

How Are Observed Snow Cover/NAO Links Represented in Two Leading CGCMs?

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SNOW COVER / NAO LINKS

Observations show that summer Northern Hemisphere snow cover and autumn Eurasian snow cover are significantly linked to the upcoming winter North Atlantic Oscillation (NAO) (Saunders et. al, 2003; Saito et. al, 2001). However, two CGCMs (HadCM3 and ECHAM4) both fail to accurately capture these links. This failure appears due to these CGCMs having inadequate atmospheric coupling above snow surfaces.

NH Snow Index

	Obs	(p)	HadCM3	(p)	ECHAM4	(p)
JUN	-0.55	0.00	-0.26	0.10	-0.08	0.45
JUL	-0.58	0.01	-0.27	0.08	-0.12	0.24
AUG	-0.39	0.05	-0.26	0.09	-0.14	0.19
SEP	-0.29	0.21	-0.26	0.09	-0.18	0.10
OCT	-0.35	0.08	-0.28	0.07	-0.22	0.03
NOV	-0.16	0.40	-0.31	0.04	-0.17	0.10
DEC	-0.15	0.47	-0.33	0.02	-0.15	0.16

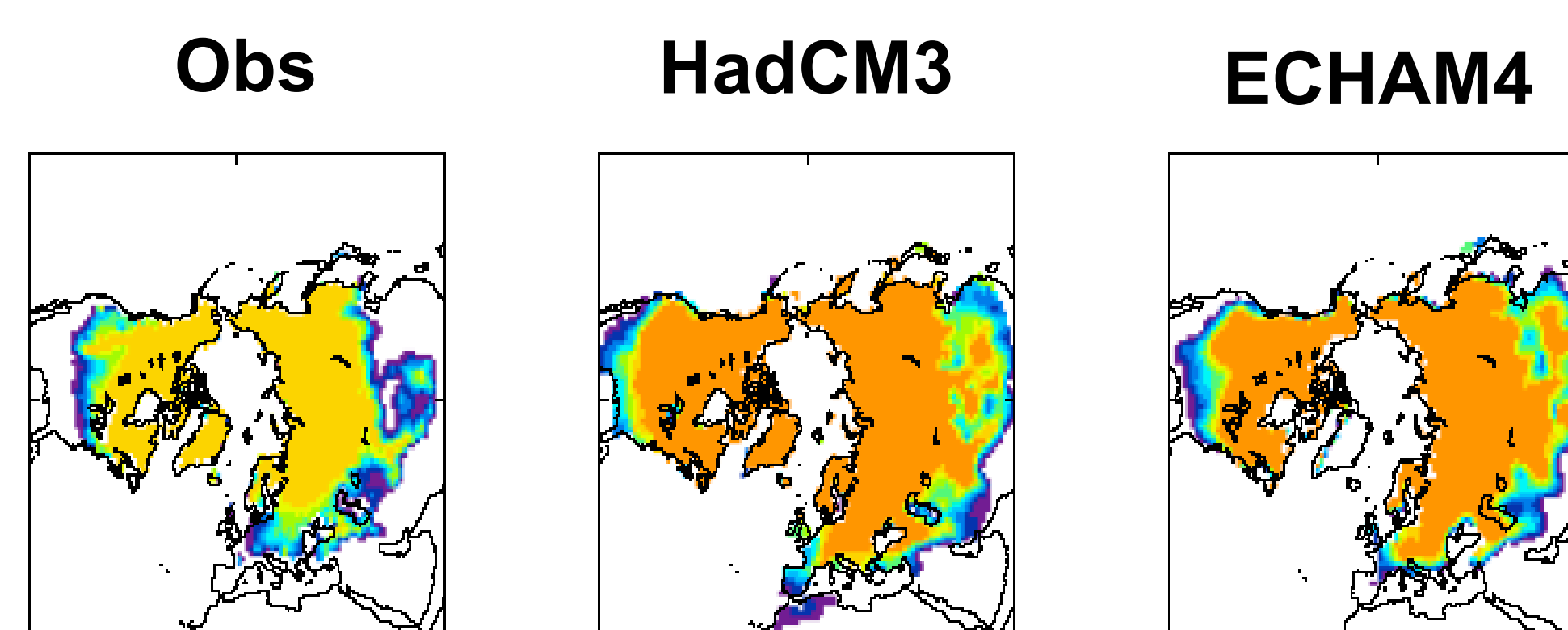
Eurasian Snow Index

	Obs	(p)	HadCM3	(p)	ECHAM4	(p)
JUN	-0.48	0.01	-0.06	0.56	0.03	0.75
JUL	-0.54	0.01	-0.01	0.92	-0.10	0.35
AUG	-0.26	0.17	0.16	0.12	-0.14	0.19
SEP	-0.22	0.36	-0.09	0.35	-0.12	0.25
OCT	-0.37	0.05	-0.17	0.10	-0.14	0.20
NOV	-0.13	0.51	-0.17	0.10	-0.11	0.26
DEC	-0.10	0.62	-0.20	0.04	-0.09	0.40

