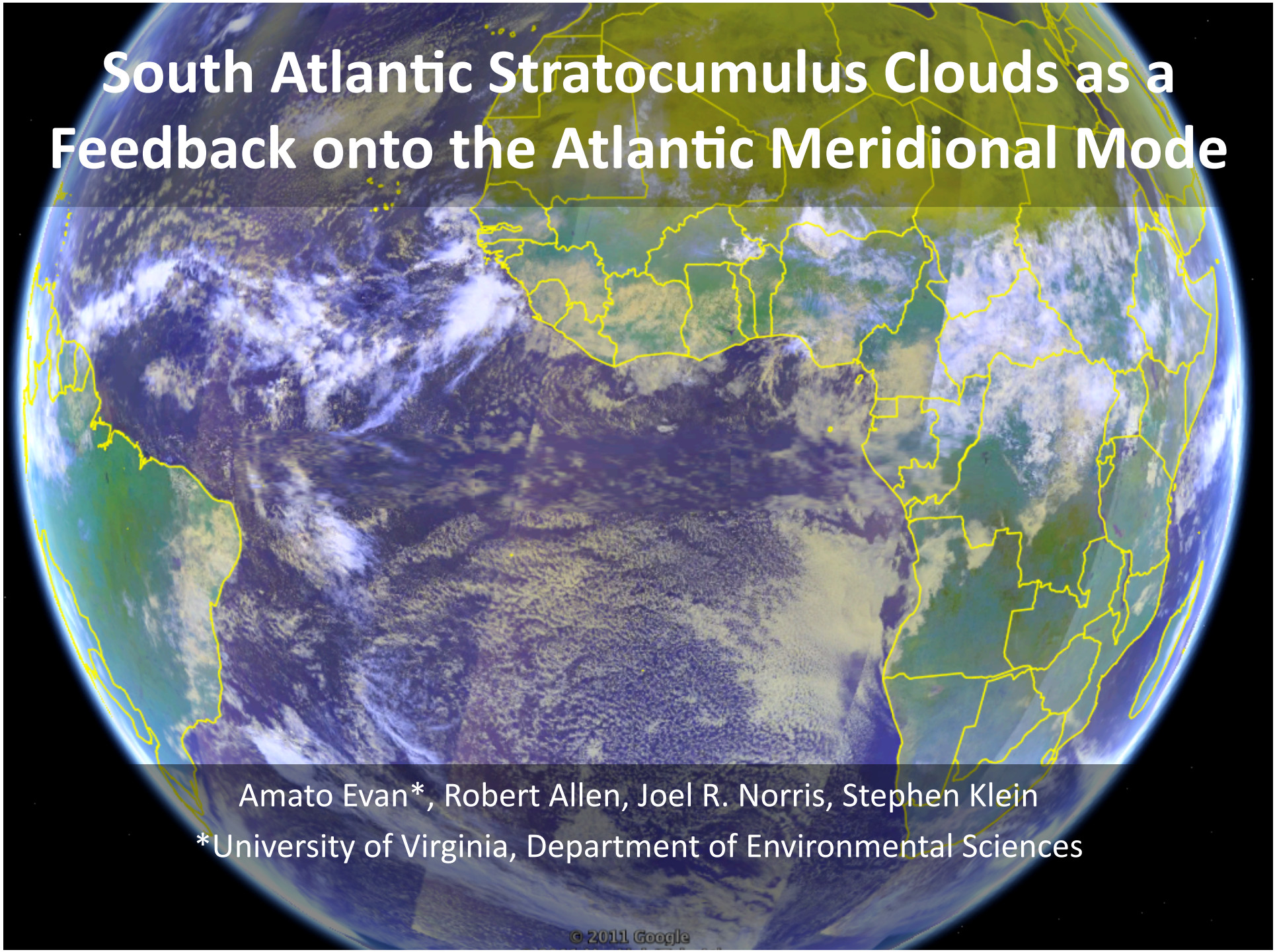
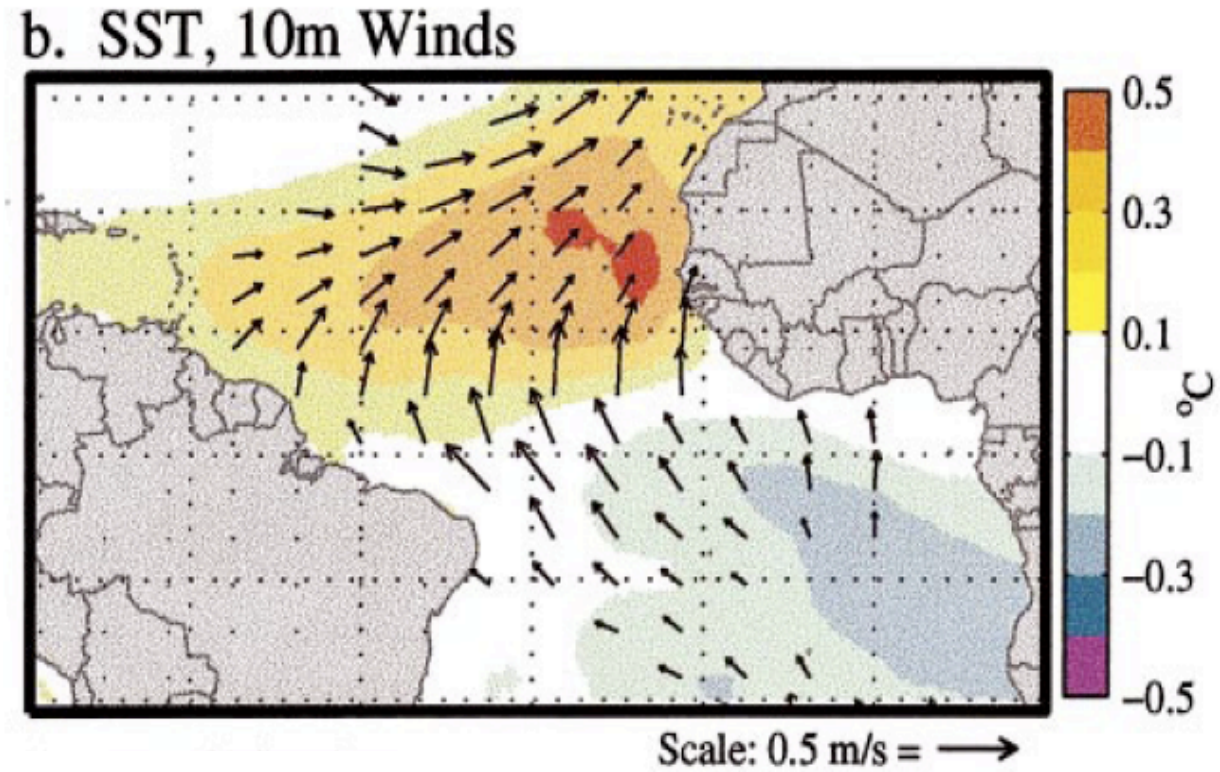
South Atlantic Stratocumulus Clouds as a Feedback onto the Atlantic Meridional Mode



