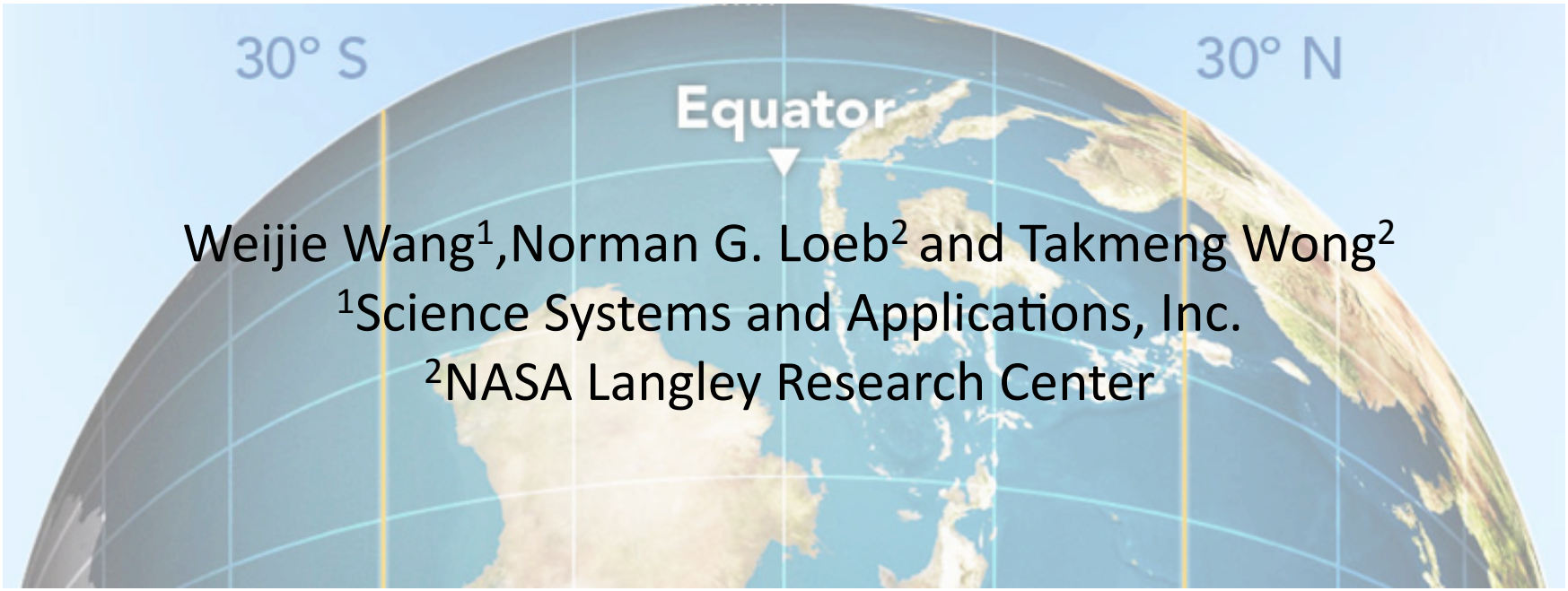
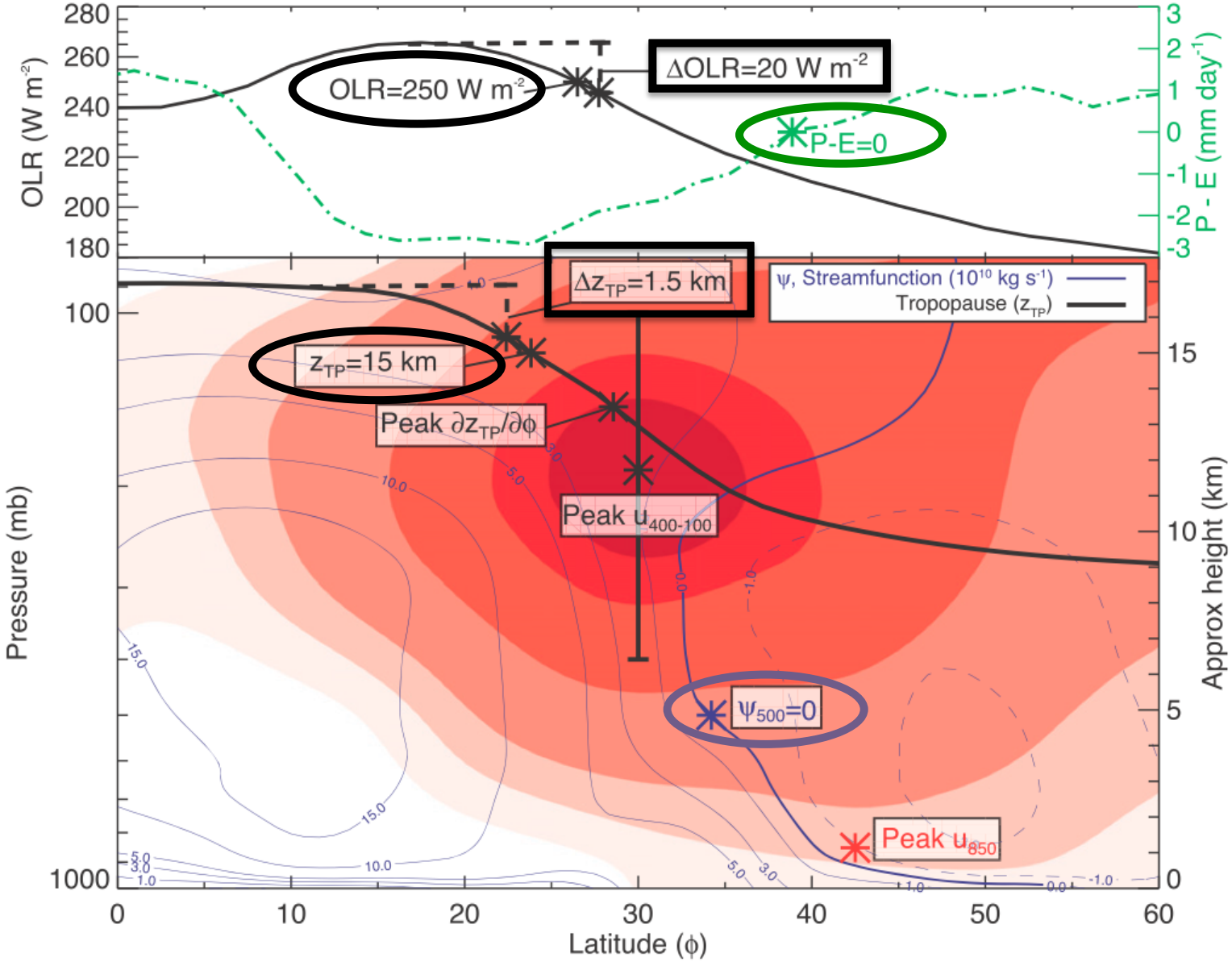
Hadley circulation variability inferred from longwave cloud radiative effect



