Variability of extratropical cloudiness and related meteorological parameters in the CCSM2

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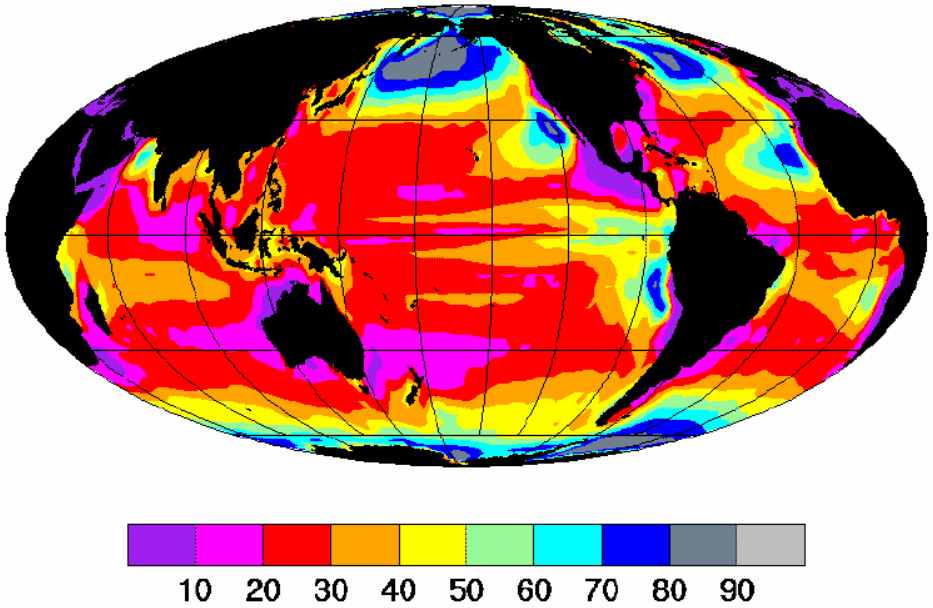
For brevity I will focus on low-level clouds over the ocean during the JJA season

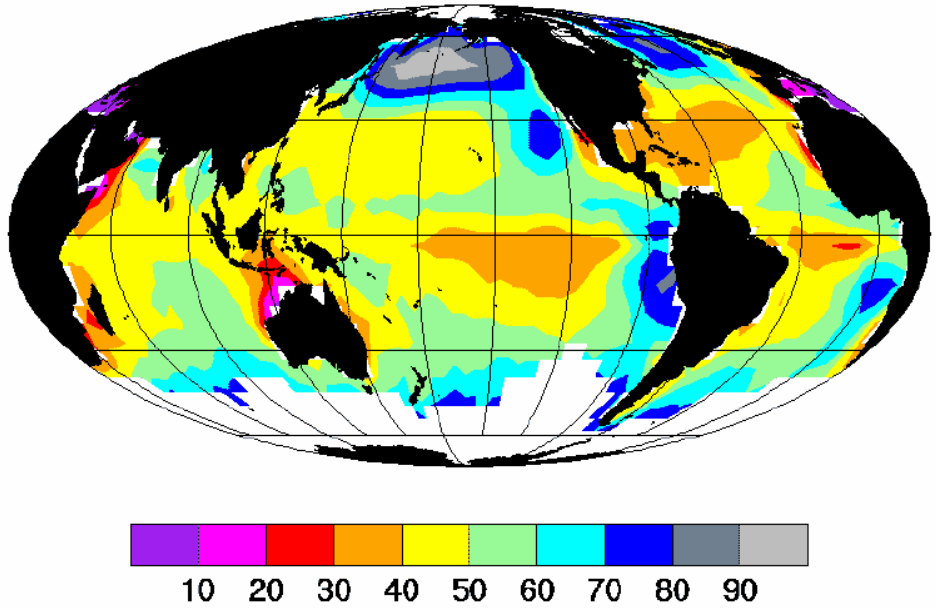
- Low-level oceanic clouds are the most common type in the extratropics
- Cloud radiative forcing is very large over northern midlatitude oceans during JJA
- Subtropical stratocumulus coverage is large in both hemispheres during JJA

Climatological Low Cloud Cover During JJA

CCSM2 (0191-0410)



Observed (1952-1996)