Amato Evan*, Robert Allen, Joel R. Norris, Stephen Klein

*University of Virginia, Department of Environmental Sciences

Atlantic Meridional Mode



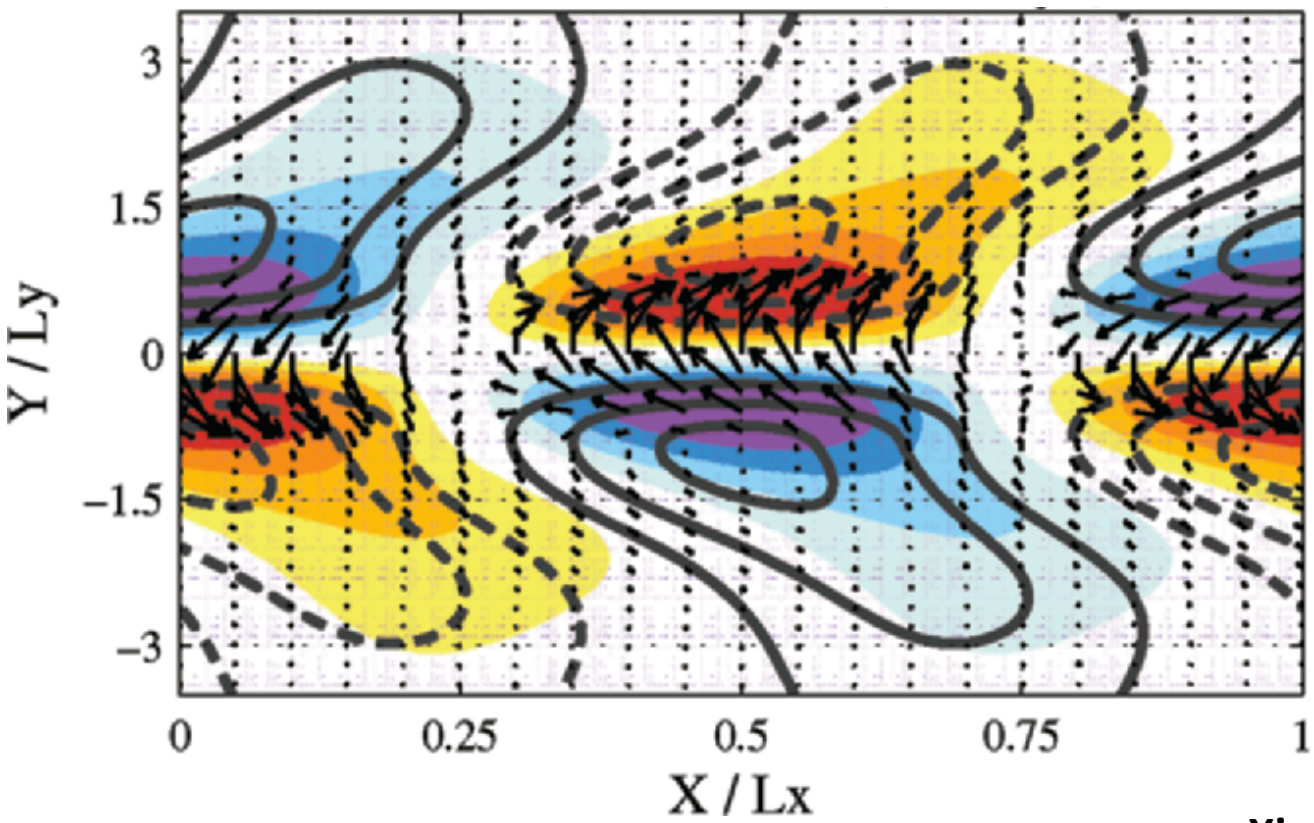
Chiang and Vimont 2004 (*J Clim*)

Atlantic Meridional Mode

$$\frac{\partial}{\partial t}\begin{pmatrix} u \\ v \\ \phi \\ T \end{pmatrix} = \begin{pmatrix} -\varepsilon_u & \beta y & -ik & 0 \\ -\beta y & -\varepsilon_u & \partial/\partial y & 0 \\ -c_a^2 ik & -c_a^2 \partial/\partial y & -\varepsilon_\phi & \boxed{-K_q(y)} \\ \boxed{\alpha(y)} & 0 & 0 & -\varepsilon_T + \gamma\nabla^2 \end{pmatrix}\begin{pmatrix} u \\ v \\ \phi \\ T \end{pmatrix}$$

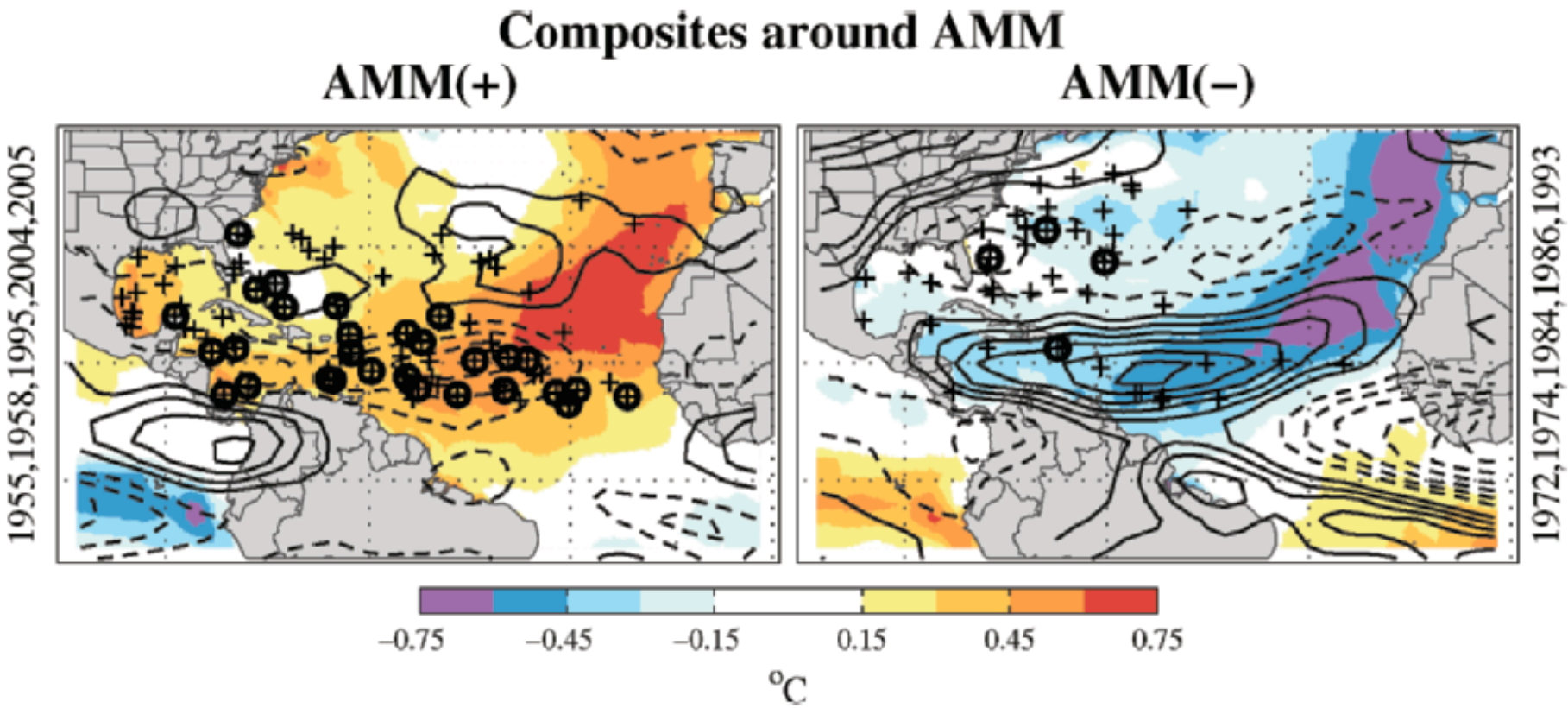
Matsuno 1966 (*J. Meteo. Soc. Japan*)
Gill 1980 (*QJRMS*)

Atlantic Meridional Mode



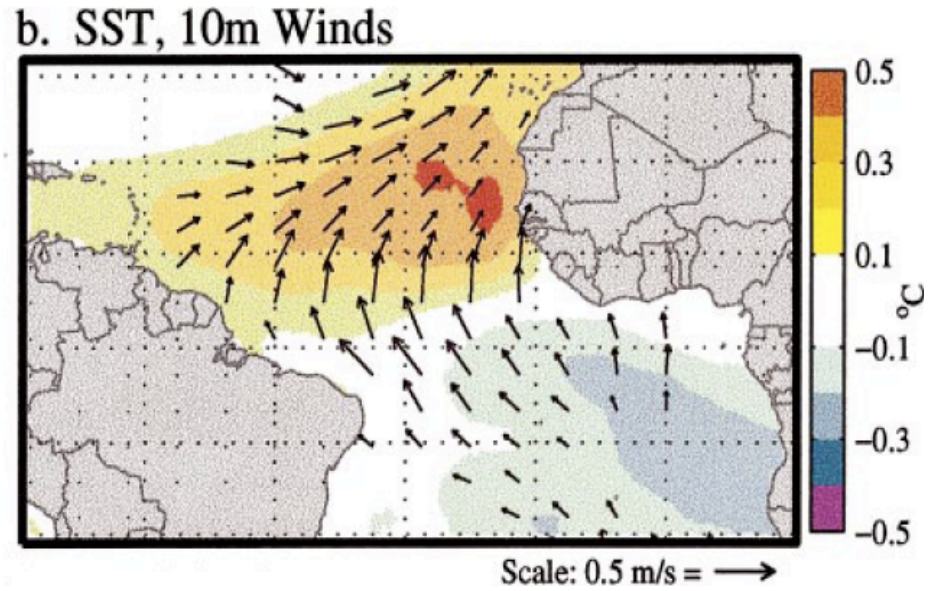
Xie 1999 (*J Clim*)
Kossin and Vimont 2007 (*BAMS*)
Vimont 2011 (*J Clim*)

