Mid-latitude cloud shifts, their primary link to the Hadley cell, & their diverse radiative effects

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[6]Lamont-Doherty Earth Observatory, Columbia University, Palisades, NY

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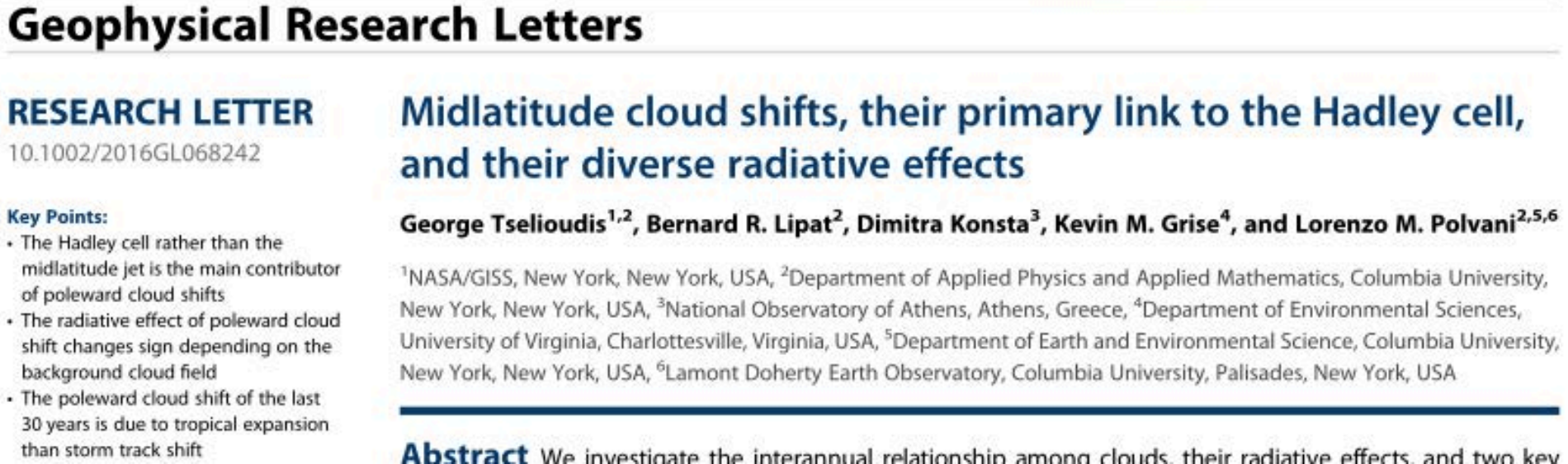

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Key Points:
- The Hadley cell rather than the midlatitude jet is the main contributor of poleward cloud shifts
- The radiative effect of poleward cloud shift changes sign depending on the background cloud field
- The poleward cloud shift of the last 30 years is due to tropical expansion than storm track shift

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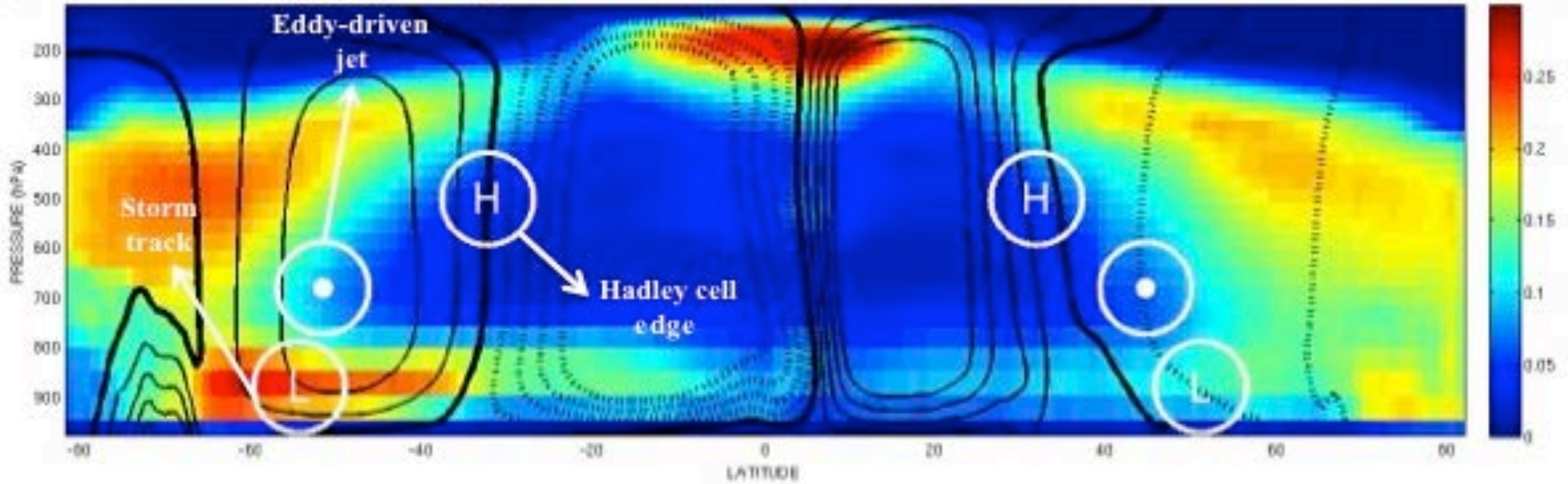
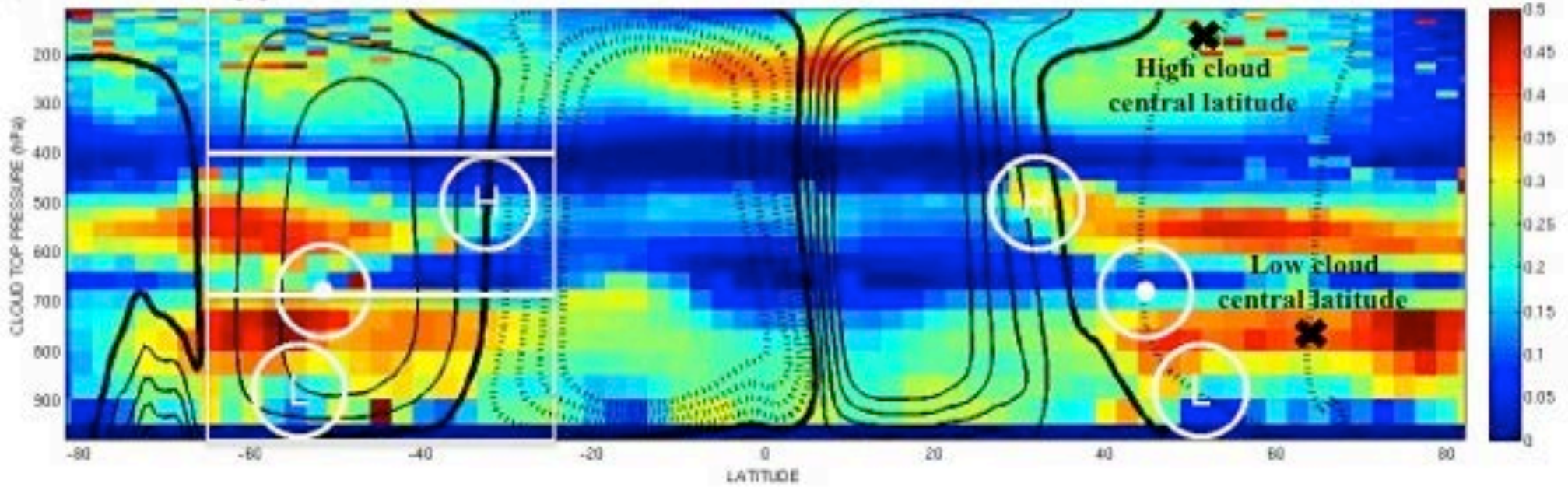
[1]NASA/GISS, New York, New York, USA, [2]Department of Applied Physics and Applied Mathematics, Columbia University, New York, New York, USA, [3]National Observatory of Athens, Athens, Greece, [4]Department of Environmental Sciences, University of Virginia, Charlottesville, Virginia, USA, [5]Department of Earth and Environmental Science, Columbia University, New York, New York, USA, [6]Lamont Doherty Earth Observatory, Columbia University, Palisades, New York, USA