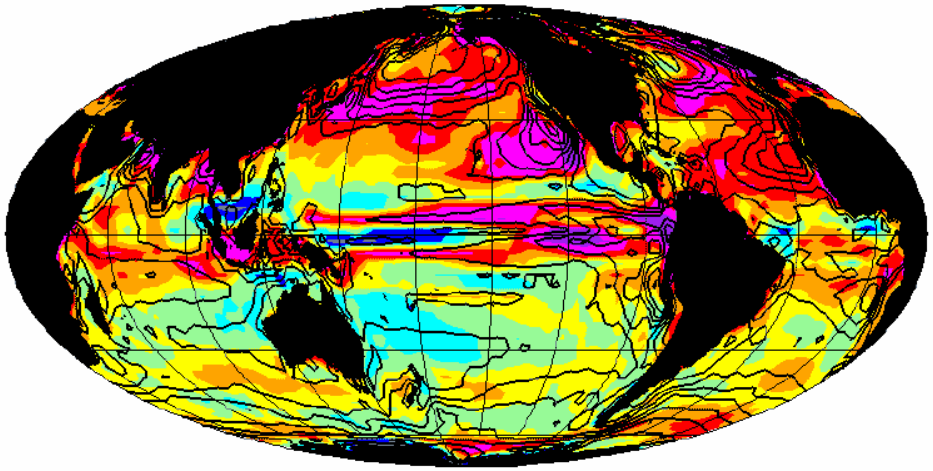
colors: cloud cover (every 10%)

model output: CLDLOW

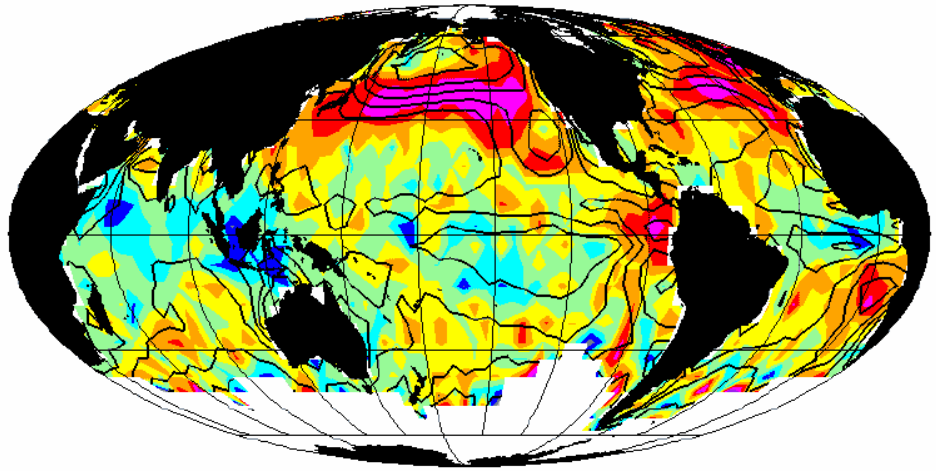
observations: surface synoptic cloud reports

Correlation between Low Cloud and SST JJA Anomalies

CCSM2 (0191-0410)



Observed (1952-1996)



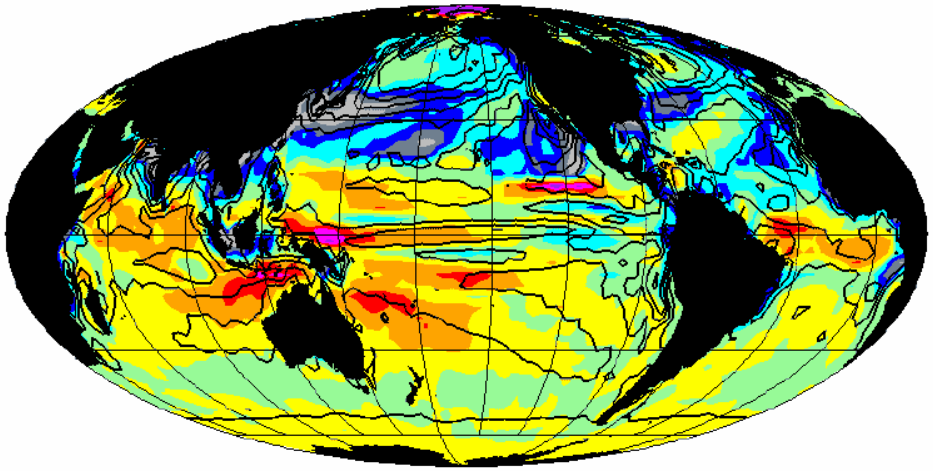
colors: local correlation (every 20%)
contours: climatological cloud cover (every 10%)