AMM & Atlantic Hurricanes

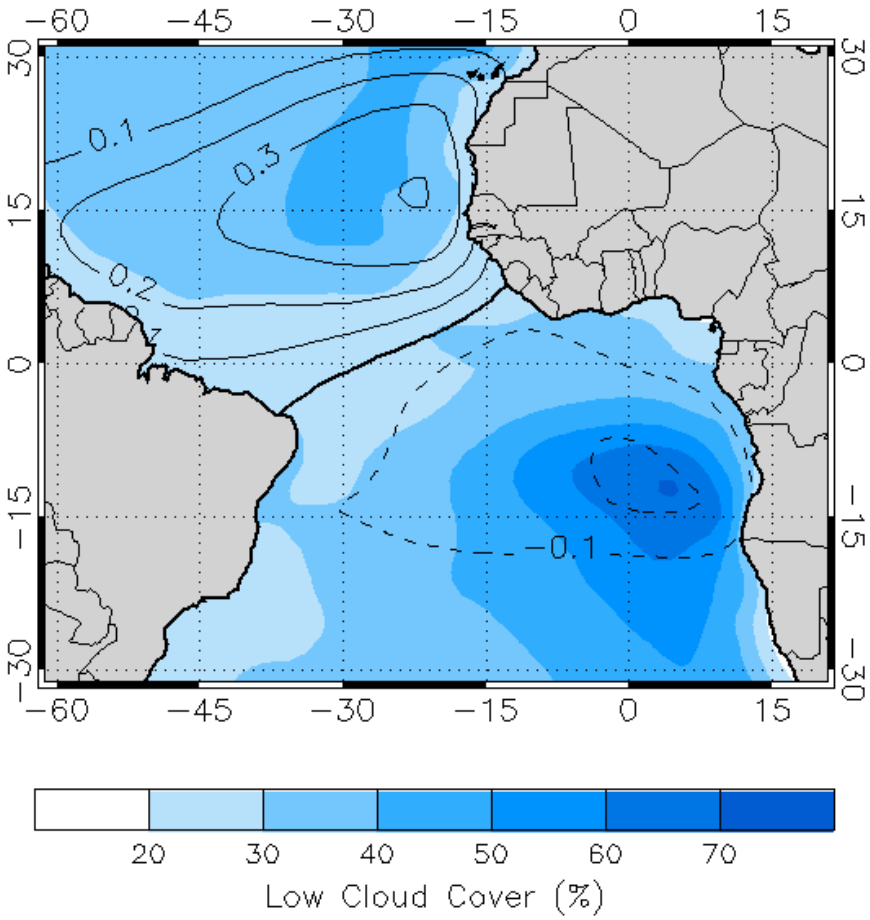


Kossin and Vimont 2007 (*BAMS*)

Similarity in AMM & LCC Spatial Pattern

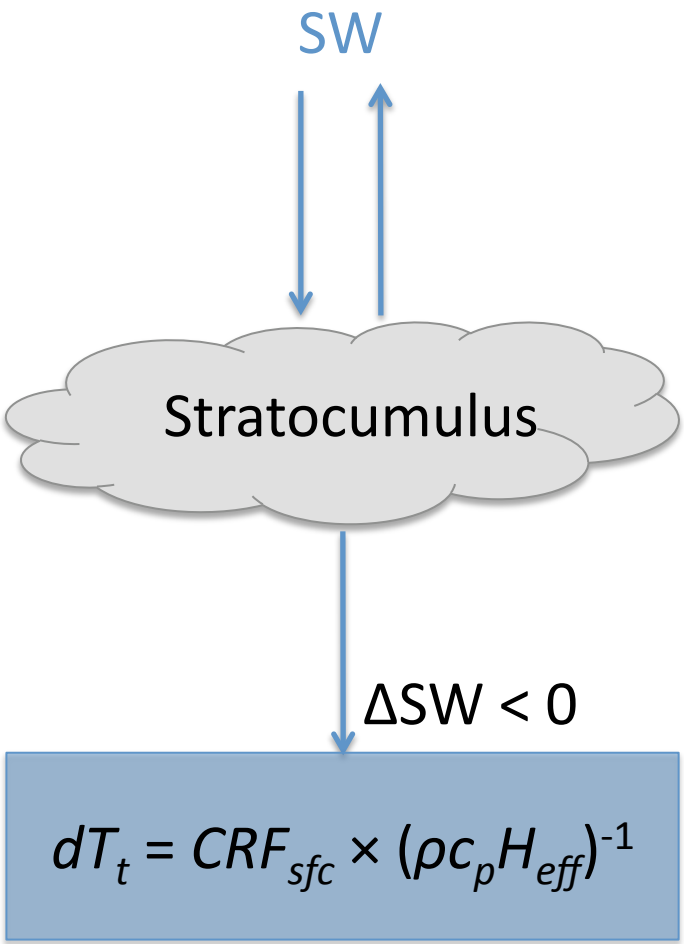


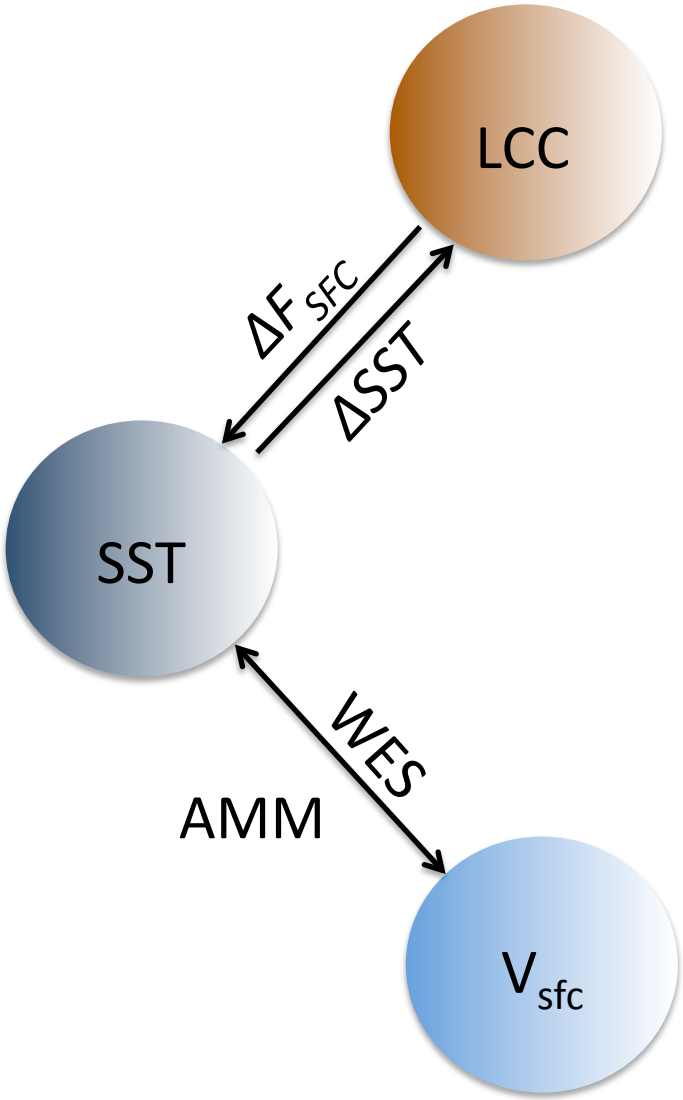
Chiang and Vimont 2004 (*J Clim*)