Weijie Wang[1],Norman G. Loeb[2] and Takmeng Wong[2]
[1]Science Systems and Applications, Inc.
[2]NASA Langley Research Center

CERES Science Team Meeting, May 7-9, 2013, Hampton, VA

Tropical edge definitions



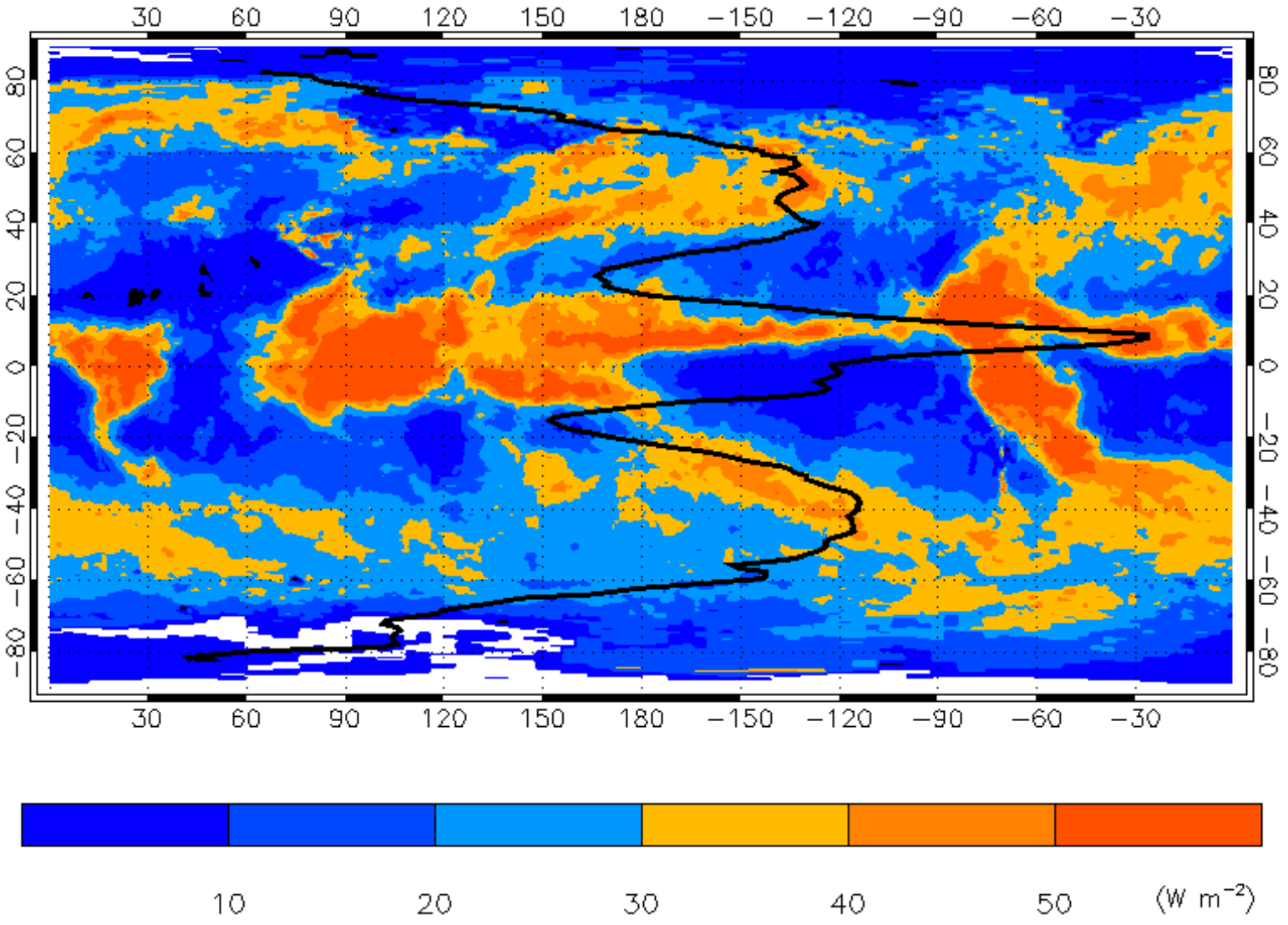
Davis and Rosenlof (2012)