model output: CLDLOW and TS

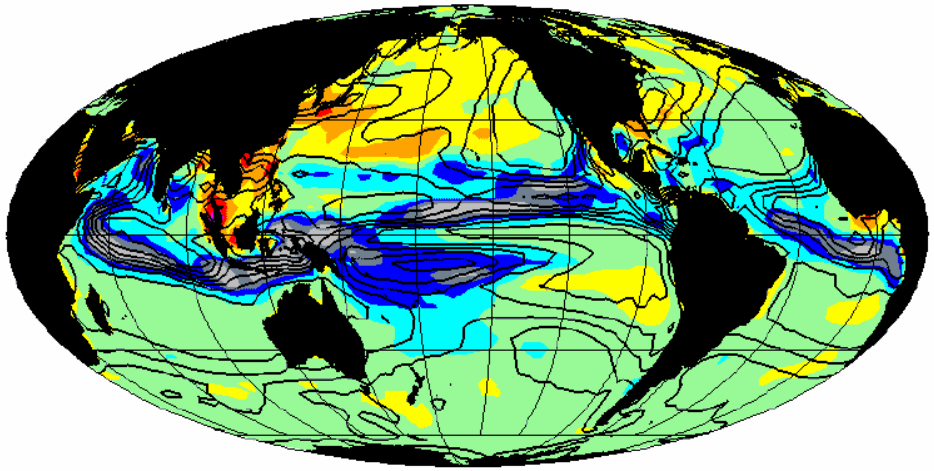
observations: surface synoptic cloud and SST reports

Regression of Cloud Radiative Forcing on SST JJA Anomalies

CCSM2 SWCRF (0191-0410)



CCSM2 LWCRF (0191-0410)



colors: local regression coefficient (every 5 W m^{-2} K^{-1})
SW contours: climatological CRF (every 20 W m^{-2})
LW contours: climatological CRF (every 10 W m^{-2})

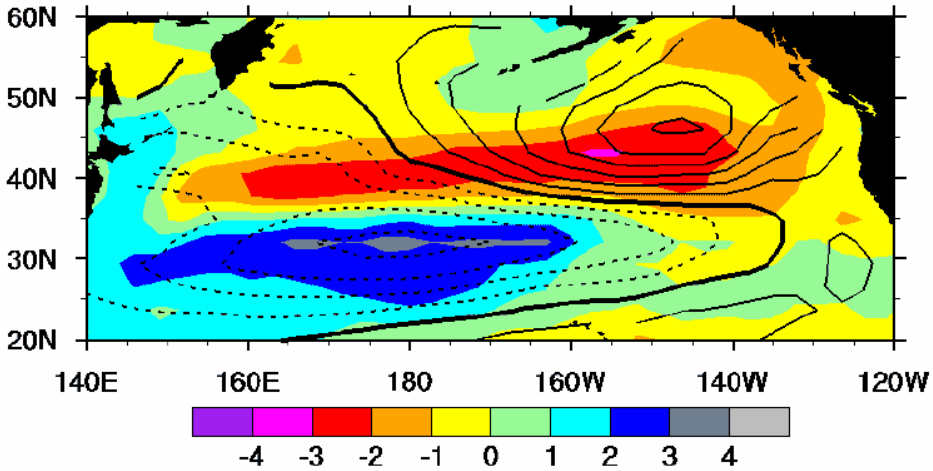
model output: SWCF, LWCF, and TS

First Summary

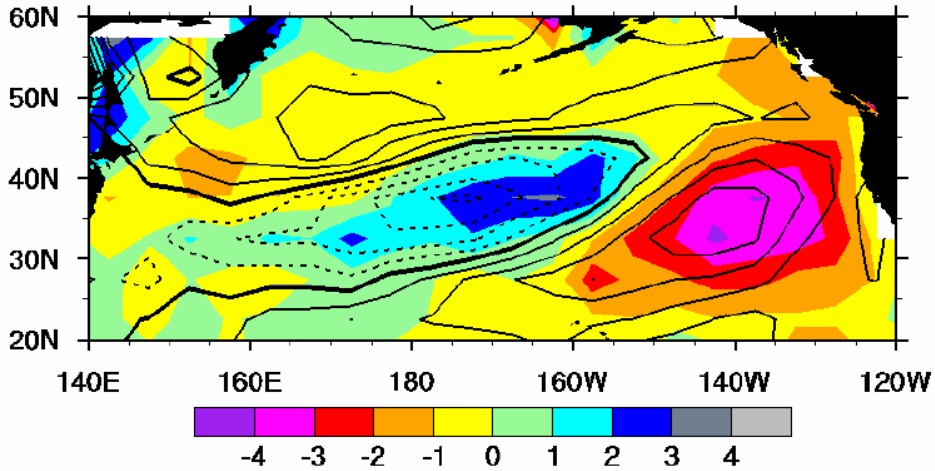
- CCSM2 does reproduce the major features of observed climatological JJA extratropical oceanic low cloudiness
- CCSM2 does not reproduce the specific magnitude and location of subtropical stratocumulus
- CCSM2 does reproduce negative correlations between interannual JJA low cloud and SST anomalies observed in the extratropics
- Positive net CRF anomalies are associated with positive SST anomalies in CCSM2, implying a positive cloud feedback on SST in the extratropics