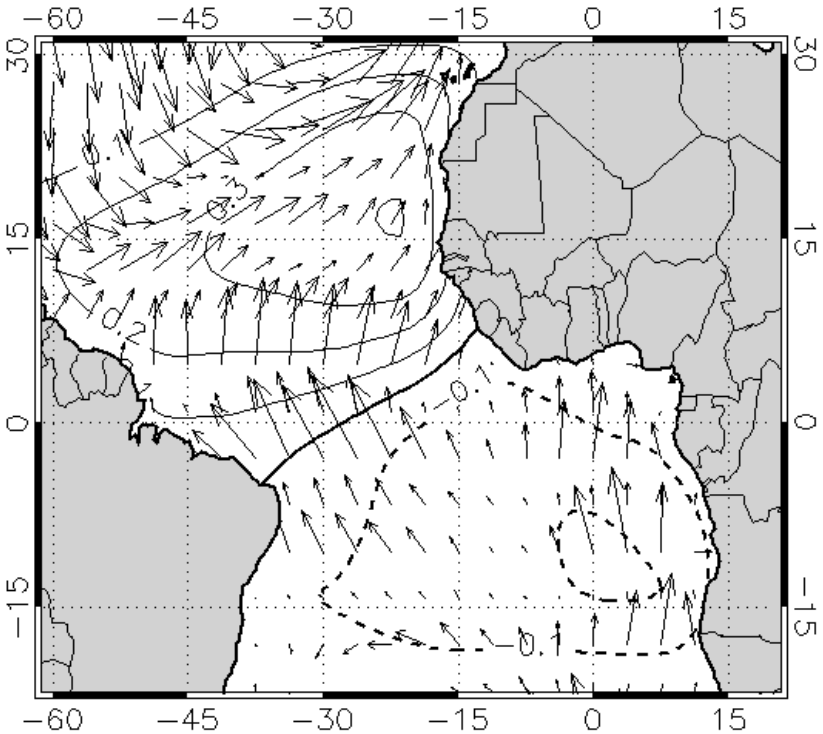
Tanimoto and Xie 2002

Coupling of the AMM and LCC

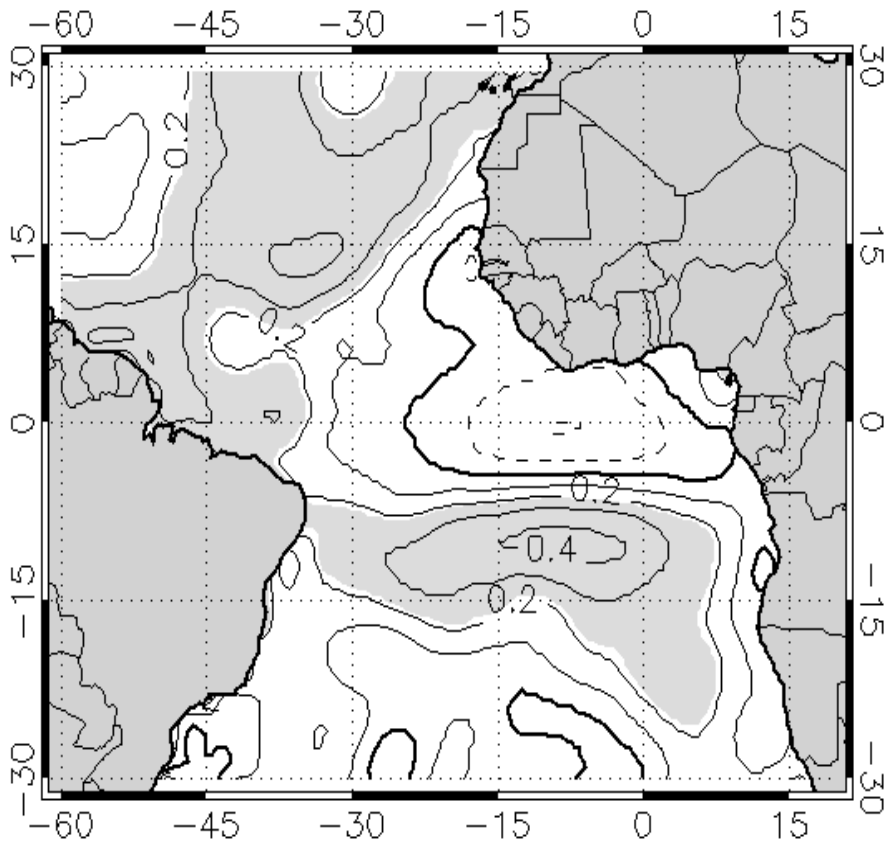




Solar Contribution to $\frac{dSST}{dt}$



Regression of 10 m wind onto AMM

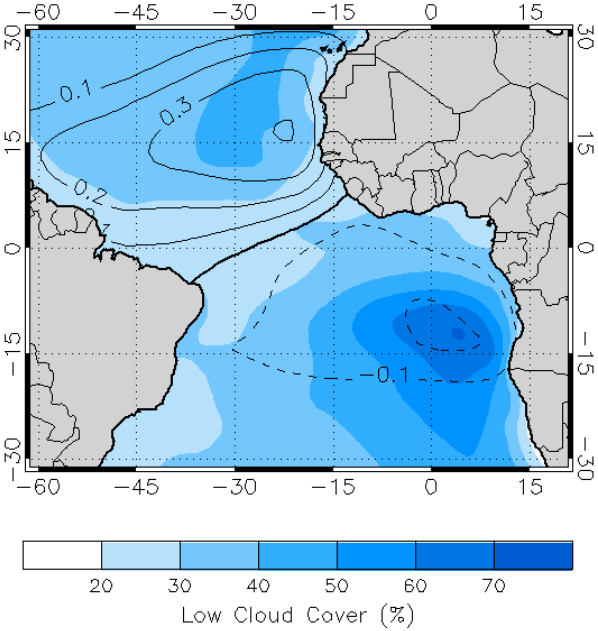


Correlation of SWR & dSST/dt

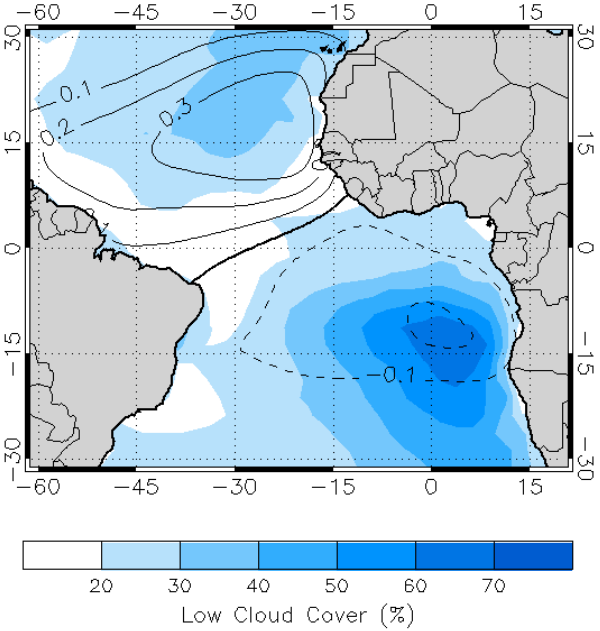
Foltz and McPhaden 2006 (*J Clim*)