Global tropical width trends from 1979-2009

	$z_{TP} = 15$ km	$\Delta z_{TP} = 1.5$ km	Mean $\partial z_{TP}/\partial\phi$	$\psi_{500} = 0$	$P - E = 0$	OLR = 250 W m^{-2}	ΔOLR = 20 W m^{-2}	Mean wind$_{400-100}$	Mean u_{850}
NCEP	0.31	−0.16	−0.18	**0.96**	0.15			0.14	0.29
	(0.34)	(0.44)	(0.25)	**(0.61)**	(0.59)			(0.16)	(0.53)
CFSR	**1.4**	**0.65**	**0.78**	0.25	0.24			0.097	0.19
	(0.48)	**(0.41)**	**(0.34)**	(0.54)	(0.65)			(0.15)	(0.5)
ERA-40[b]	0.76	0.48	0.19	0.35	−0.25			0.22	0.59
	(0.95)	(0.66)	(0.69)	(1.2)	(1.4)			(0.26)	(0.95)
ERA-I[c]	−0.23	−0.48	−0.13	0.98	**1.4**			−0.03	−0.34
	(1.2)	(1.2)	(0.73)	(1.7)	**(1.2)**			(0.29)	(0.96)
JRA	0.29	0.038	0.062	**1.5**	1.9			0.1	0.34
	(0.53)	(0.42)	(0.27)	**(1)**	(2.1)			(0.12)	(0.62)
MERRA	**0.56**	0.33	0.29	**1.2**	**−0.52**			0.11	0.19
	(0.33)	(0.35)	(0.36)	**(0.81)**	**(0.48)**			(0.16)	(0.5)
NCEP						**1.1**	0.39		
						(0.99)	(0.67)		
HIRS[d]						**1.9**	0.83		
						(1.8)	(0.95)		
GEWEX[e]						**0.92**	0.51		
						(0.63)	(1.5)		
ISCCP[e]						**1.6**	−0.29		
						(1.3)	(1.5)		

Davis and Rosenlof (2012)