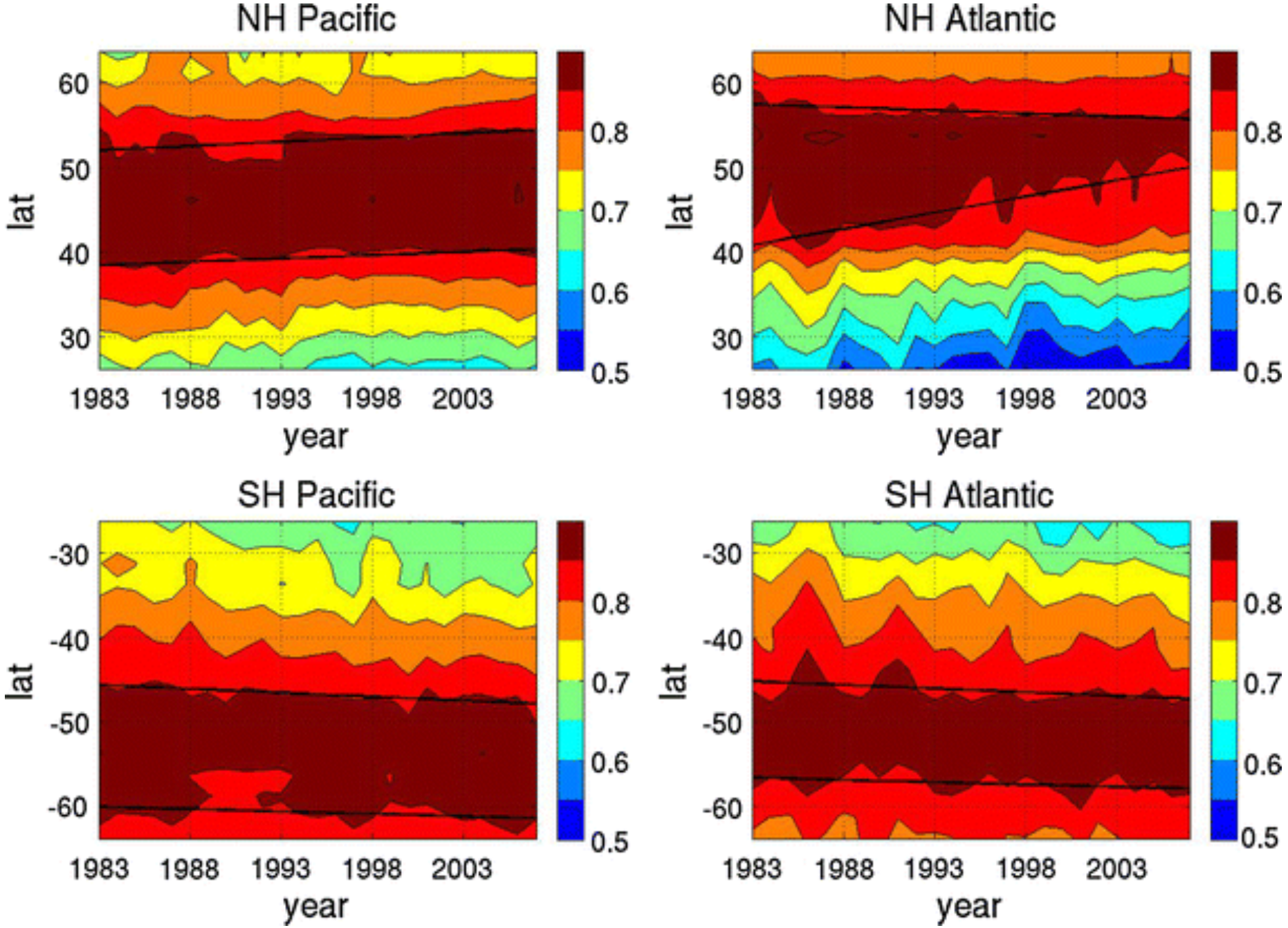
Abstract We investigate the interannual relationship among clouds, their radiative effects, and two key

a) CloudSat/CALIPSO cloud vertical profile

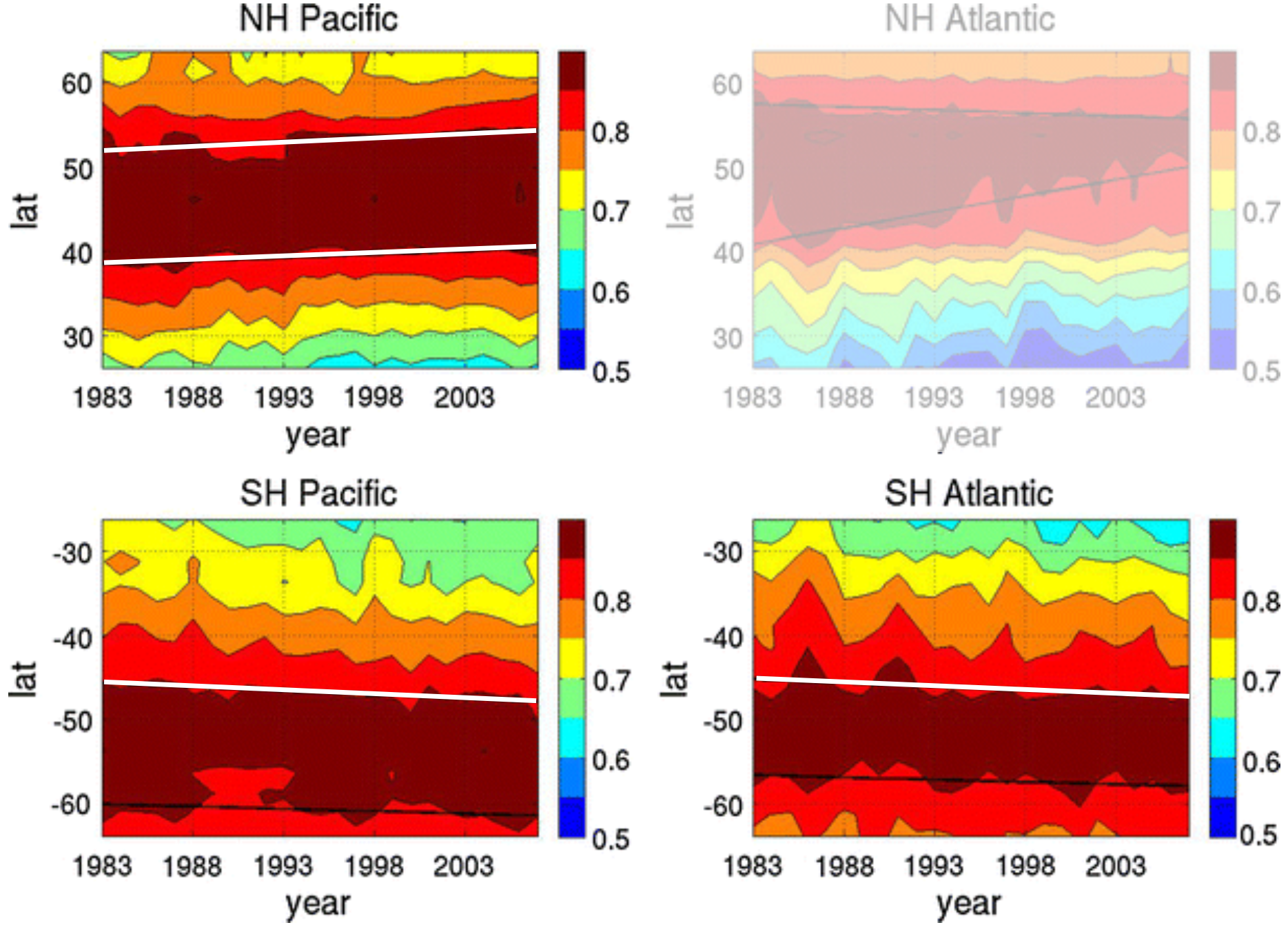


b) ISCCP cloud top profile





Bender et al. (2012) *Clim. Dyn.*



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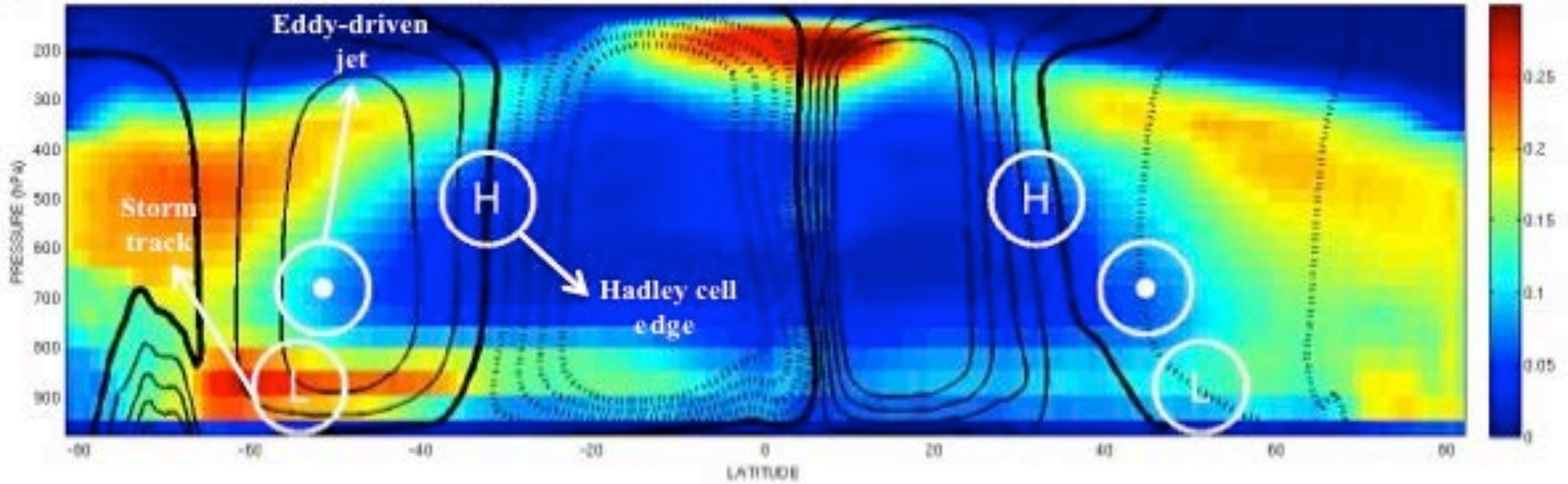