Independently Calculated Low Cloud and SST JJA EOF 1

CCSM2 (0191-0410)



Observed (1952-1996)



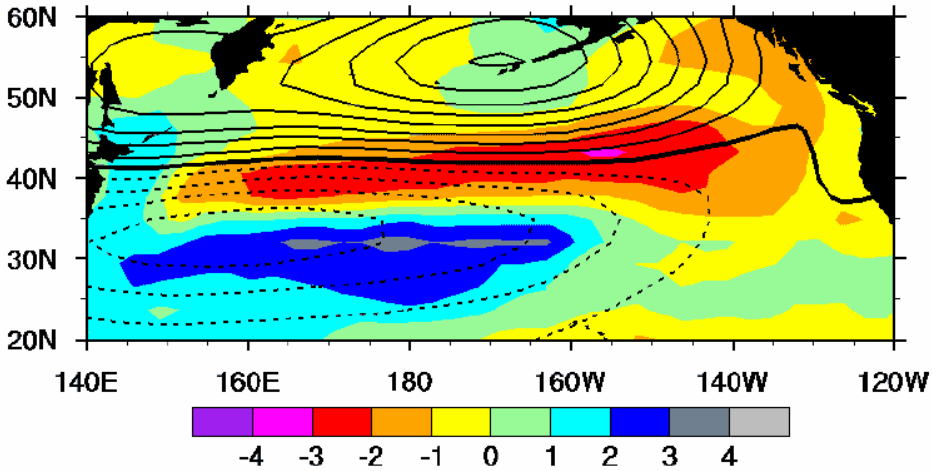
colors: cloud cover (every 1%)
contours: SST (every 0.1°C)

<u>CCSM2</u>
Cloud–SST correlation = 63%
Cloud EOF1 variance = 22%
SST EOF1 variance = 35%

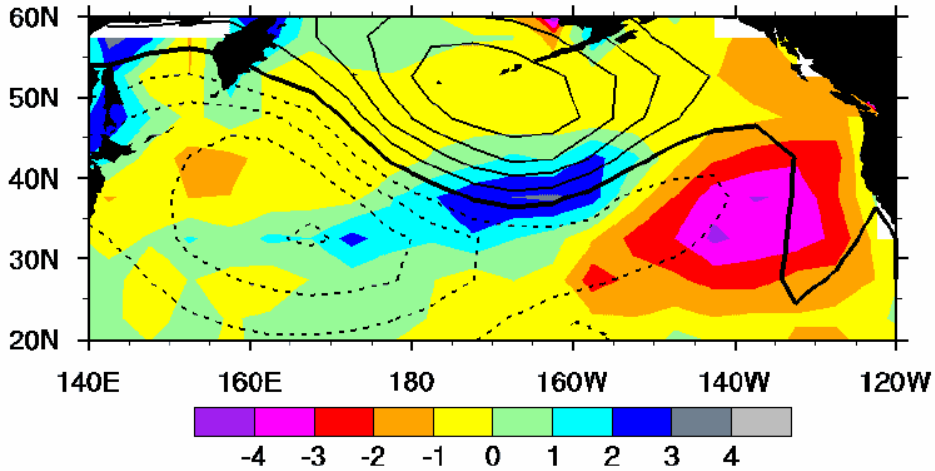
<u>Observed</u>
Cloud–SST correlation = 75%
Cloud EOF1 variance = 28%
SST EOF1 variance = 30%

Independently Calculated Low Cloud and SLP JJA EOF 1

CCSM2 (0191-0410)



Observed (1952-1996)



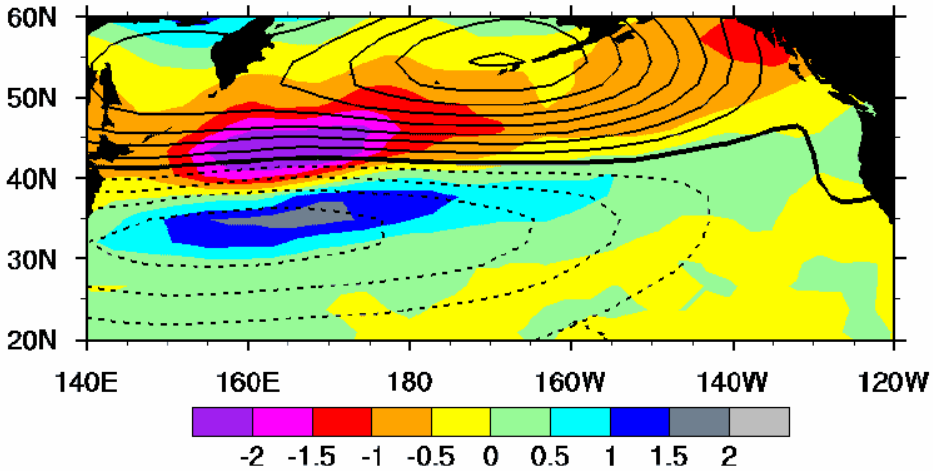
colors: cloud cover (every 1%)
contours: SLP (every 0.2 mb)