CERES Longwave cloud radiative effect at TOA in Oct 2005

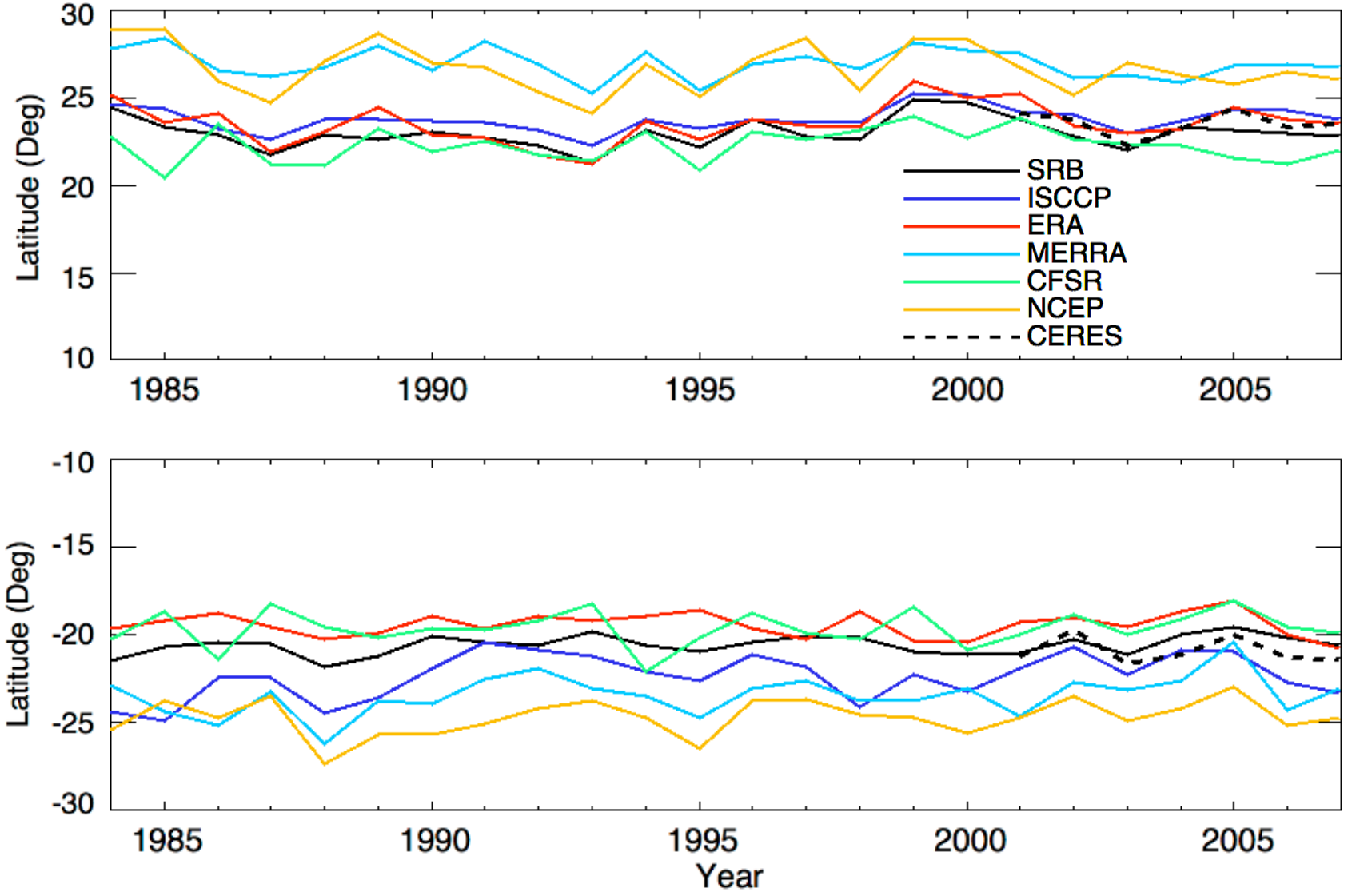


Data

Data	Time frequency	Variable	Resolution	Time period
GEWEX SRB	Monthly mean	Longwave all sky & longwave clear sky at TOA	360 × 180	1984-2007
ISCCP			144 × 72	
ERA-Interim			240 × 121	
MERRA			560 × 361	
NCEP CFSR			720 × 360	
NCEP NCAR			192 × 94	
CERES-EBAF TOA			360 × 180	2001-2007

GEWEX SRB: Global Energy and Water Cycle Experiment Surface Radiation Budget
ISCCP: International Satellite Cloud Climatology Project
ERA-Interim: ECWMF Interim Reanalysis
MERRA: Modern-Era Retrospective Analysis for Research and Applications
CFSR: Climate Forecast System Reanalysis
CERES-EBAF: CERES Energy Balanced and Filled

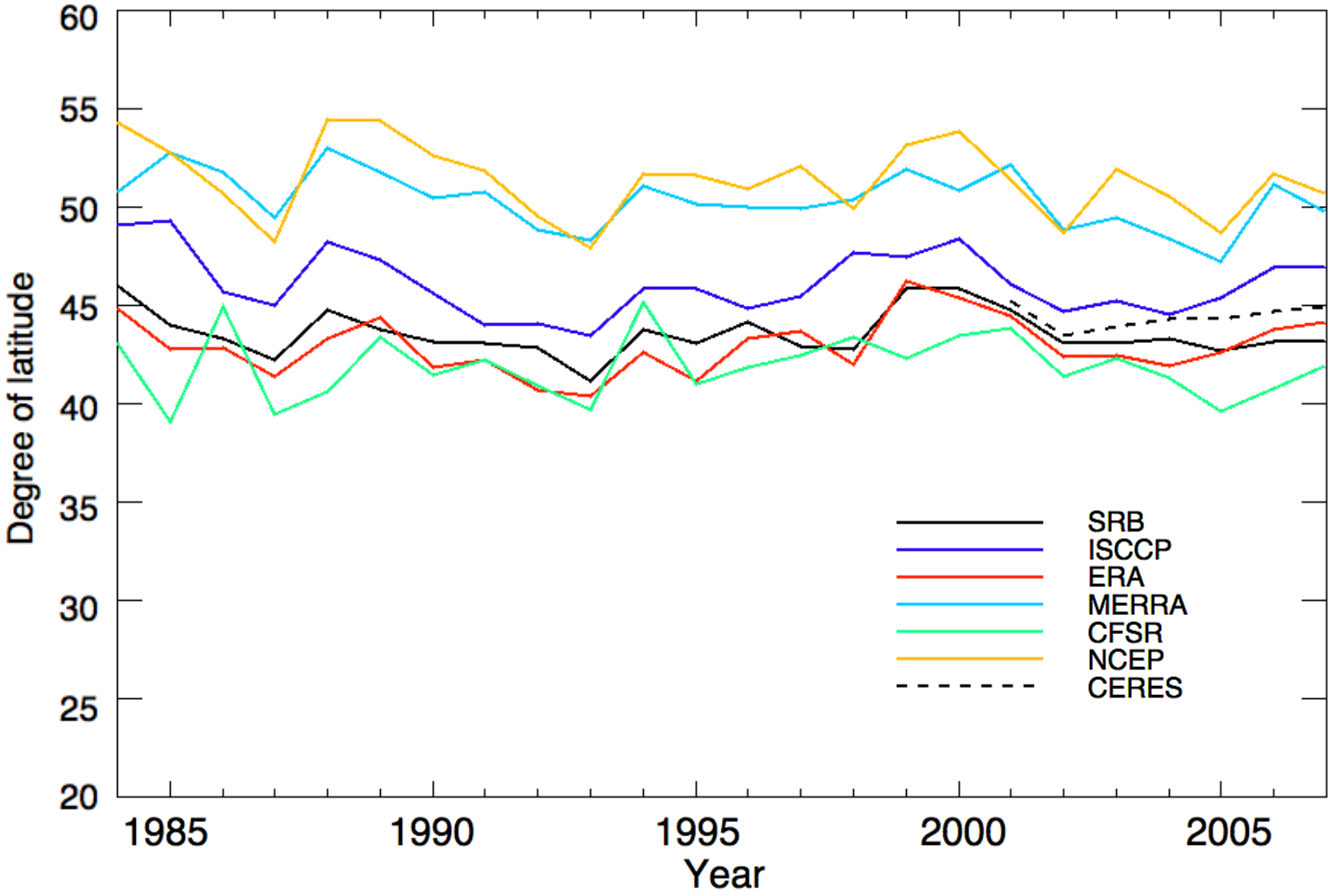
Time series of the annual mean positions of the minimum LW CRE