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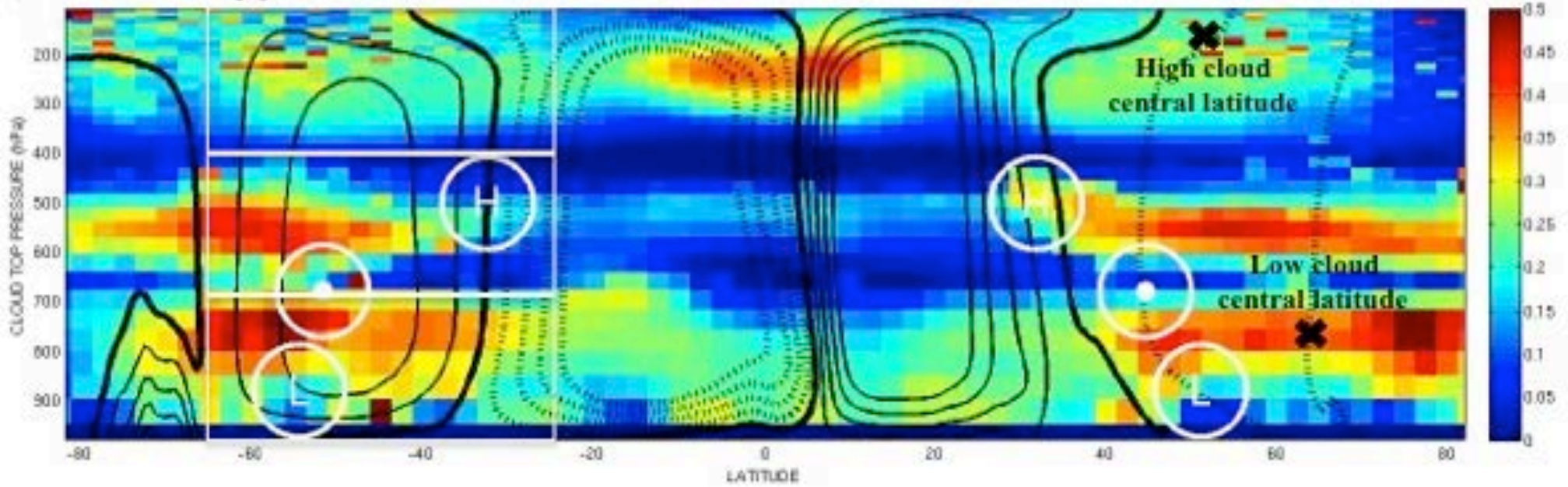