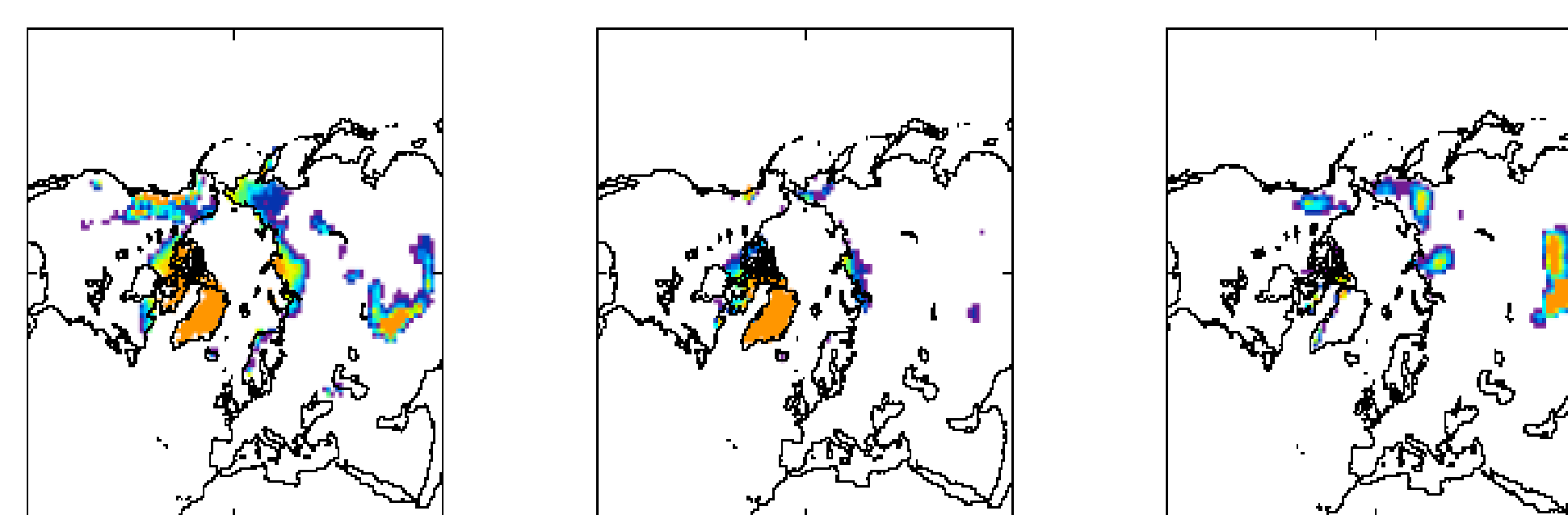
Correlation and significance: Linearly detrended snow indices and upcoming winter (DJF) NAO. Red values significant at 5% level with time series corrected for serial correlation.

SNOW DISTRIBUTION

WINTER (DJF)



SUMMER (JJ)