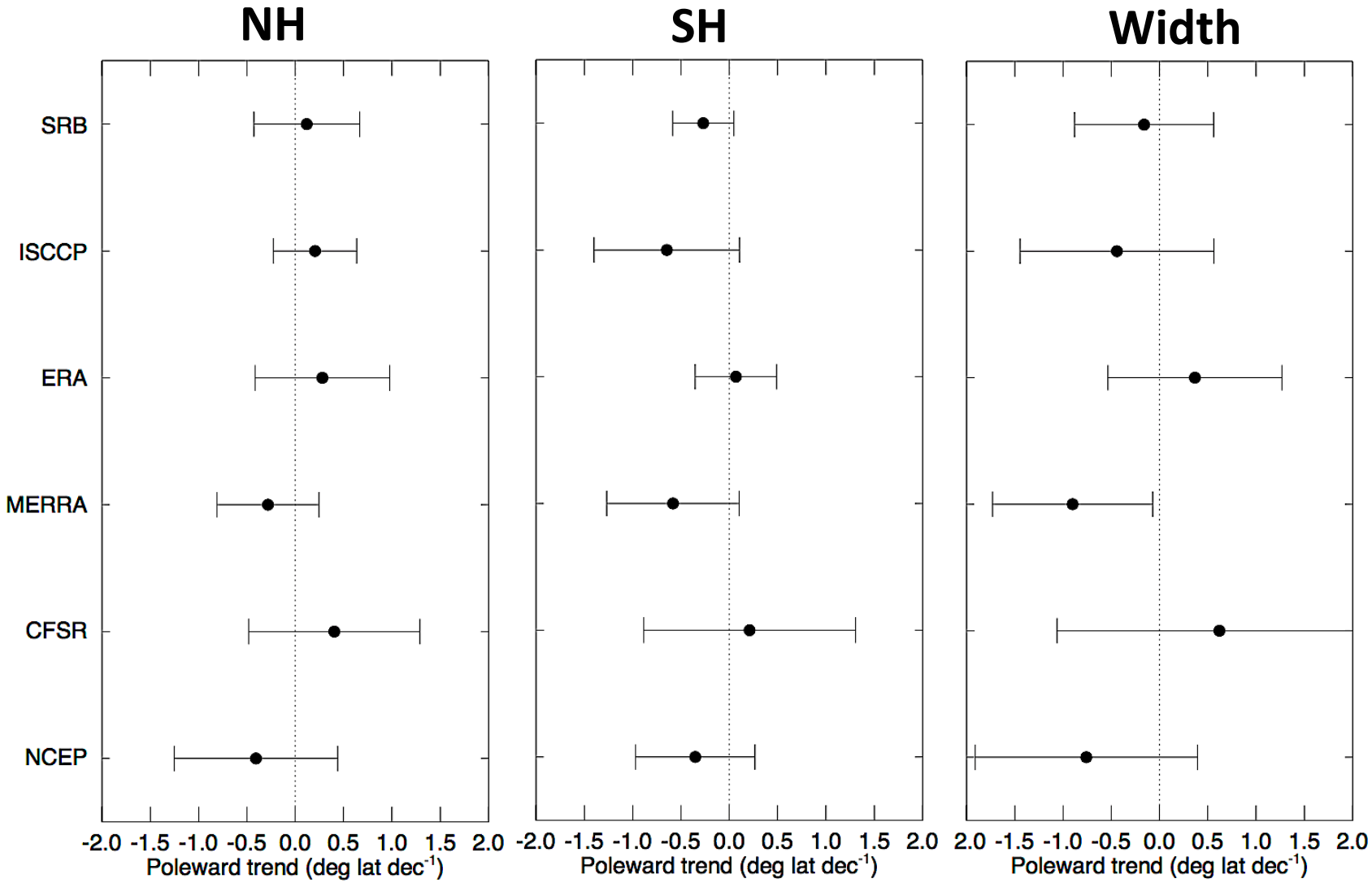
T-mean test of the tropical edges (p = 0.05)

Data	NH	SH
SRB	**0.13**	**0.14**
ISCCP	**0.24**	**0.07**
ERA-Interim	**0.46**	0.003
MERRA	0.00	0.005
CFSR	0.01	0.002
NCEP-NCAR	0.00	0.00

Time series of the annual mean width of the tropics



Trend of the poleward migration (1984-2007)