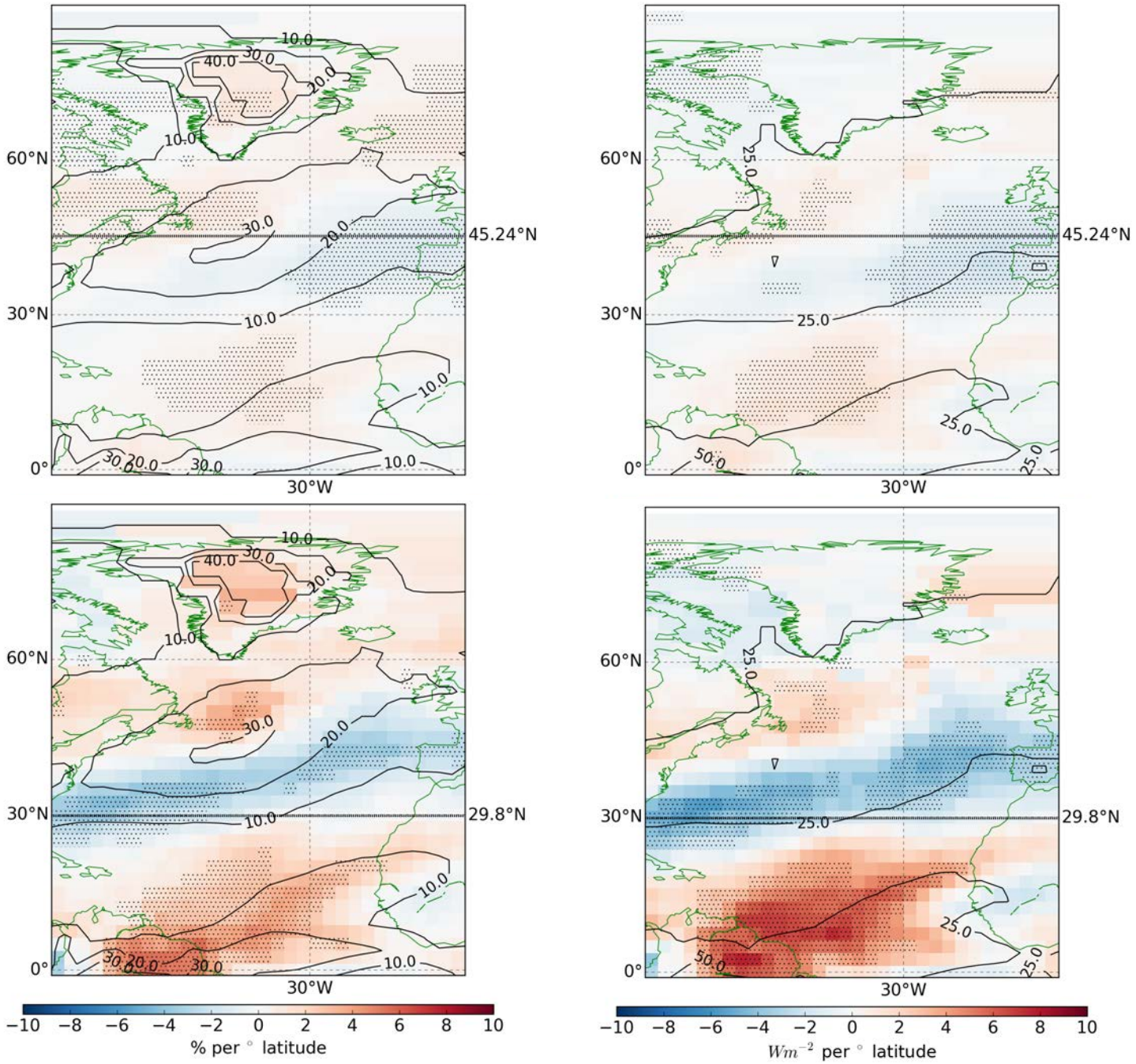
DJF NH Atlantic

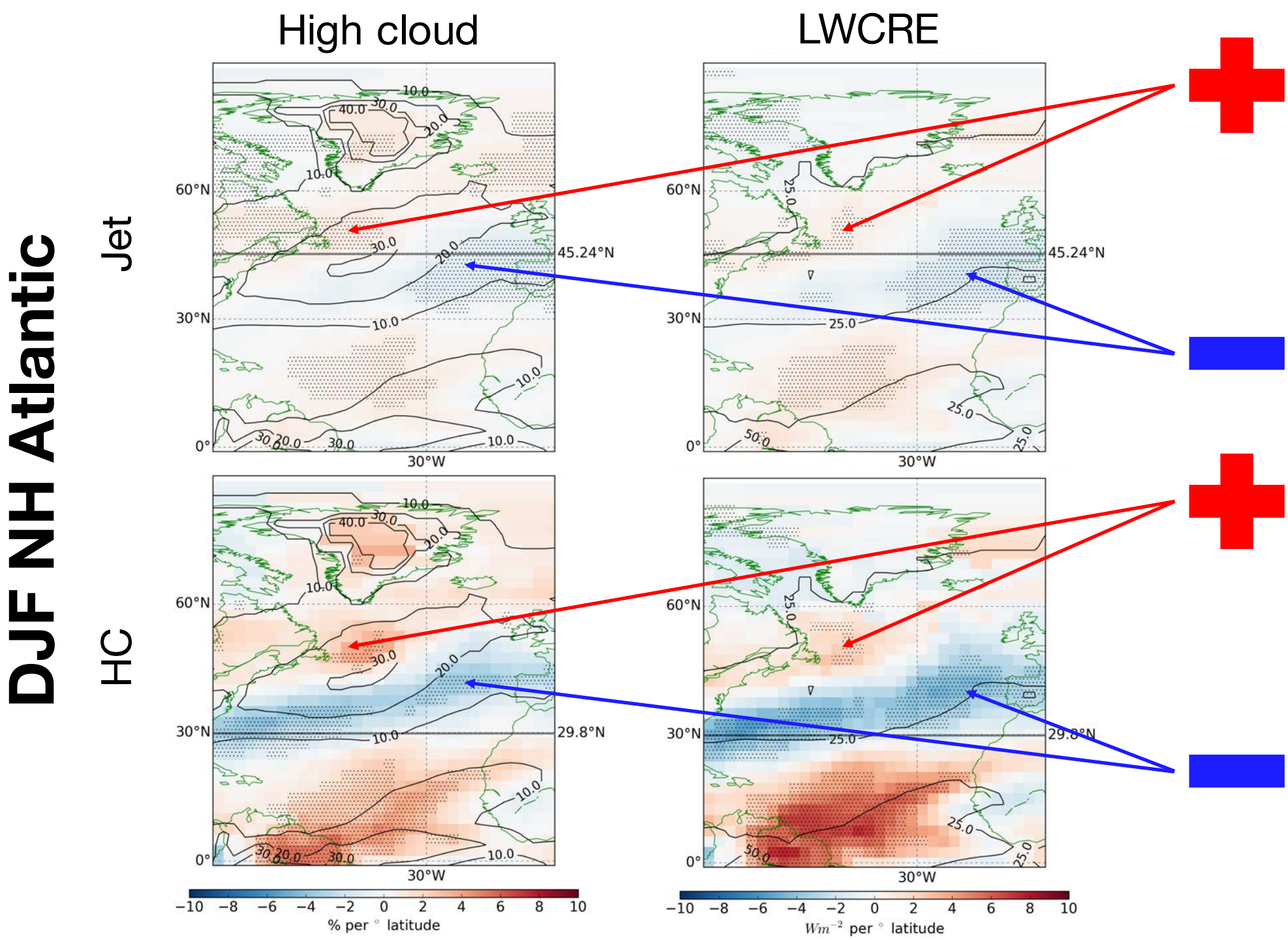
High cloud

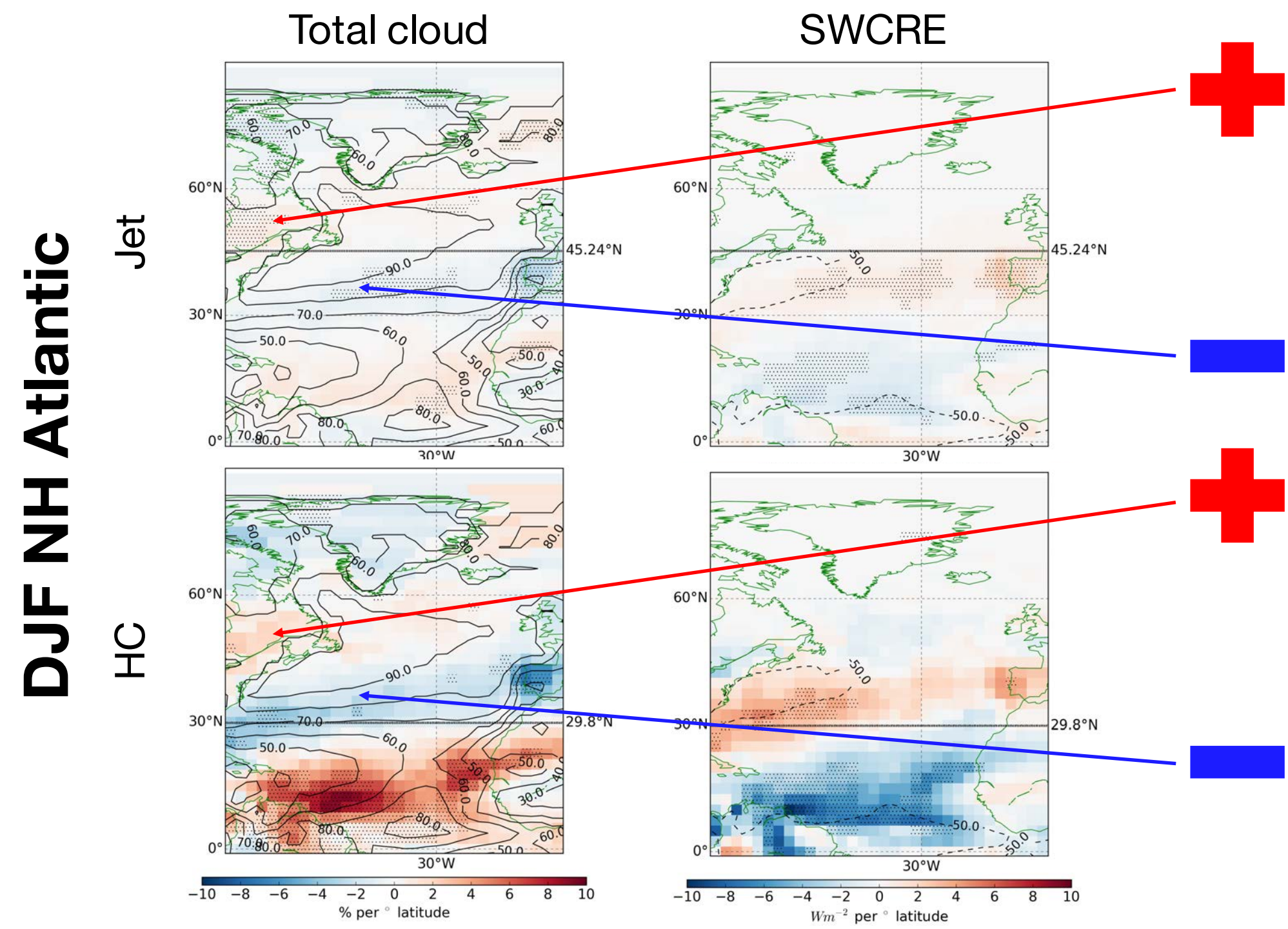
LWCRE

Jet

HC (Hadley cell)




DJF NH Atlantic
Jet
HC
High cloud
LWCRE
60°N
30°N
0°
30°W
45.24°N
29.8°N
% per ° latitude
Wm⁻² per ° latitude


DJF NH Atlantic
Jet
HC
Total cloud
SWCRE
60°N
30°N
0°
45.24°N
29.8°N
30°W
% per ° latitude
Wm^{-2} per ° latitude