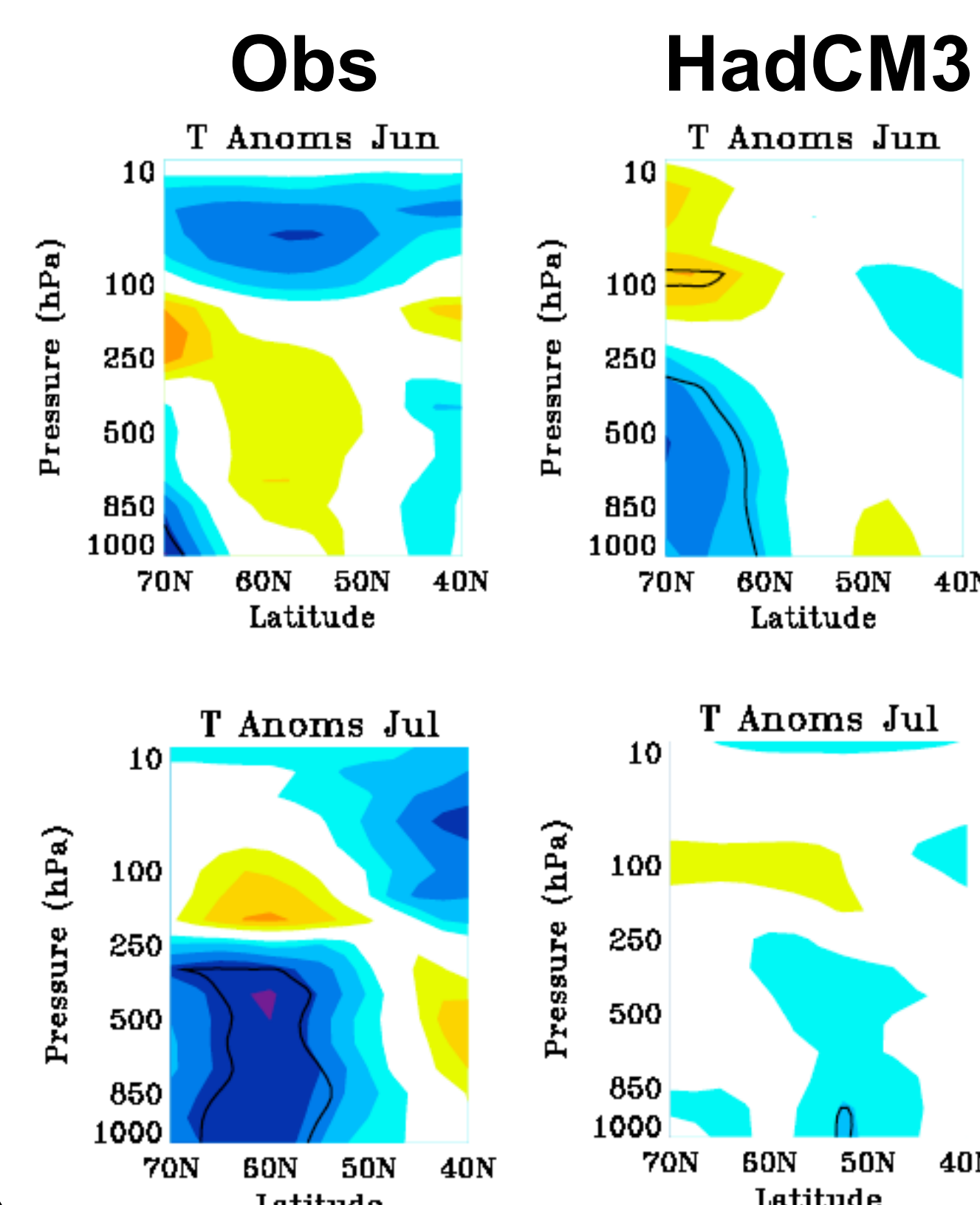


Mean seasonal snow covered fractional area

Both CGCMs exhibit greater than observed snow amounts in winter but less than observed amounts in summer. Largest differences occur over southern Eurasia and the Tibetan Plateau in winter and over North America during summer.