<u>CCSM2</u>
Cloud–SLP correlation = 50%
Cloud EOF1 variance = 22%
SLP EOF1 variance = 64%

<u>Observed</u>
Cloud–SLP correlation = 11%
Cloud EOF1 variance = 28%
SLP EOF1 variance = 40%

Nimbostratus and Large Scale Precipitation JJA EOF 1

CCSM2 (0191-0410)

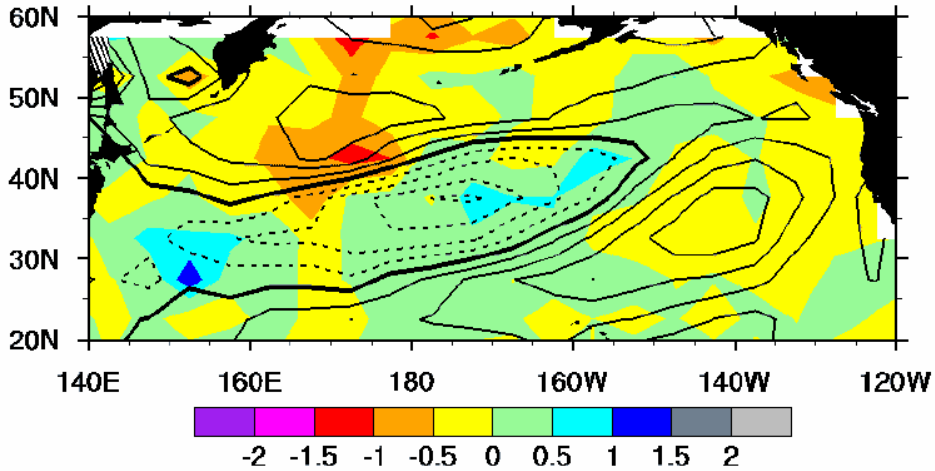


colors: precip rate (0.1 mm/dy)
contours: SLP (every 0.2 mb)

CCSM2
Precip–SLP correlation = 51%
Precip EOF1 variance = 27%

model output: PRECL

Observed (1952-1996)



colors: Ns frequency (0.5%)
contours: SST (every 0.1°C)

Observed
Ns–SST correlation = 41%
Ns EOF1 variance = 13%

observations:
present weather report

Correlations of JJA EOF 1 Time Series

CCSM2 (0191-0410)

	Low Cloud	SST	SLP
Precip	39	12	51
SLP	50	20	
SST	63		

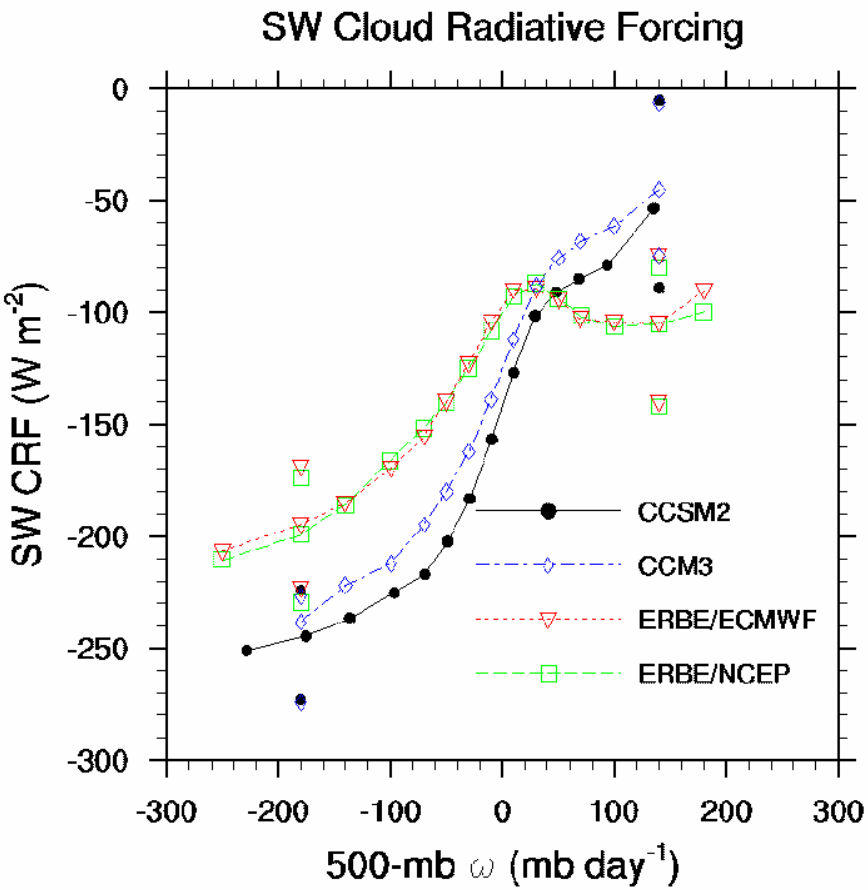
Observed (1952-1996)