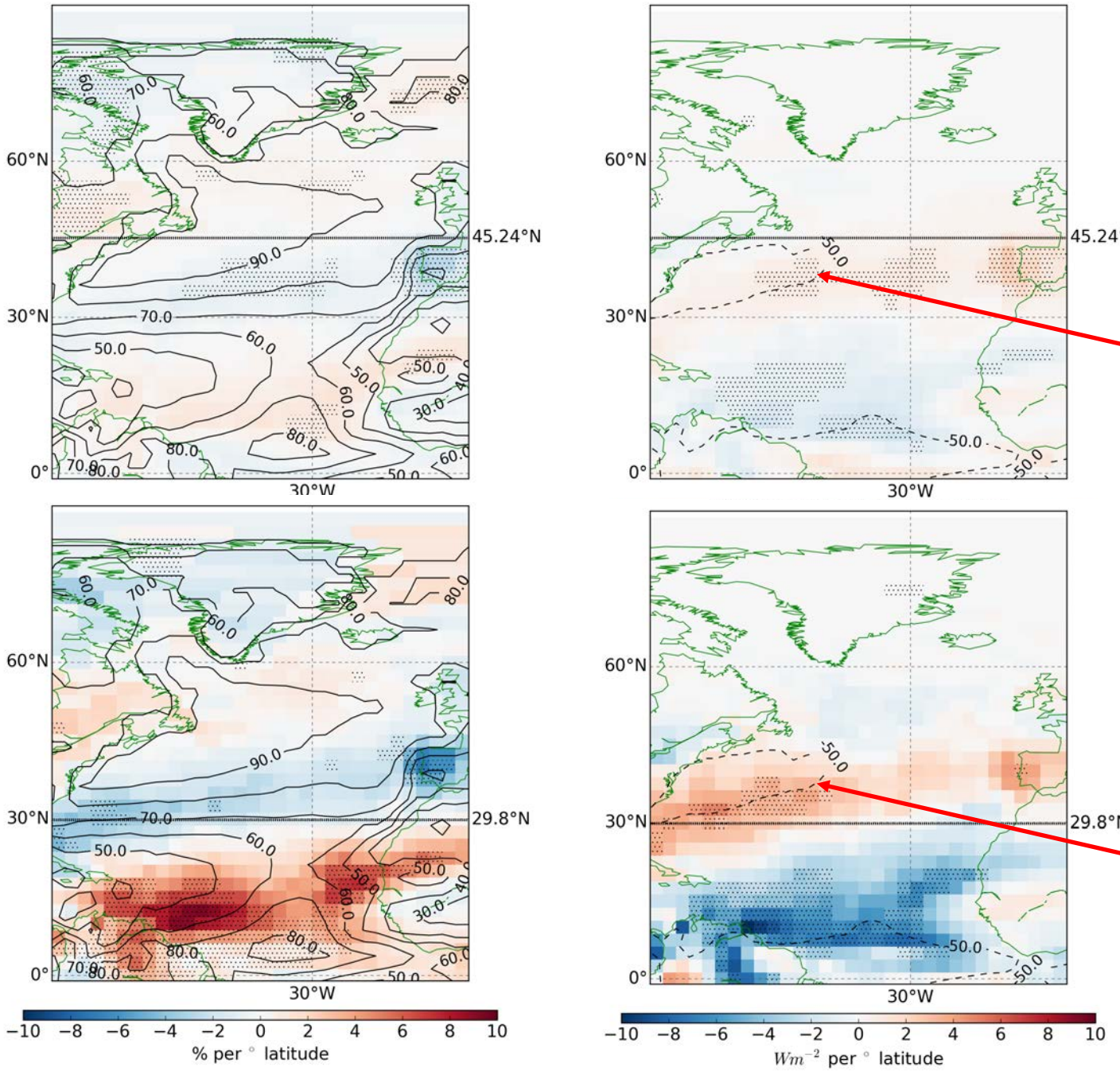
DJF NH Atlantic

Total cloud

SWCRE

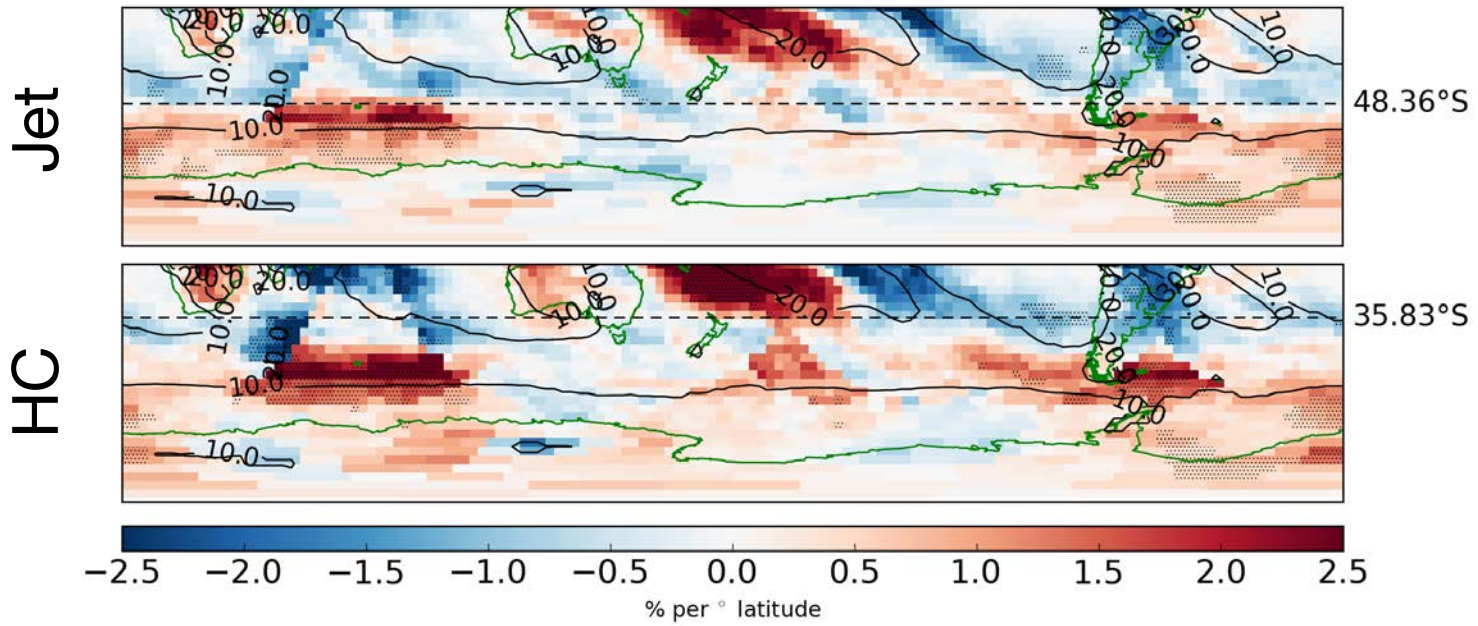
Jet

HC

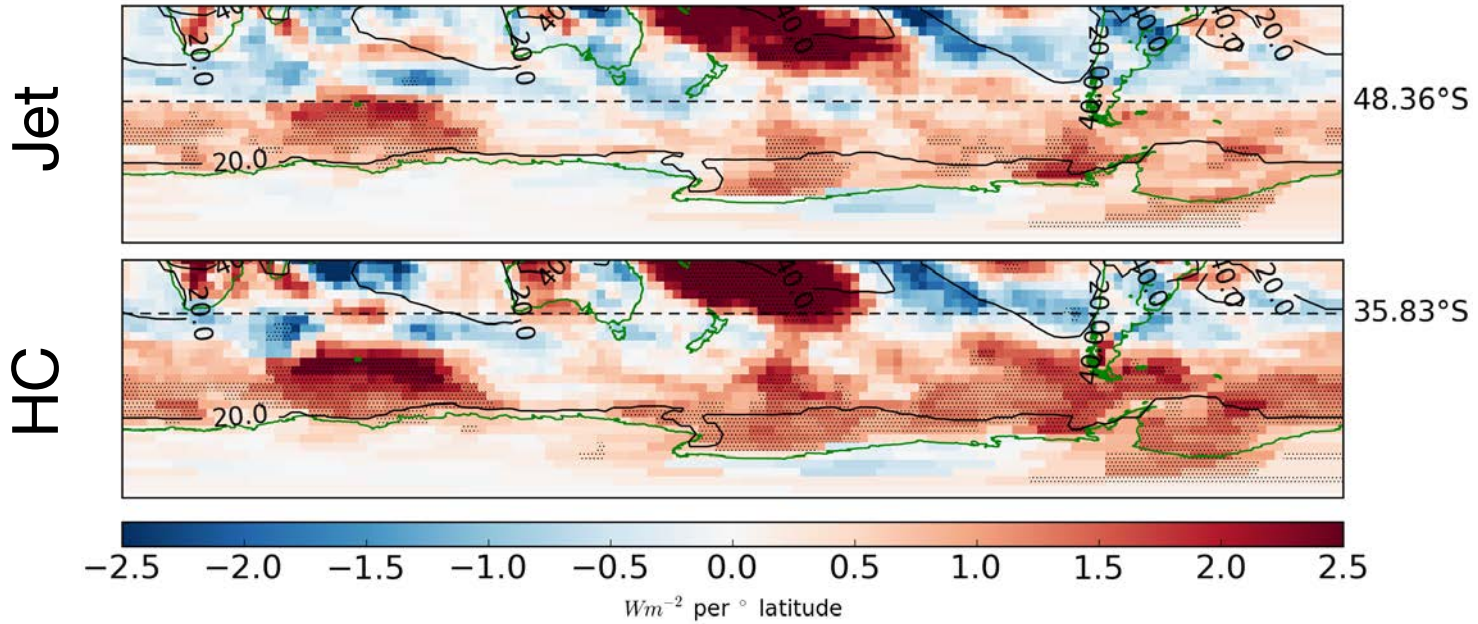


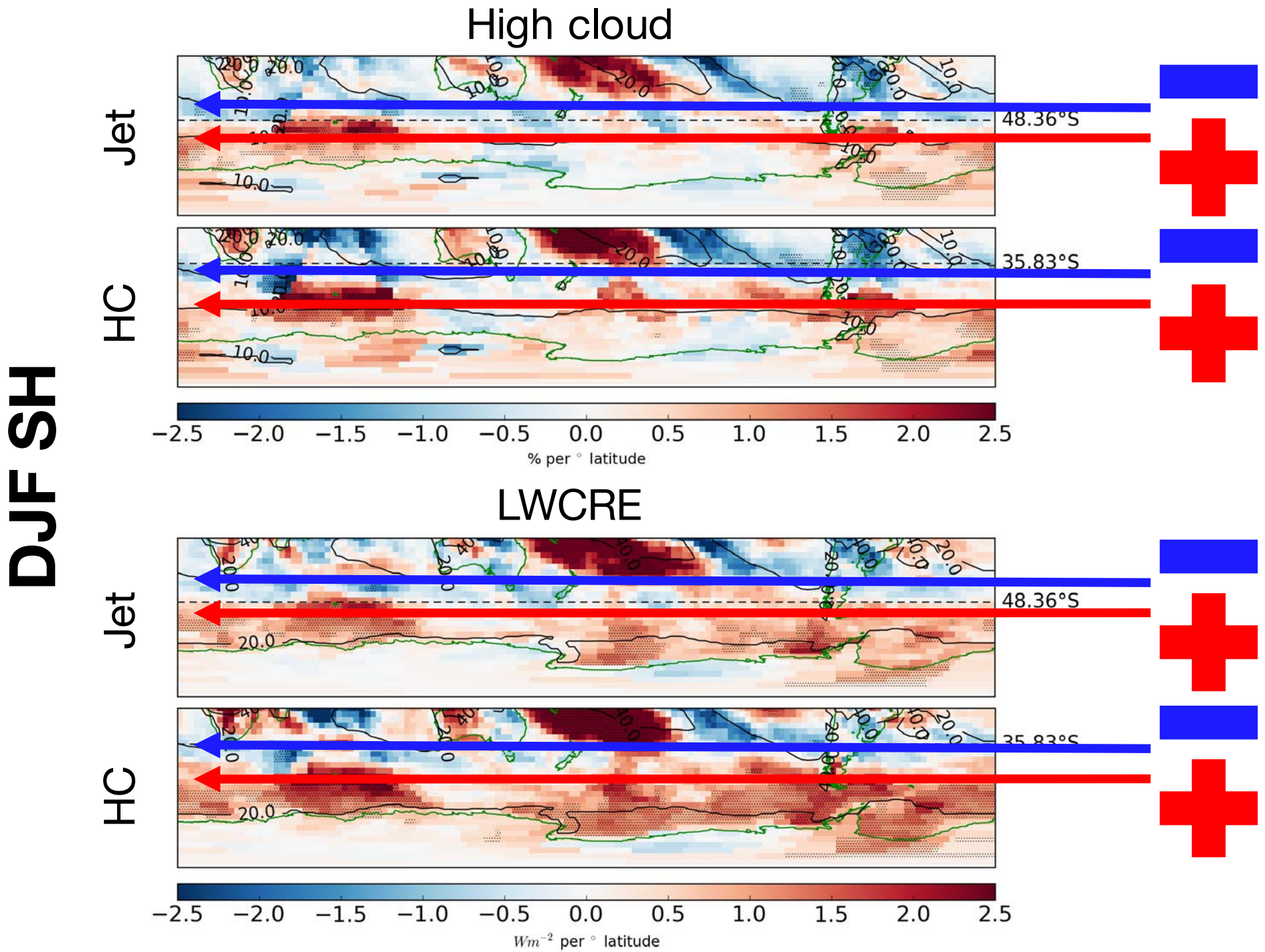
DJF SH

High cloud



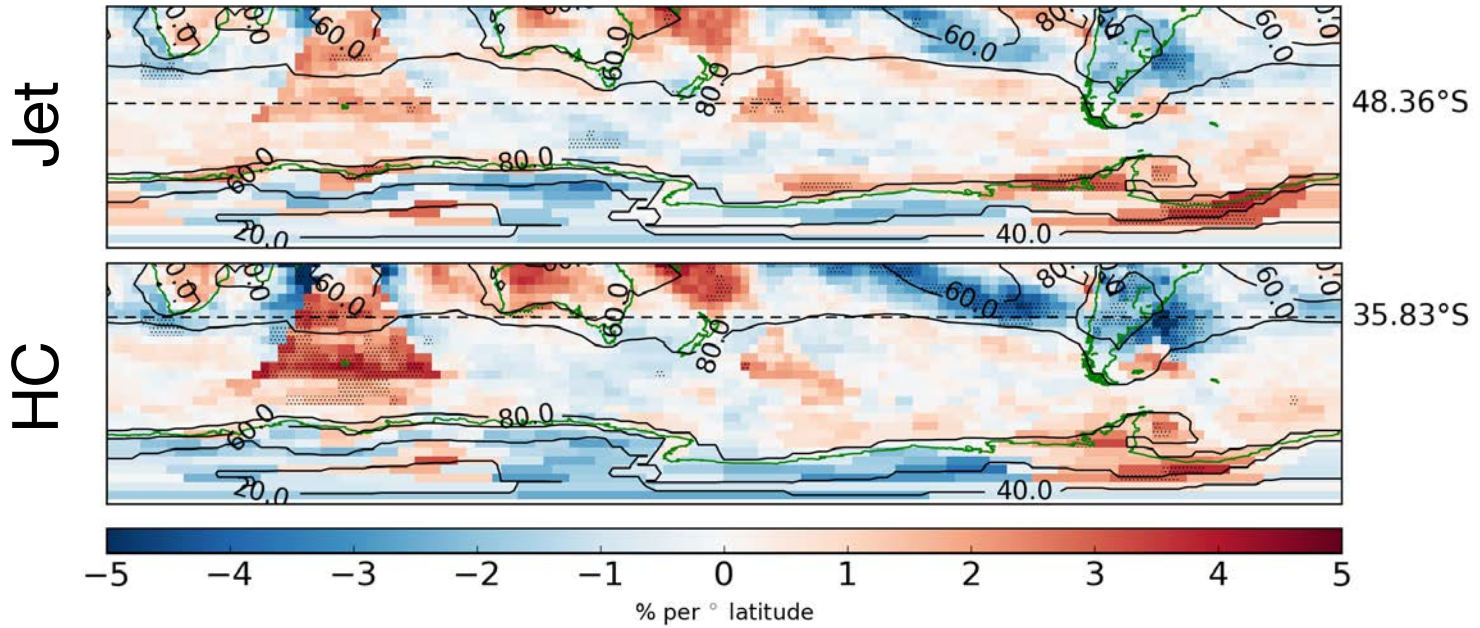