Long Term Mean LCC

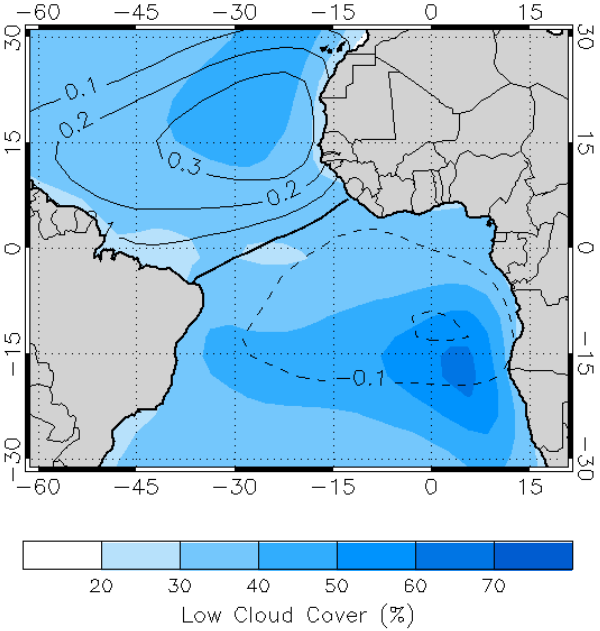
PATMOSx



ISCCP



CAM+SOM

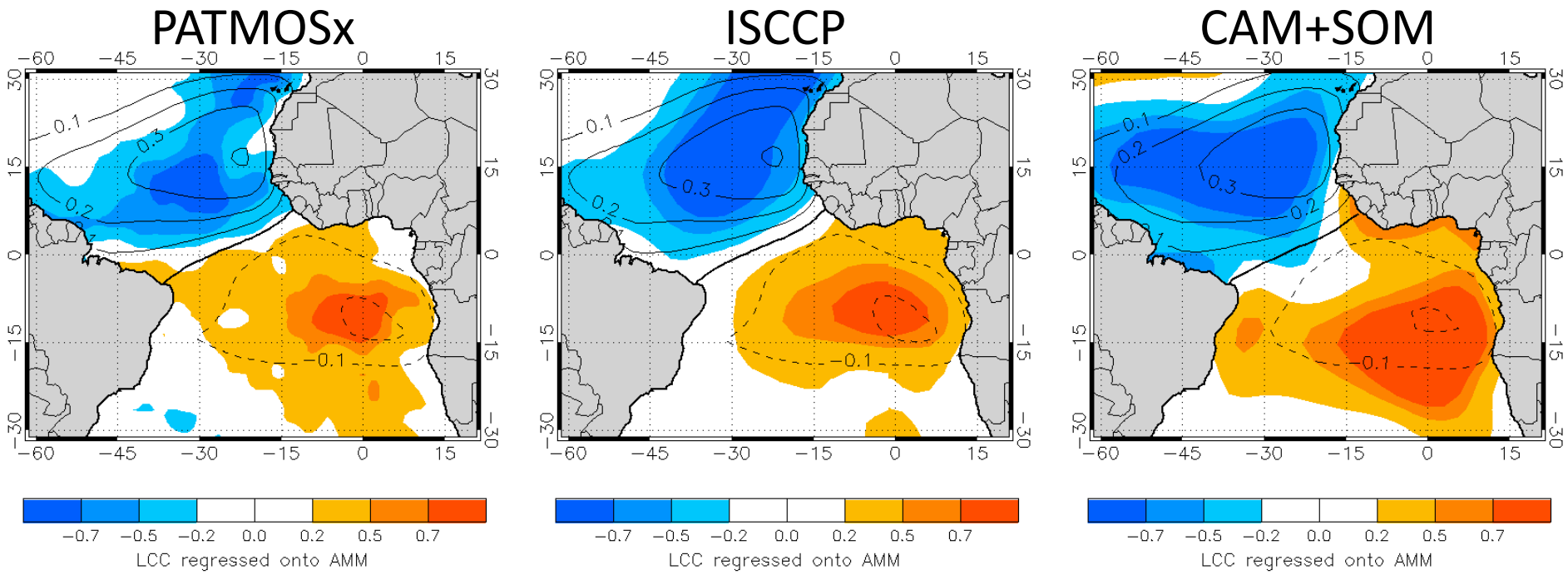


PATMOSx: AVHRR (vis+ir), polar, monthly clim. from 1x daily obs: 1982–2010.

ISCCP: GOES (vis +ir), geo, monthly climatology from 8x daily obs: 1983–2008

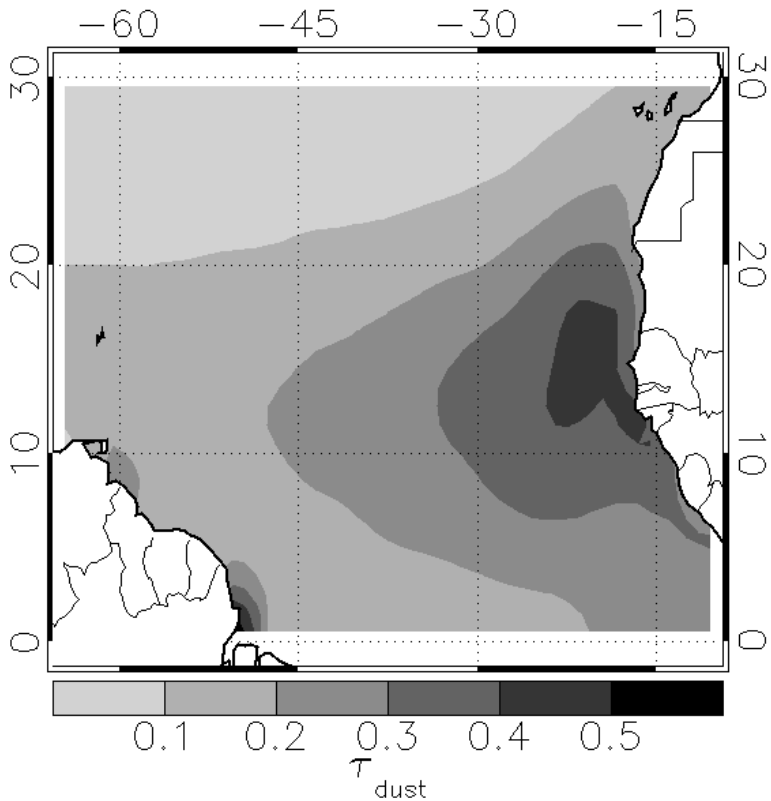
CCSM: CAM +SOM, one ens. realization, hist. forcing: 1950–1999.

Low clouds regressed onto AMM



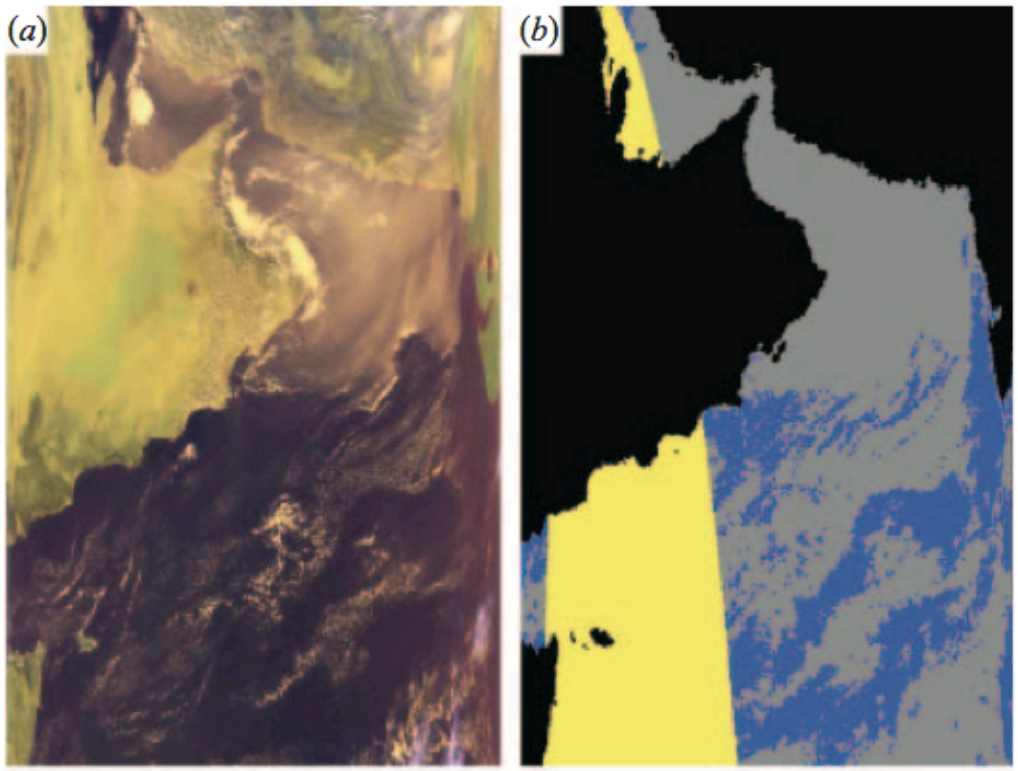
$$AMM_{obs}(t = t_0) = \frac{SST(t = t_0) \times AMM_{x,y}}{\sigma_{AMM(t)}}$$

Dust Contamination in the NH?