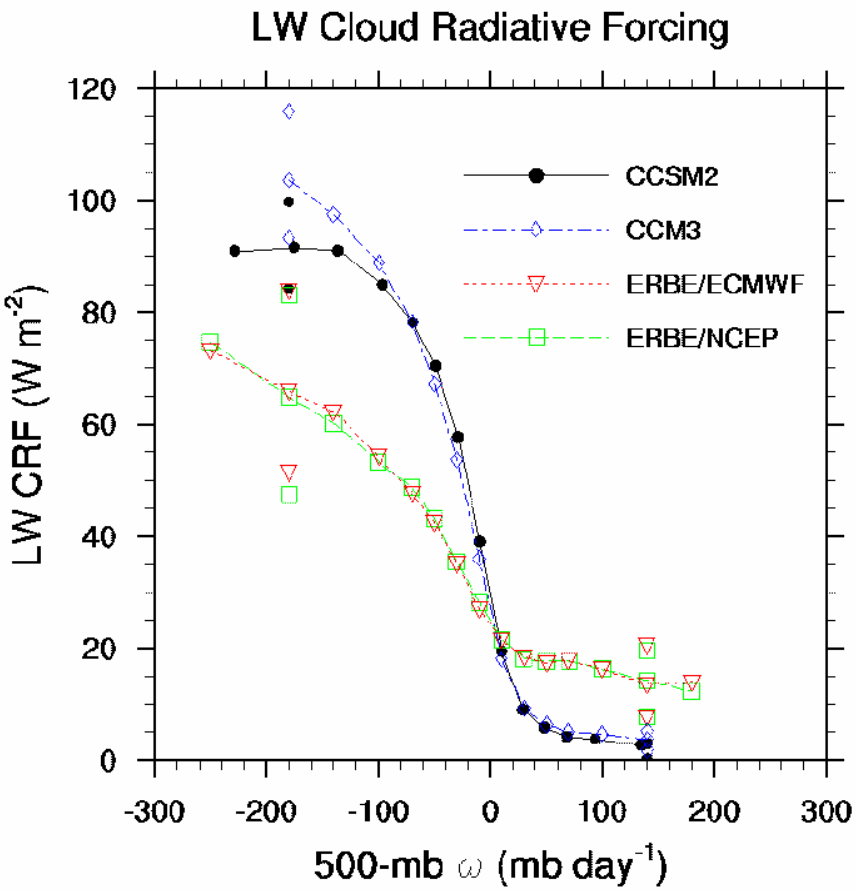
	Low Cloud	SST	SLP
Ns FQ	38	41	07
SLP	11	15	
SST	75		

Second Summary

- Leading patterns of low cloud and SST interannual variability are coupled in both CCSM2 and observations
- Leading patterns of low cloud and SLP interannual variability are coupled in CCSM2 but not observations
- Anomalous southwesterly flow is associated with increased low cloud cover in CCSM2
- Leading patterns of precipitation and SLP interannual variability are coupled in CCSM2 but not observations
- Leading patterns of precipitation and SST interannual variability are coupled in observations but not CCSM2