LWCRE



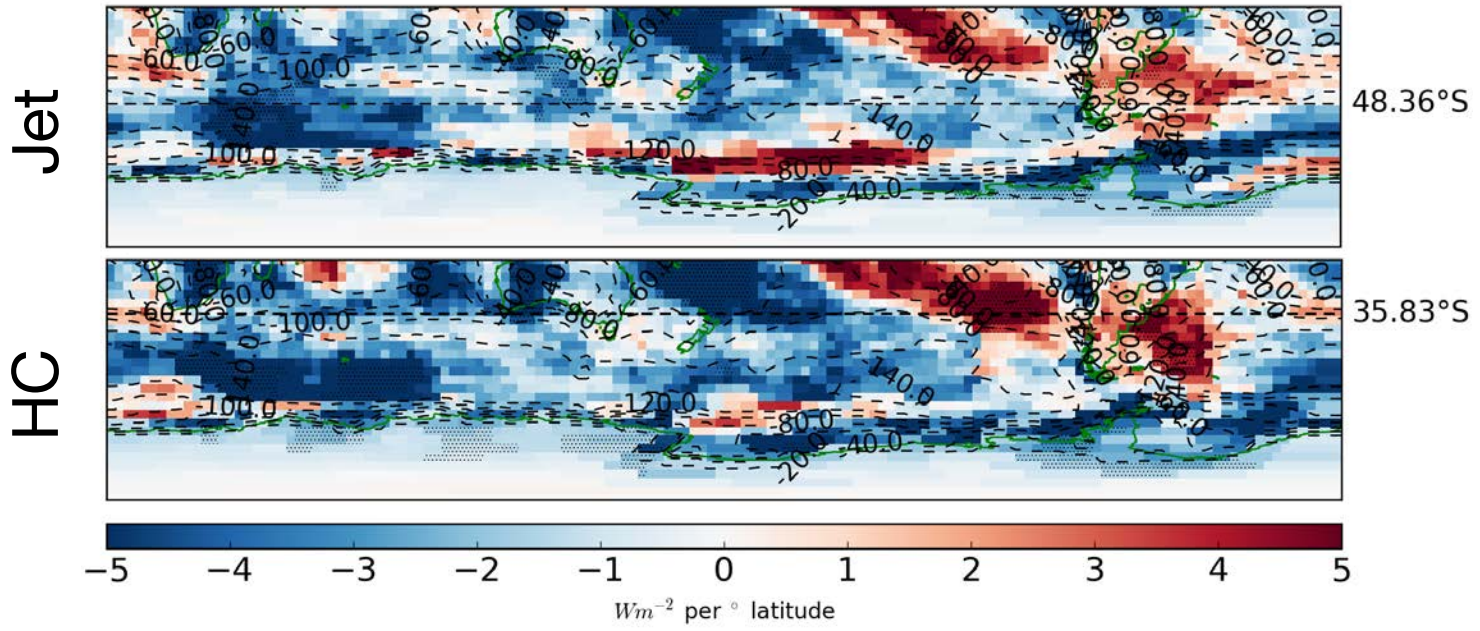

DJF SH
High cloud
Jet
HC
48.36°S
35.83°S
−2.5 −2.0 −1.5 −1.0 −0.5 0.0 0.5 1.0 1.5 2.0 2.5
% per ° latitude
LWCRE
Jet
HC
48.36°S
35.83°S
−2.5 −2.0 −1.5 −1.0 −0.5 0.0 0.5 1.0 1.5 2.0 2.5
Wm^{-2} per ° latitude