REGIONAL ATMOSPHERIC RESPONSE

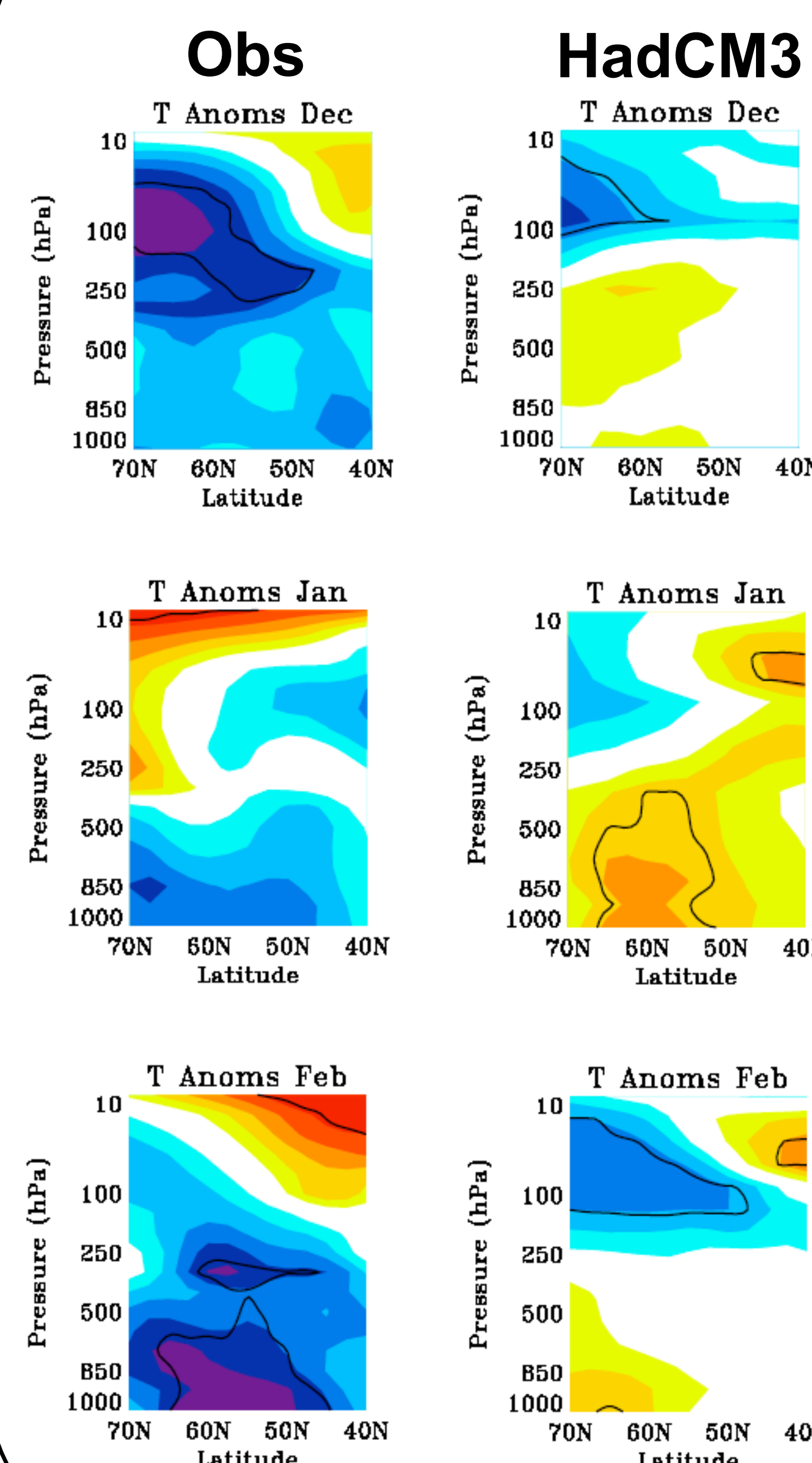
SUMMER



Composite: Shading is zonal mean temperature anomaly on pressure levels over Eurasia (25E-70E) for high minus low Eurasian snow cover. Contours show 5% significance level.

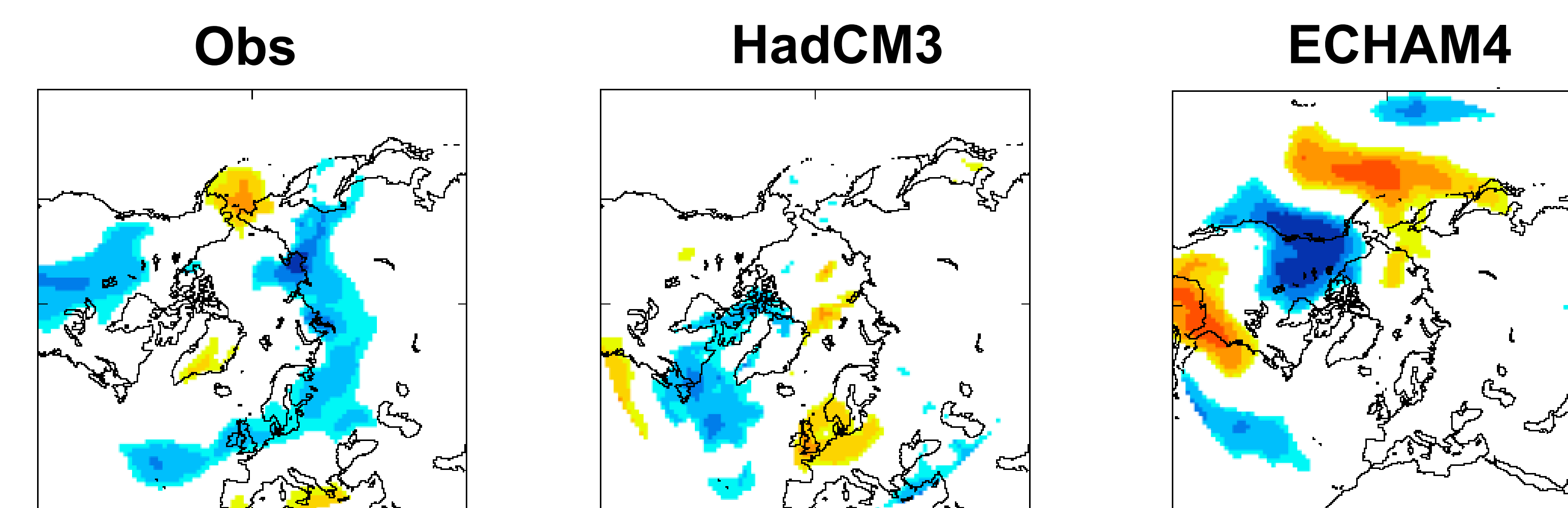
The atmospheric response over Eurasia to local snow cover variations in HadCM3 differs significantly to observations. Neither the observed tropospheric cooling or the stratospheric warming associated with increased Eurasian snow amounts are captured in the model. This suggests limitations in the snow-atmosphere coupling scheme in HadCM3.