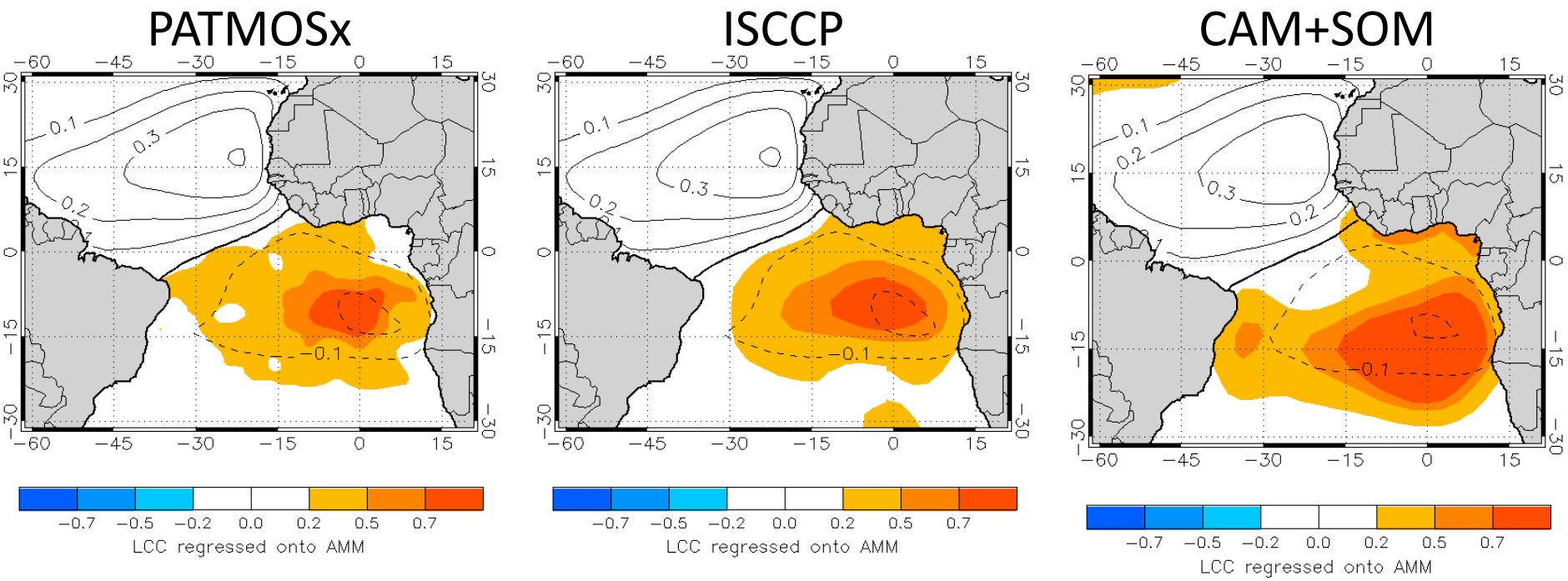
Evan and Mukhopadhyay 2010 (*JAMC*)

Evan et al. 2011 (*Nature Geo.*)

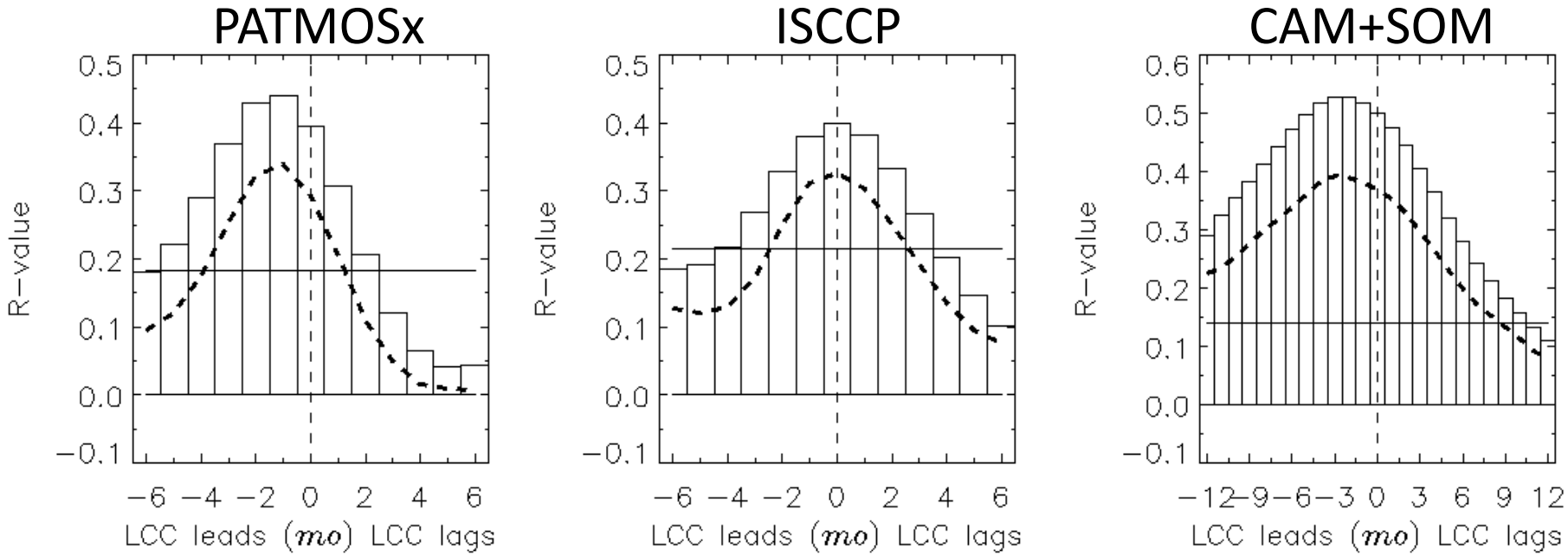


Evan et al. 2005 (*IJRS*)