DJF SH

Total cloud



SWCRE



		SH				**NH Atlantic**				**NH Pacific**			
DJF		Hadley (deg)	***m*=0.54** ***R*=0.58**		Jet (deg)	Hadley (deg)	***m*=0.15** ***R*=0.57**		Jet (deg)	Hadley (deg)	*m*=0.10 *R*=-0.29		Jet (deg)
		m	*R*	*m*	*R*	*m*	*R*	*m*	*R*	*m*	*R*	*m*	*R*
	Total (deg)	0.04	0.29	0.01	0.06	0.11	0.37	**0.04**	**0.52**	0.00	0.01	-0.02	-0.35
	High (deg)	**0.26**	**0.47**	0.12	0.22	**0.65**	**0.65**	**0.14**	**0.56**	0.09	0.10	-0.03	-0.08
	Low (deg)	**-0.15**	**0.44**	-0.08	-0.25	-0.17	-0.36	-0.04	-0.31	-0.05	-0.12	-0.04	-0.24
	SWCRE (Wm^{-2})	**-1.11**	**0.43**	**-0.98**	**-0.40**	**0.55**	**0.39**	**0.21**	**0.58**	-0.15	-0.10	-0.06	-0.11
	LWCRE (Wm^{-2})	0.22	0.36	0.17	0.20	**0.94**	**-0.54**	**0.22**	**0.50**	0.29	0.21	-0.02	-0.03
JJA		Hadley (deg)	*m*=0.15 *R*=0.17		Jet (deg)	Hadley (deg)	*m*=0.37 *R*=0.31		Jet (deg)	Hadley (deg)	*m*=0.33 *R*=0.39		Jet (deg)
		m	*R*	*m*	*R*	*m*	*R*	*m*	*R*	*m*	*R*	*m*	*R*
	Total (deg)	0.07	0.24	-0.02	-0.01	0.05	0.29	-0.01	-0.08	0.03	0.34	0.02	0.22
	High (deg)	**0.47**	**0.49**	0.04	0.06	**0.12**	**0.52**	-0.04	0.13	**0.09**	**0.40**	0.05	0.25
	Low (deg)	**-0.45**	**0.63**	-0.12	-0.27	-0.02	-0.10	-0.04	-0.15	-0.04	0.28	0.02	0.15
	SWCRE (Wm^{-2})	**-0.47**	**-0.41**	-0.16	-0.23	-0.02	-0.02	0.3	0.31	-0.16	-0.12	0.41	0.35
	LWCRE (Wm^{-2})	0.28	0.19	0.15	0.16	-0.02	-0.05	-0.13	-0.33	0.06	0.14	0.35	-0.37

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	SWCRE (Wm^{-2})	**-0.47**	**-0.41**	-0.16	-0.23	-0.02	-0.02	0.3	0.31	-0.16	-0.12	0.41	0.35
	LWCRE (Wm^{-2})	0.28	0.19	0.15	0.16	-0.02	-0.05	-0.13	-0.33	0.06	0.14	0.35	-0.37

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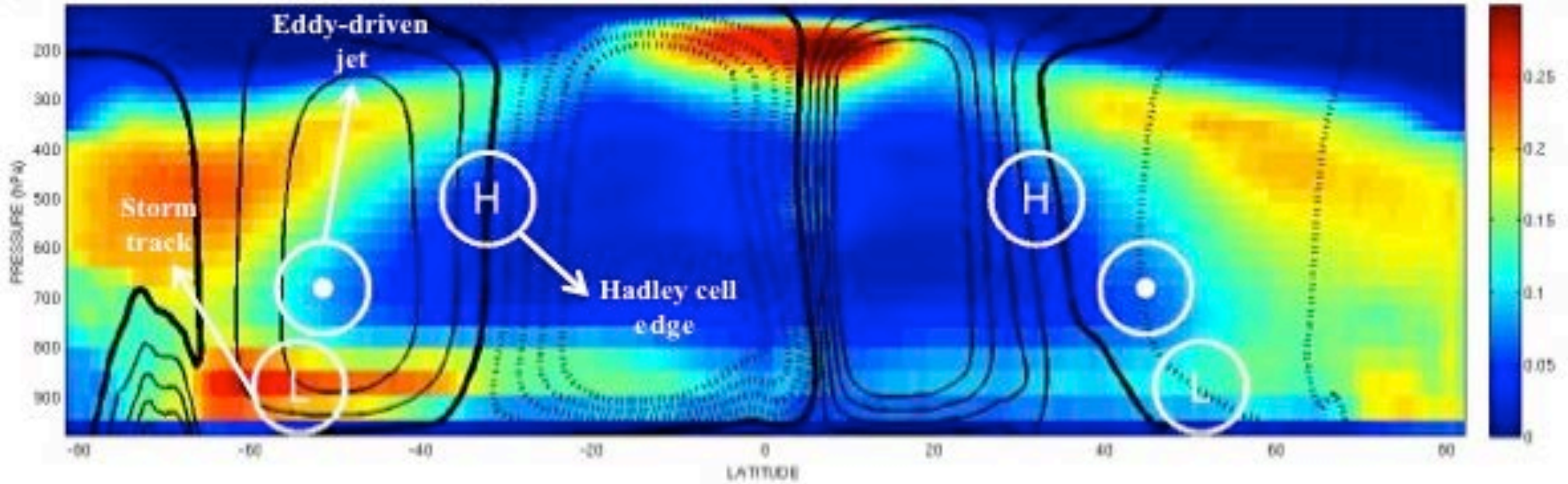
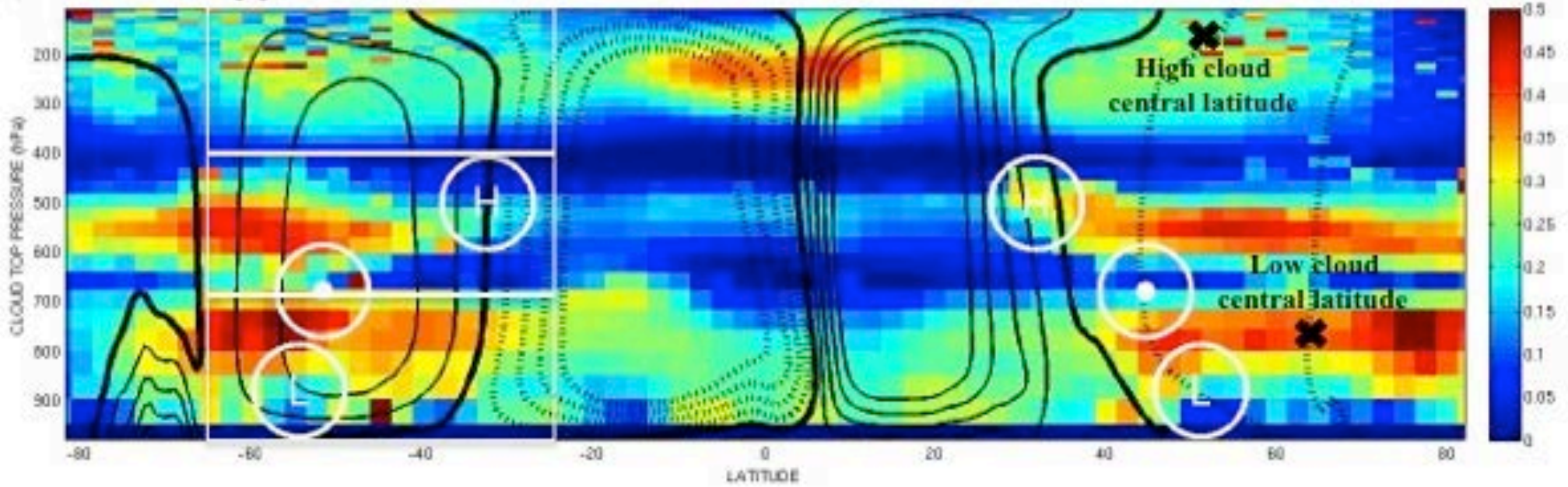
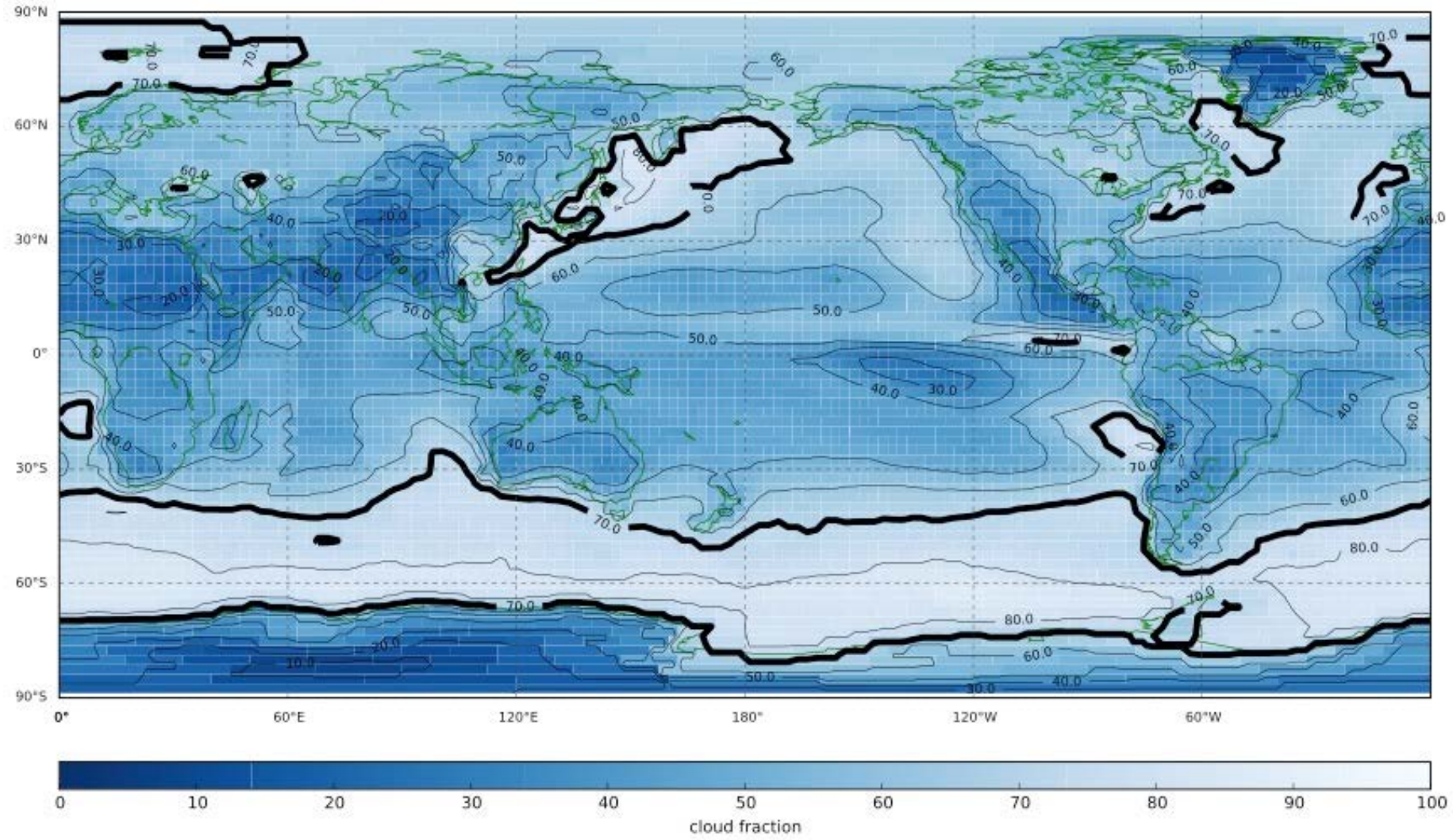