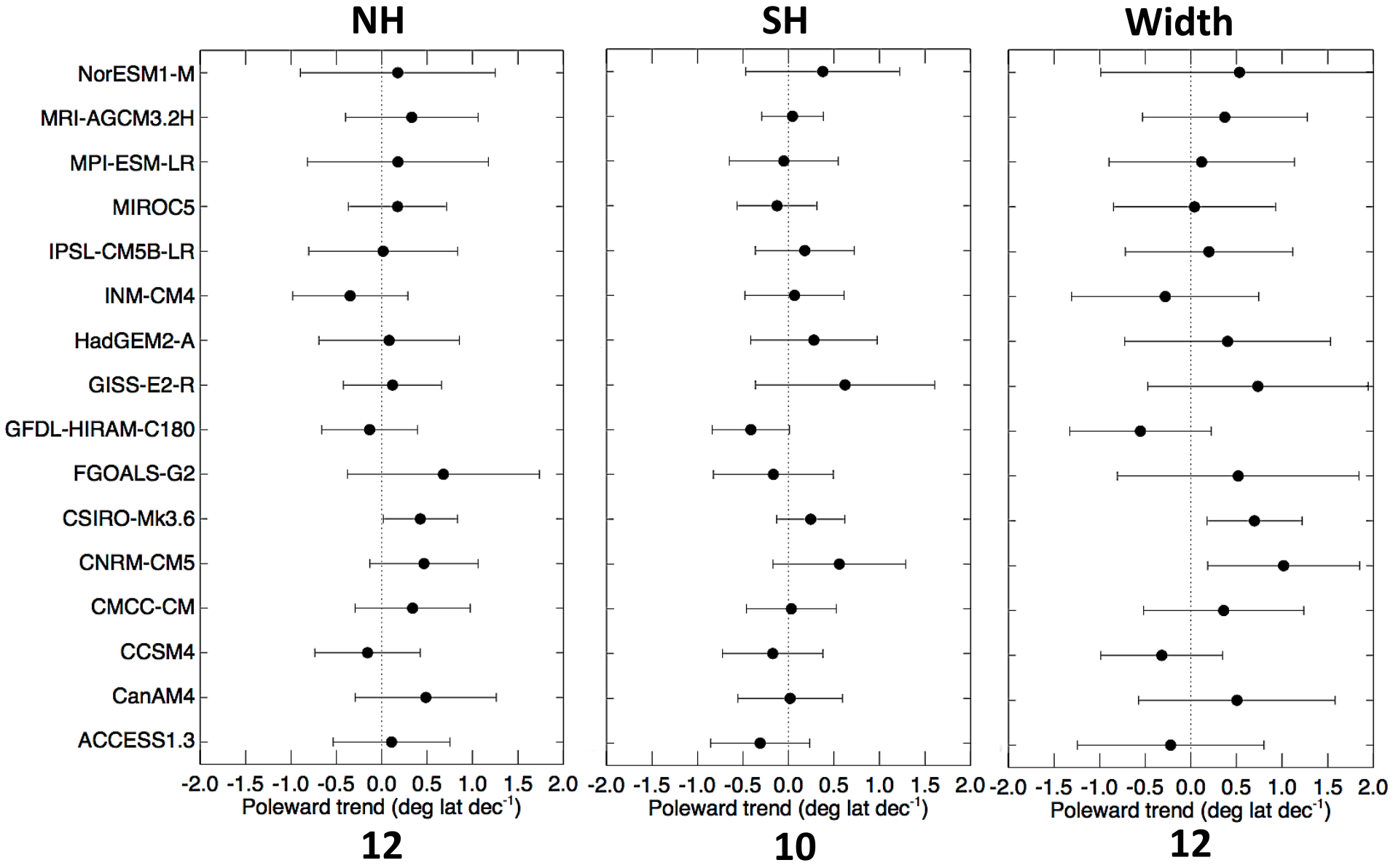
AMIP5 models

Model	Country	Lon x Lat
ACCESS1.3	Australia	192 x 145
CanAM4	Canada	128 x 64
CCSM4	US-NCAR	288 x 192
CMCC-CM	Italy	480x 240
CNRM-CM5	France	256 x 128
CSIRO-Mk3.6	Australia	192 x 96
FGOALS-g2	China	128 x 60
GFDL-HIRAM-C180	US-GFDL	576 x 360
GISS-E2-R	US-NASA	144 x 90
HadGEM2-A	UK	192 x 145
INM-CM4	Russia	180 x 120
IPSL-CM5B-LR	France	96 x 96
MIROC5	Japan	256 x 128
MPI-ESM-LR	Germany	192 x 96
MRI-AGCM3.2H	Japan	640 x 320
NorESM1-M	Norway	144 x 96

T-mean test of the tropical edges (p = 0.05)

Model	NH	SH
ACCESS1.3	0.001	**0.44**
CanAM4	0.003	0.00
CCSM4	0.00	0.00
CMCC-CM	**0.12**	0.00
CNRM-CM5	0.00	0.00
CSIRO-Mk3.6	0.00	0.00
FGOALS-g2	**0.17**	**0.52**
GFDL-HIRAM-C180	0.00	0.00
GISS-E2-R	**0.37**	0.00
HadGEM2-A	**0.71**	**0.50**
INM-CM4	0.50	0.00
IPSL-CM5B-LR	0.001	**0.67**
MIROC5	0.00	0.00
MPI-ESM-LR	**0.70**	0.00
MRI-AGCM3.2H	0.00	0.00
NorESM1-M	0.00	0.00