Low clouds regressed onto AMM



Cross-correlation function of LCC & AMM

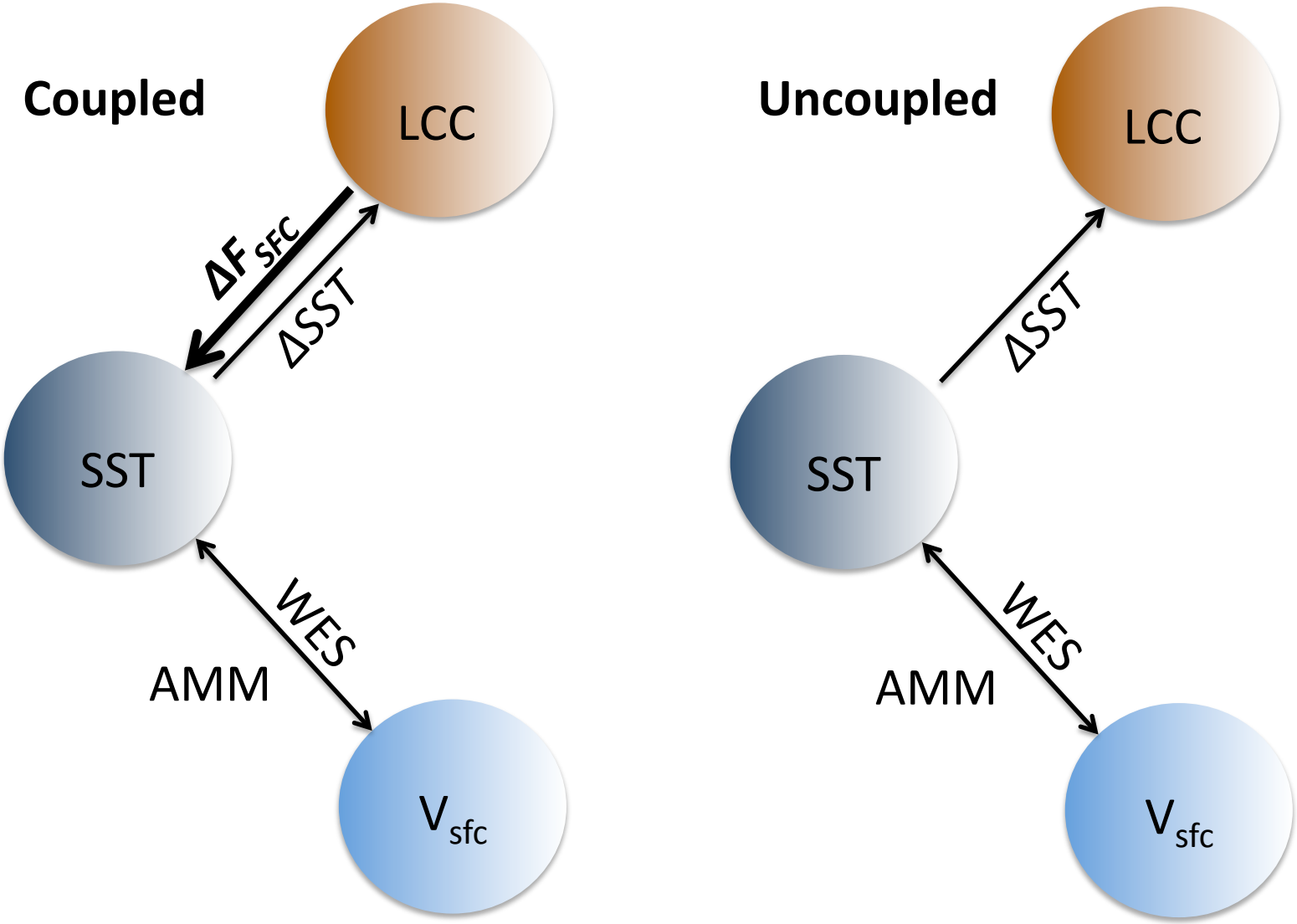


S.H. only

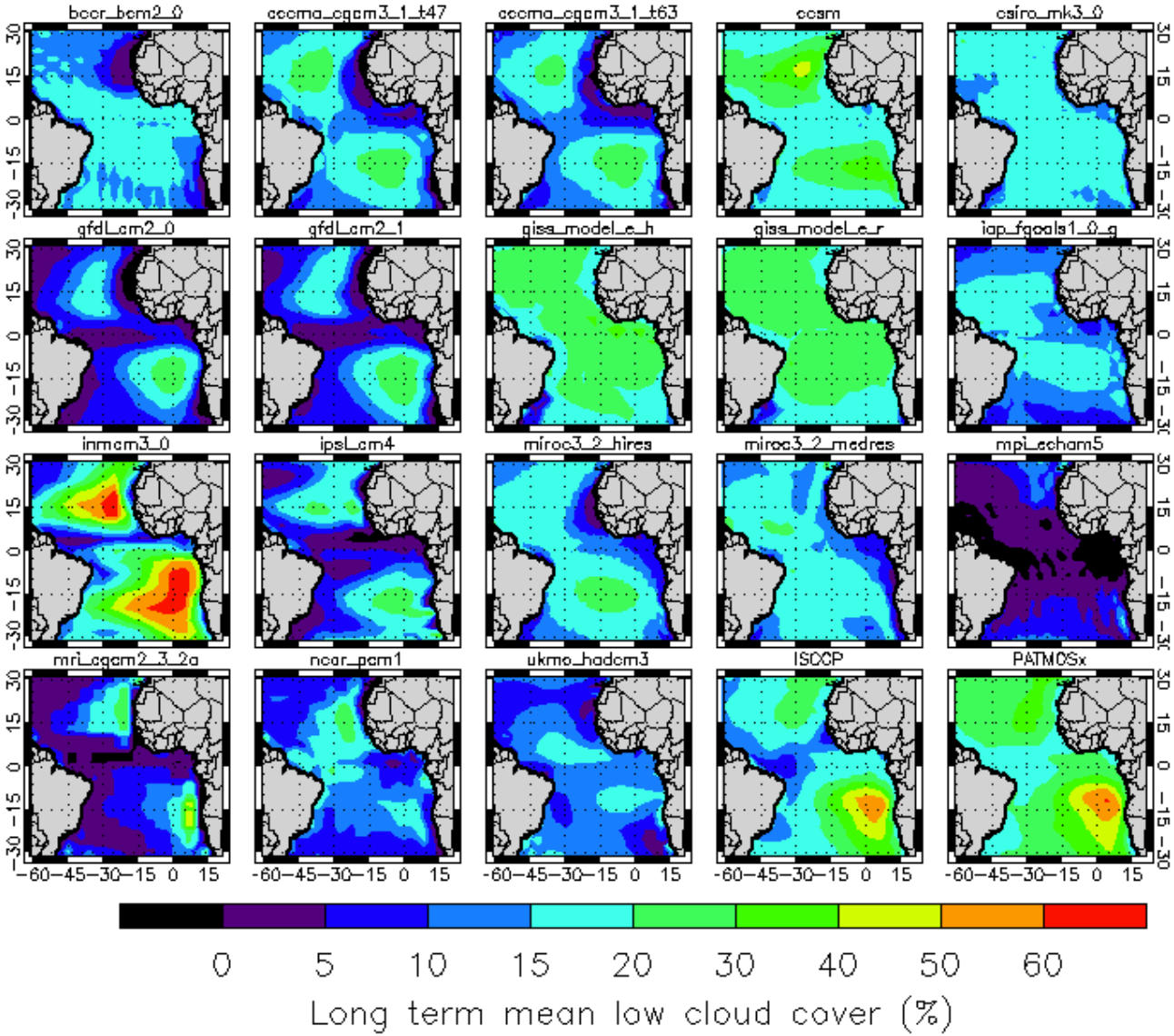
$$AMM_{obs}(t = t_0) = \frac{SST(t = t_0) \times AMM_{x,y}}{\sigma_{AMM_{obs}(t)}}$$

$$AMM_{LCC}(t = t_0) = \frac{LCC(t = t_0) \times AMM_{x,y}}{\sigma_{AMM_{LCC}(t)}}$$