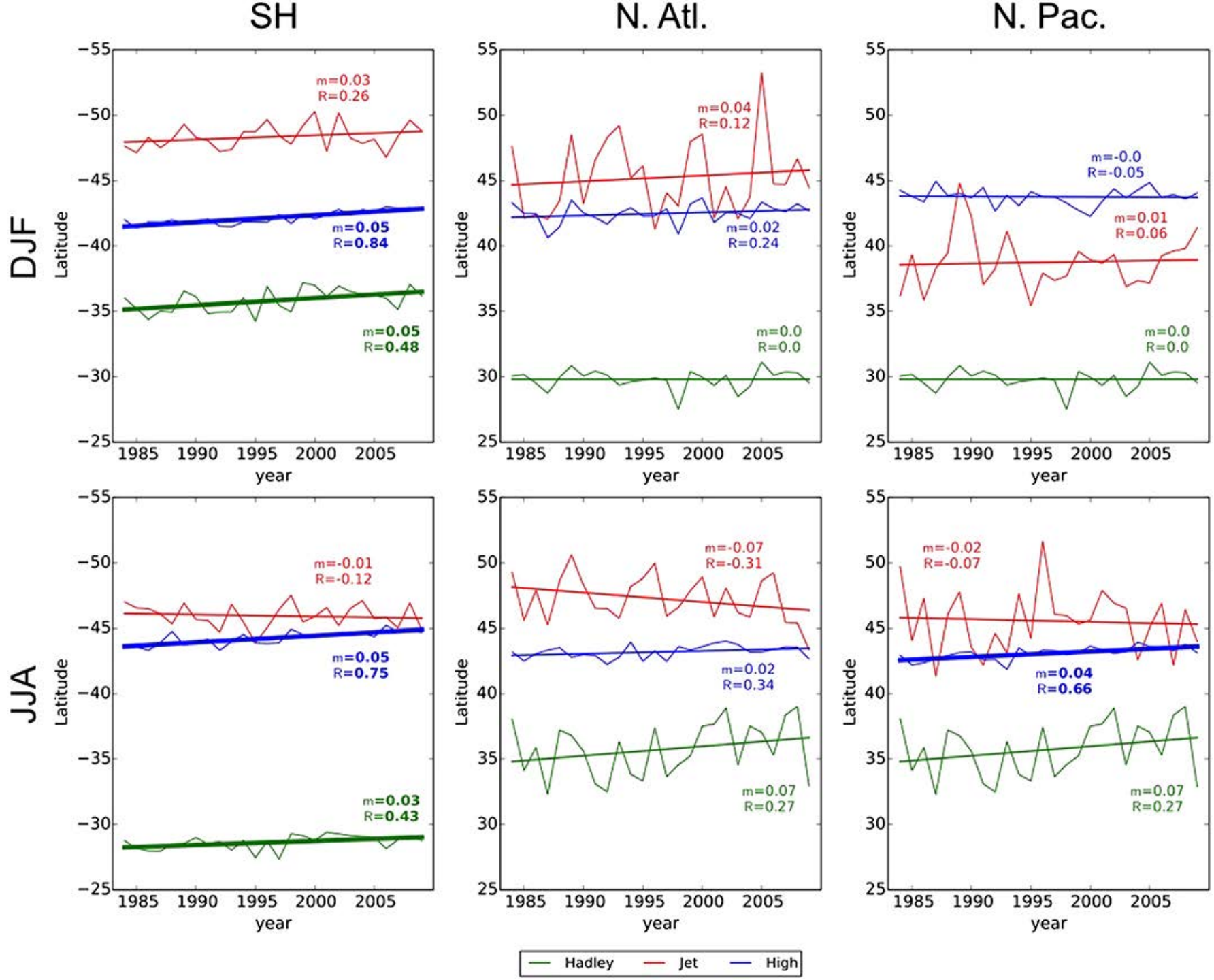
b) ISCCP cloud top profile



DJF

low+middle cloud




SH
N. Atl.
N. Pac.
DJF
JJA
Latitude
year
m=0.03
R=0.26
m=0.05
R=0.84
m=0.05
R=0.48
m=0.04
R=0.12
m=0.02
R=0.24
m=0.0
R=0.0
m=-0.0
R=-0.05
m=0.01
R=0.06
m=0.0
R=0.0
m=-0.01
R=-0.12
m=0.05
R=0.75
m=0.03
R=0.43
m=-0.07
R=-0.31
m=0.02
R=0.34
m=0.07
R=0.27
m=-0.02
R=-0.07
m=0.04
R=0.66
m=0.07
R=0.27
Hadley
Jet
High

Conclusions

HC v. Jet:

- HC shifts correlate with high cloud shifts in many regions and seasons.
- Jet shifts correlate with high cloud shifts only in DJF NH Atlantic

NH v SH:

- Poleward shifts associated with SW radiative warming in DJF NH Atlantic but SW radiative cooling in SH

Bender et al. (2012) *Clim. Dyn.*:

- Observed poleward high cloud shifts more likely related to poleward HC than jet shifts