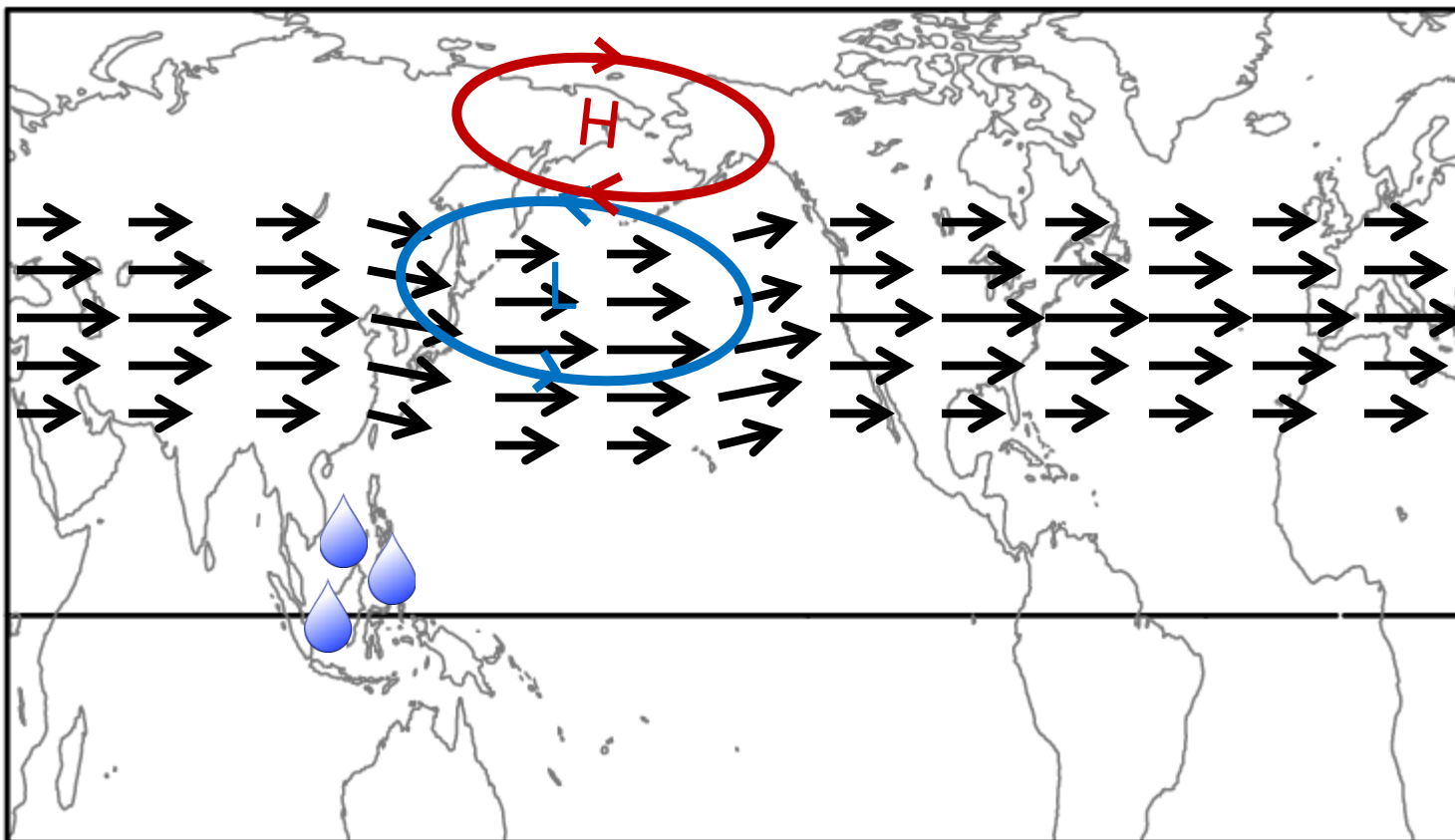
Future Changes - Poleward Models



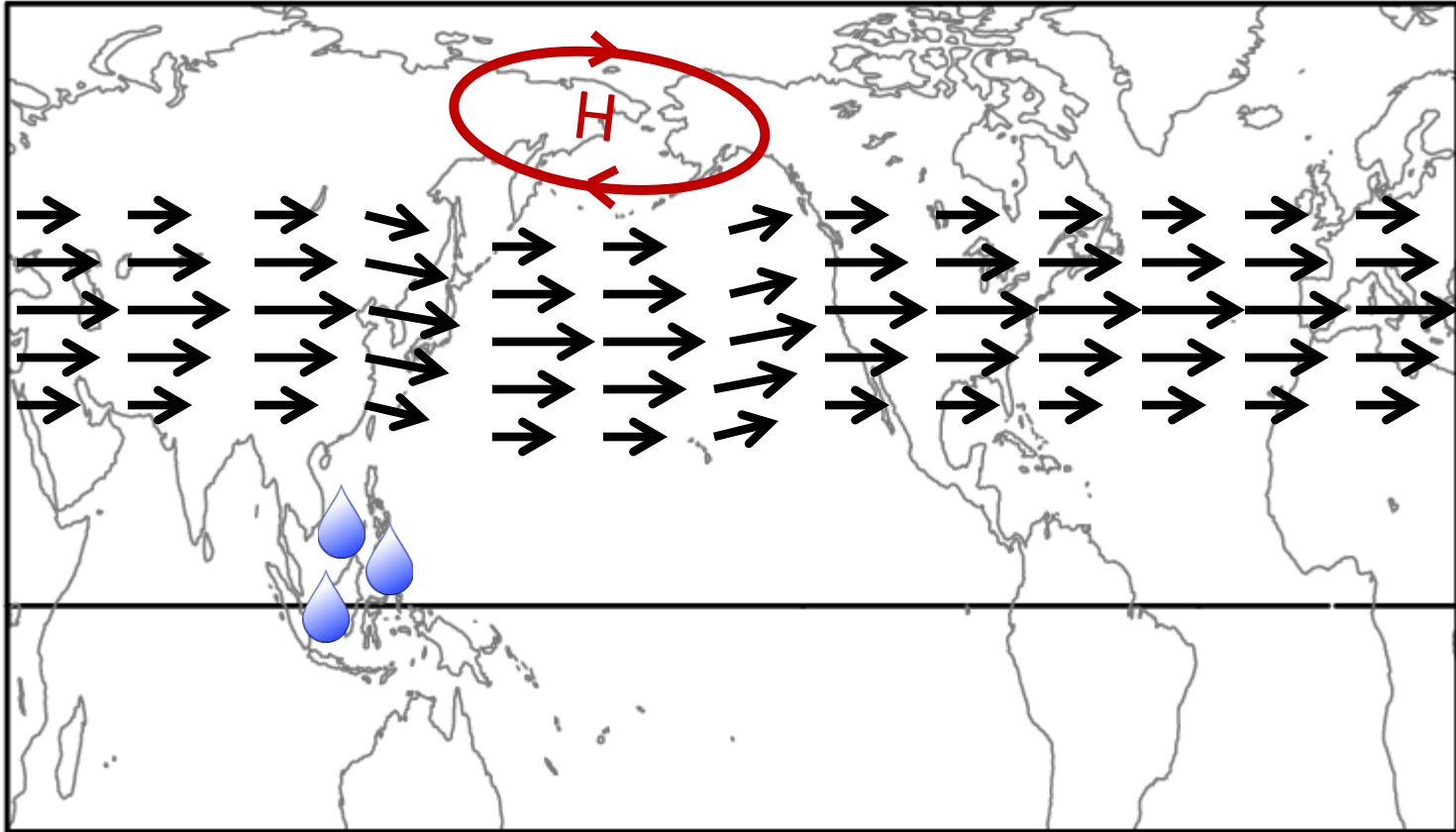