WINTER

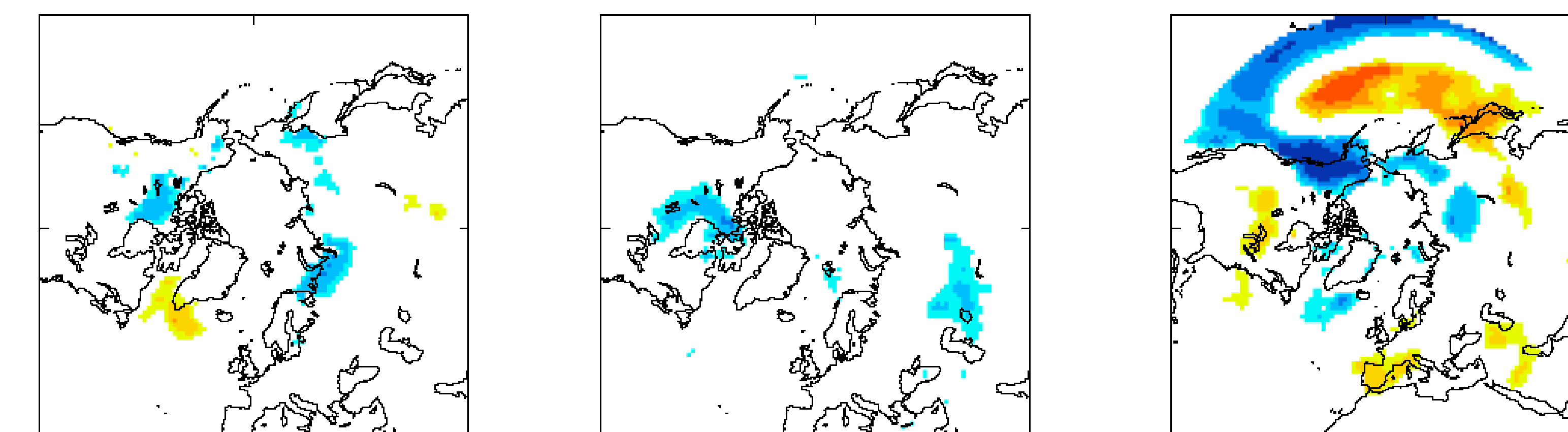


TELECONNECTED SURFACE RESPONSE

WINTER (DJF)



SUMMER (JJ)



Correlation significance: NH Snow Cover & 2m Air Temperature

Observations show that NH snow cover is significantly linked to 2m air temperature over Eurasia, North America and Greenland during both winter and summer. This zonal tripolar pattern in summer is the first stage in a proposed remote snow/NAO link involving several feedbacks (Saunders et. al, 2003). However, the contemporaneous relationship between snow and NH temperature is not captured in the two CGCMs.

REFERENCES

- Saunders, M. A., B. Qian, and B. Lloyd-Hughes, Summer snow extent heralding of the winter North Atlantic Oscillation, *Geophys. Res. Lett.*, 30(7), 1378, 2003.
- Saito, K., J. Cohen, and D. Entekhabi, Evolution of atmospheric response to early-season Eurasian snow cover anomalies, *Mon. Wea. Rev.*, 129, 2746-2760, 2001.