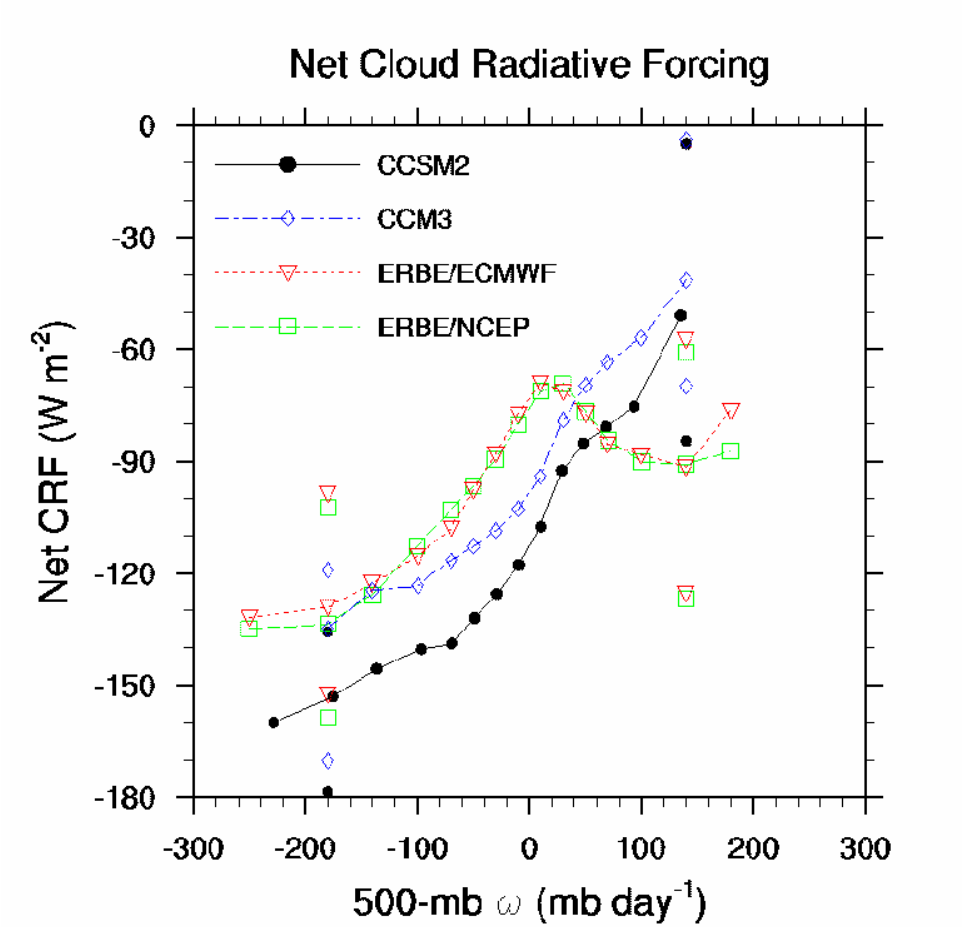
Daily Cloud Radiative Forcing as a Function of Vertical Velocity





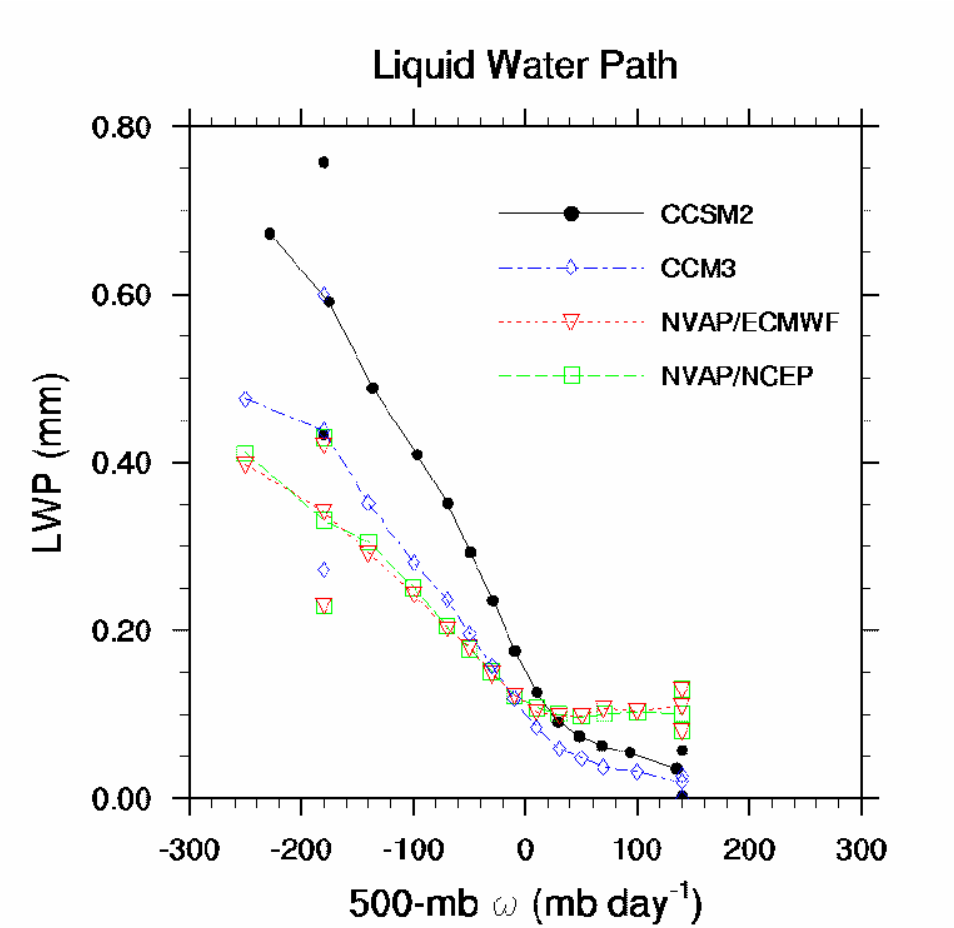
Composited during July over 30-60°N, 160-220°E