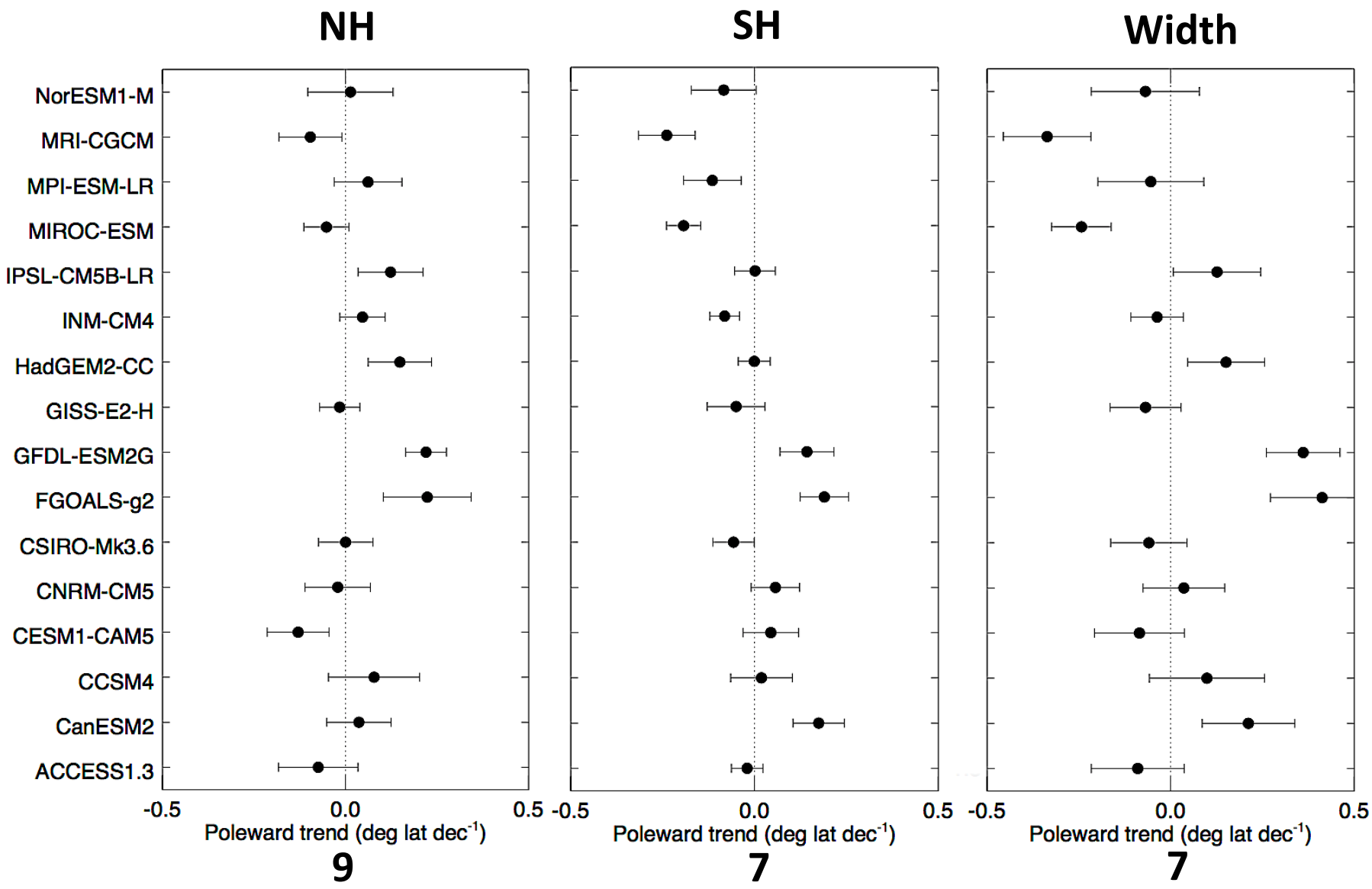
Trend of the poleward migration (1984-2007)