Future Changes - Poleward Models



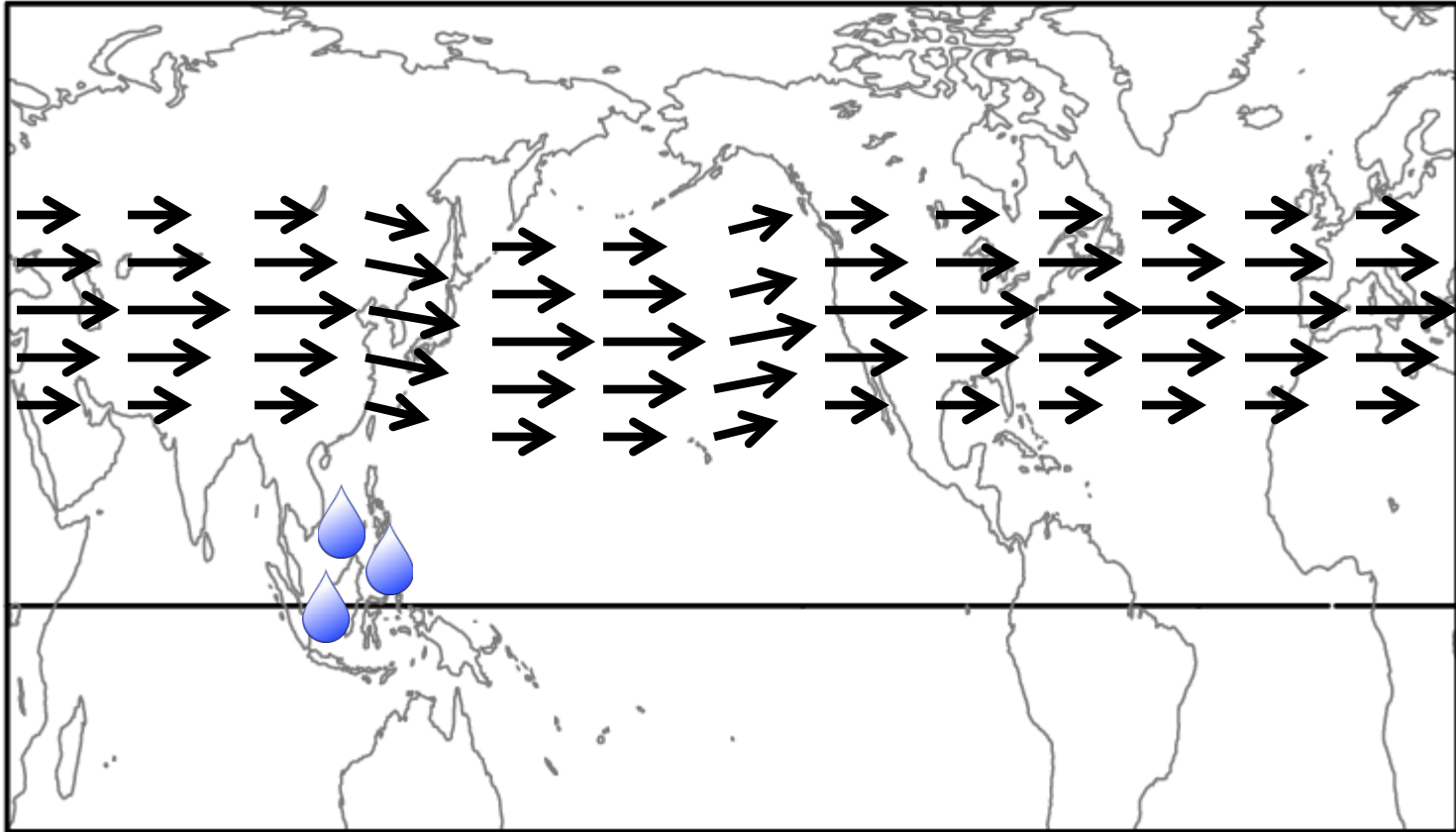
Future Changes - Poleward Models



Future Changes - Poleward Models



Future Changes - Poleward Models



Future Changes - Poleward Models