Daily Cloud Radiative Forcing as a Function of Vertical Velocity



Composited during July over 30-60°N, 160-220°E

Daily All-Sky Liquid Water Path as a Function of Vertical Velocity

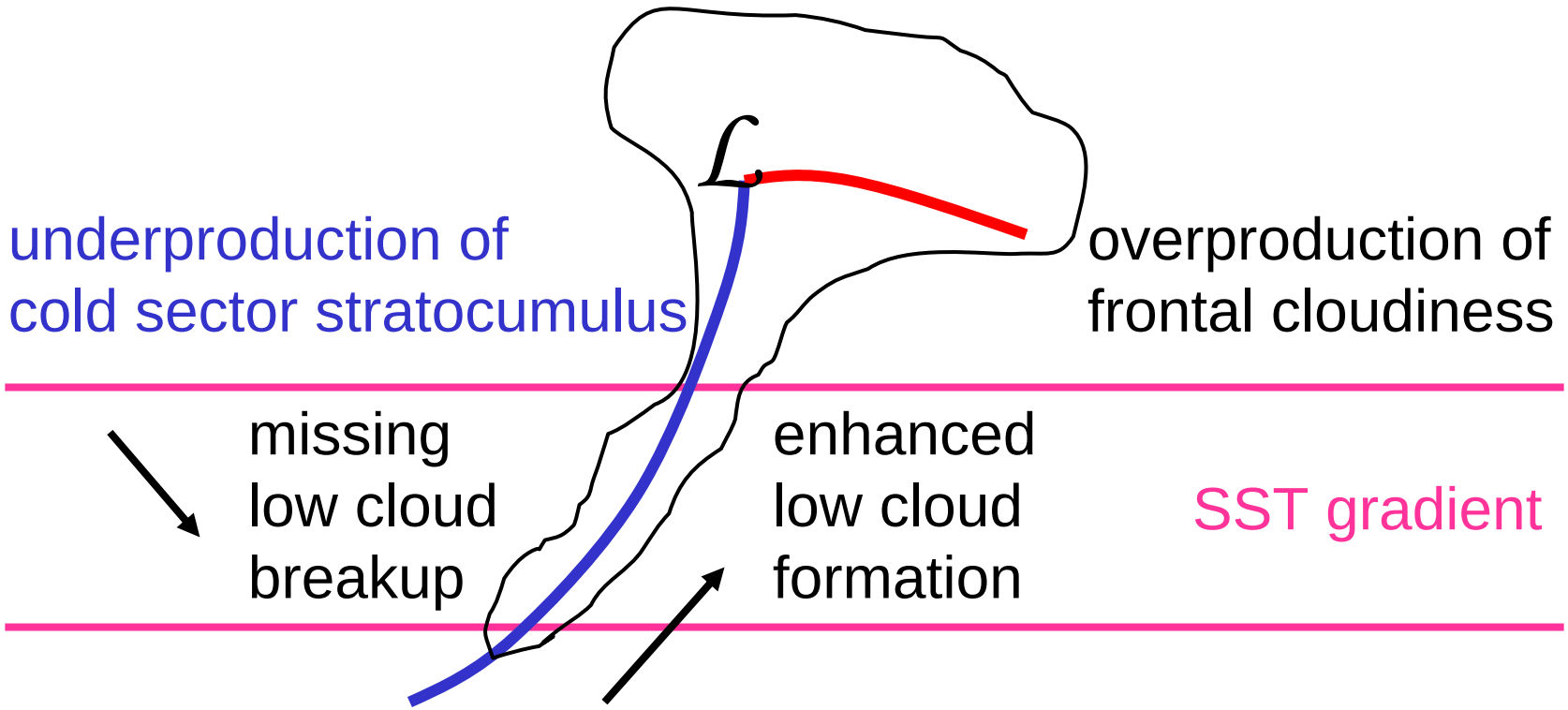


Composited during July over 30-60°N, 160-220°E

Third Summary

- CCSM2 overproduces both SWCRF and LWCRF under conditions of synoptic ascent
- CCSM2 underproduces both SWCRF and LWCRF under conditions of synoptic descent
- The SW bias exceeds the opposing LW bias
- SWCRF under all conditions is larger in CAM2 than in CCM3 (with prognostic water) due to greater LWP

CCSM2 Synoptic Cloud Processes over Extratropical Oceans during Summer



Result: CCSM2 low cloudiness has realistic coupling to variability in the SST gradient and storm track but is unrealistically sensitive to changes in low-level circulation