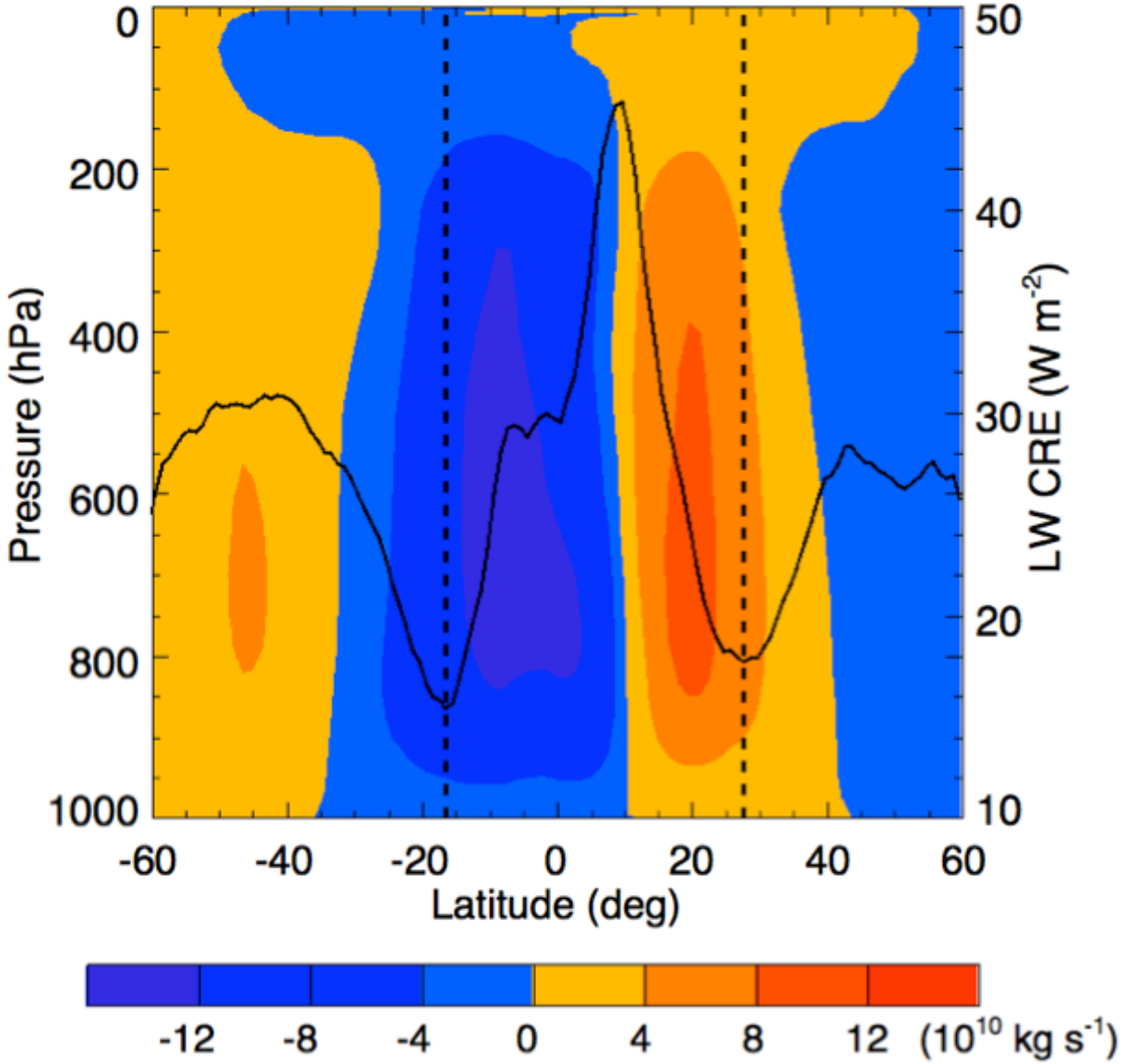
CMIP5 RCP 8.5 models

Model	Country	Lon x Lat
ACCESS1.3	Australia	192 x 145
CanESM2	Canada	128 x 64
CCSM4	US-NCAR	288 x 192
CESM-CAM5	US-NSF-DOE-NCAR	288 x 192
CNRM-CM5	France	256 x 128
CSIRO-Mk3.6	Australia	192 x 96
FGOALS-g2	China	128 x 60
GFDL-ESM2G	US-GFDL	0.625 x 0.5
GISS-E2-H	US-NASA	144 x 90
HadGEM2-CC	UK	192 x 145
INM-CM4	Russia	180 x 120
IPSL-CM5B-LR	France	96 x 96
MIROC-ESM	Japan	128 x 64
MPI-ESM-LR	Germany	192 x 96
MRI-CGCM3	Japan	320 x 160
NorESM1-M	Norway	144 x 96

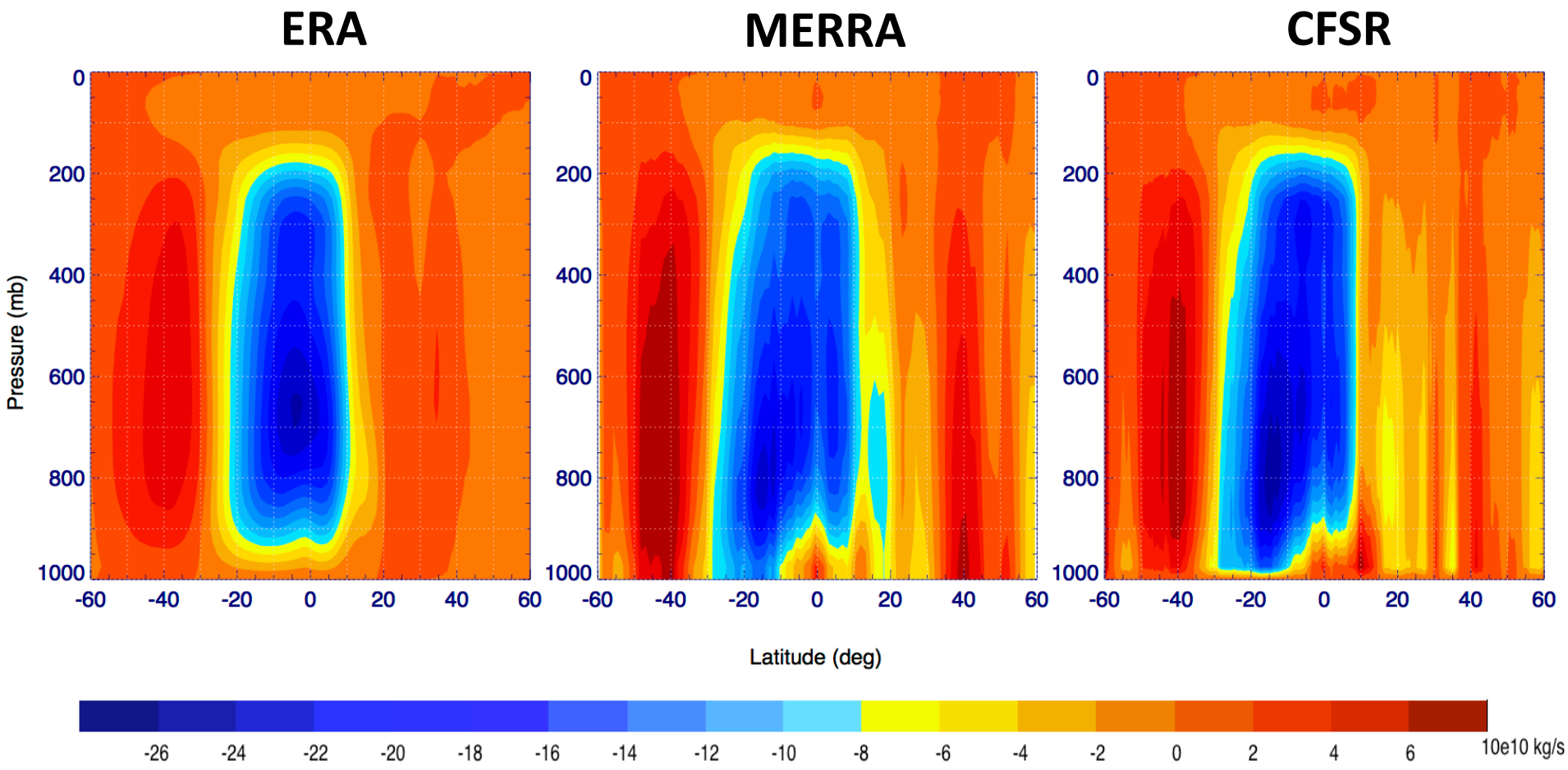
Trend of the poleward migration (2006-2100)



Stream function and LW CRE in Oct 2005



Stream function in July



Conclusions

- A novel method to study Hadley circulation variability using LW CRE.
- The expansion of the tropics is not statistically significant in the past three decades.
- 21st century model projection does not reach an agreement in the changes of the width of the tropics.