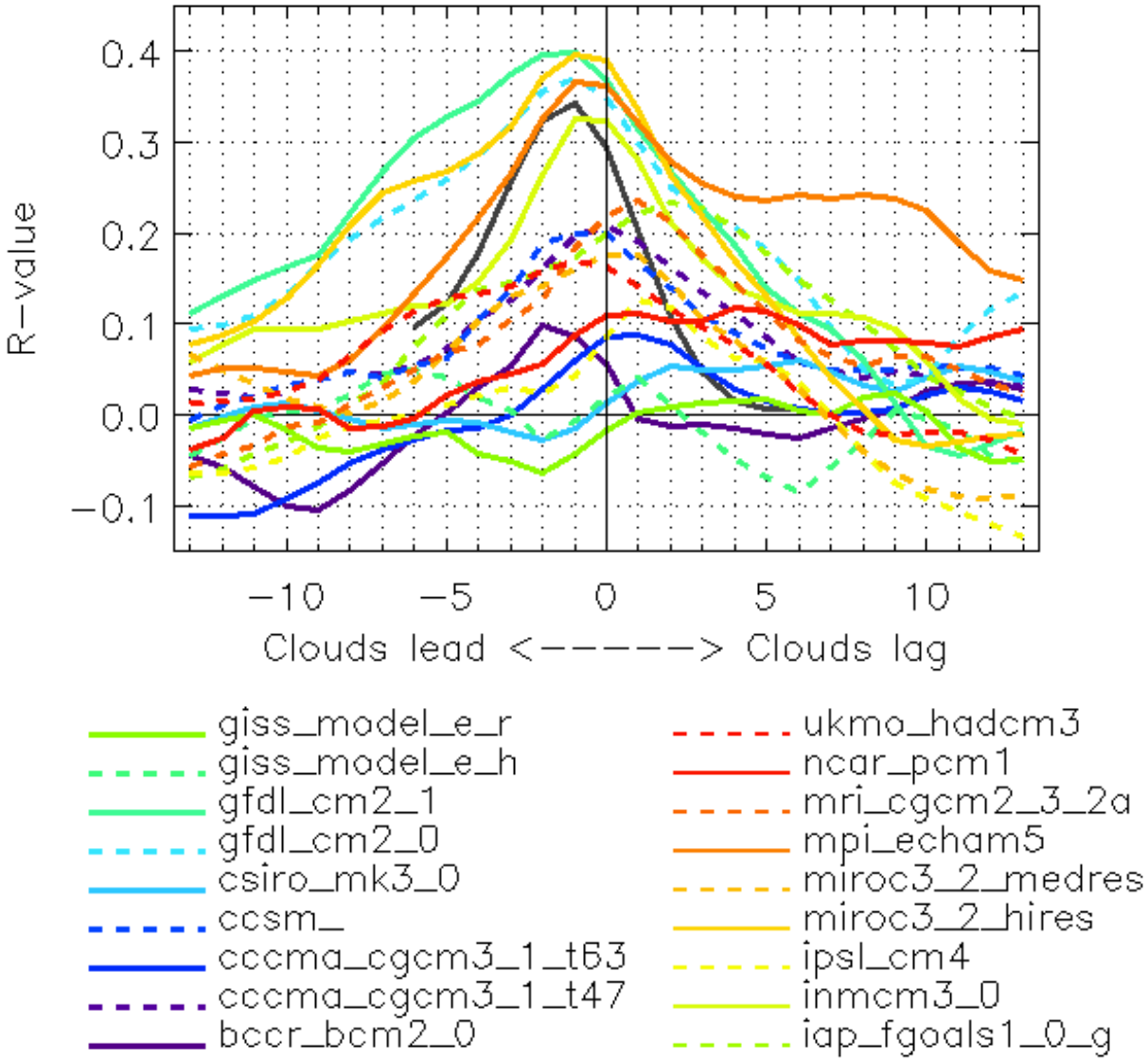
Coupling of the AMM and LCC



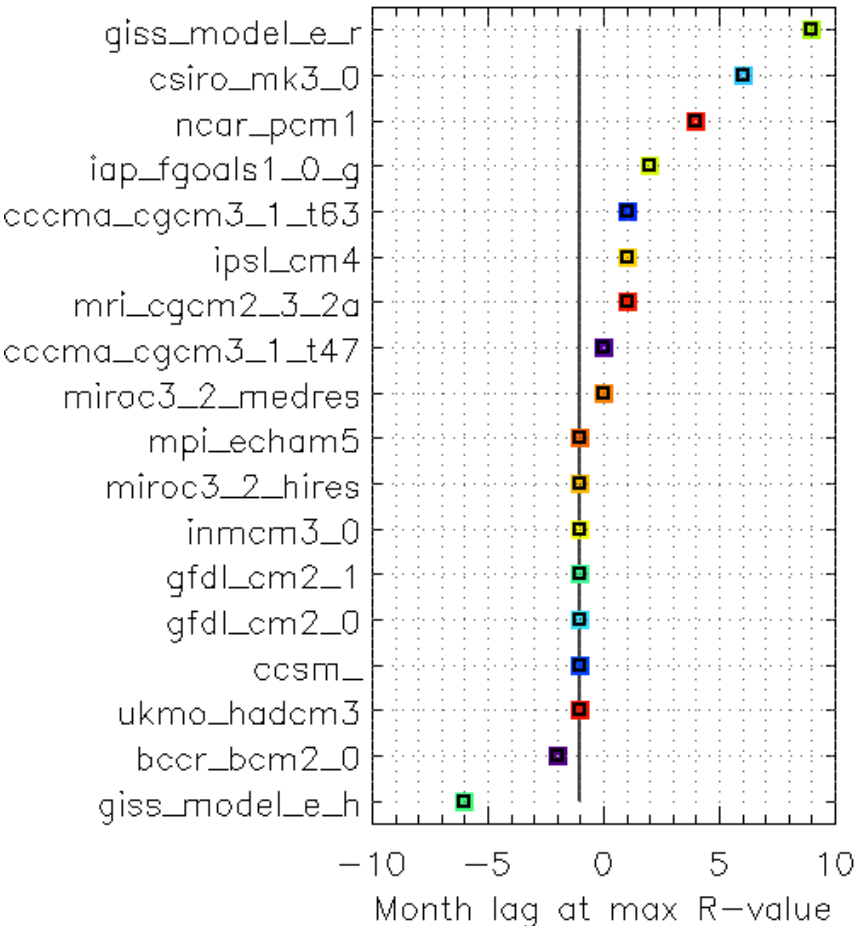
Comparison to CMIP3 models (1950–2000)

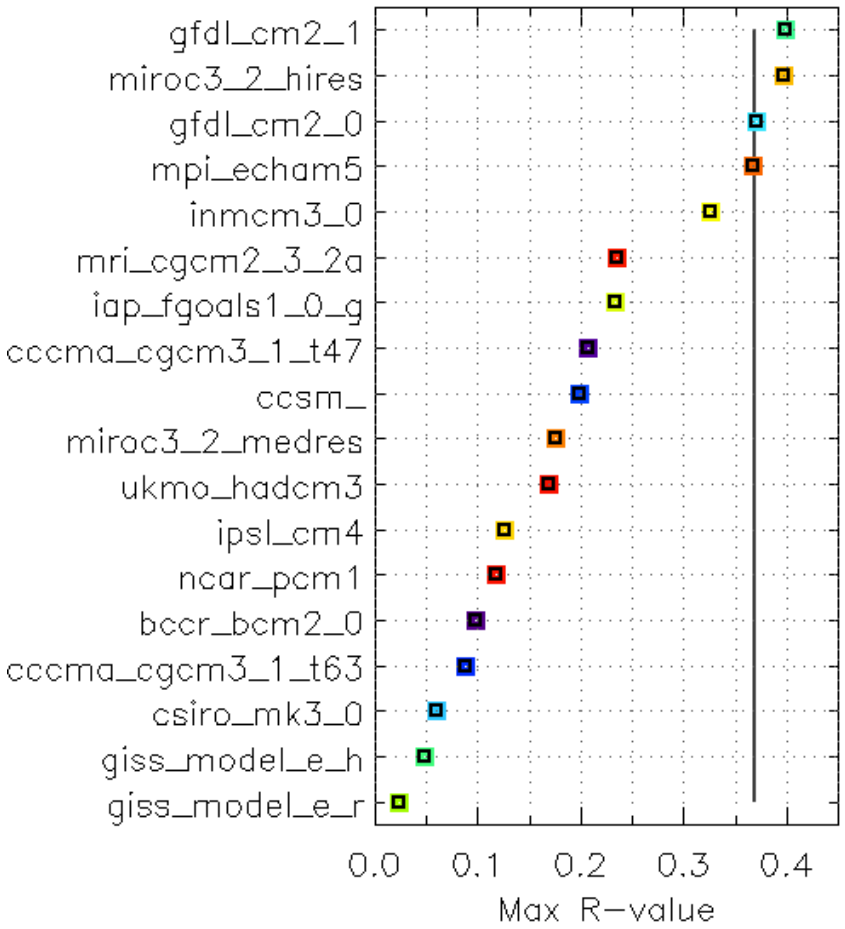


Cross-correlation function of AMM & LCC

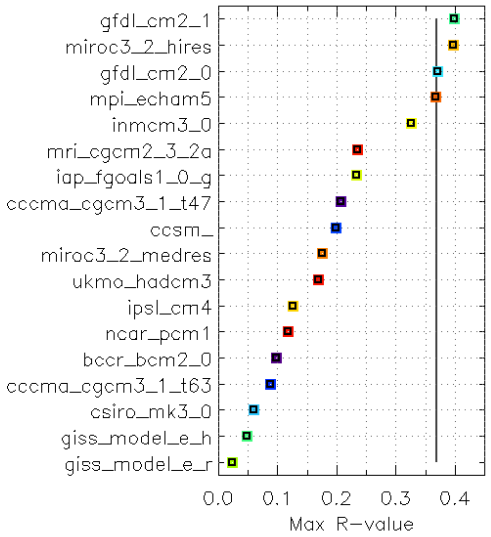


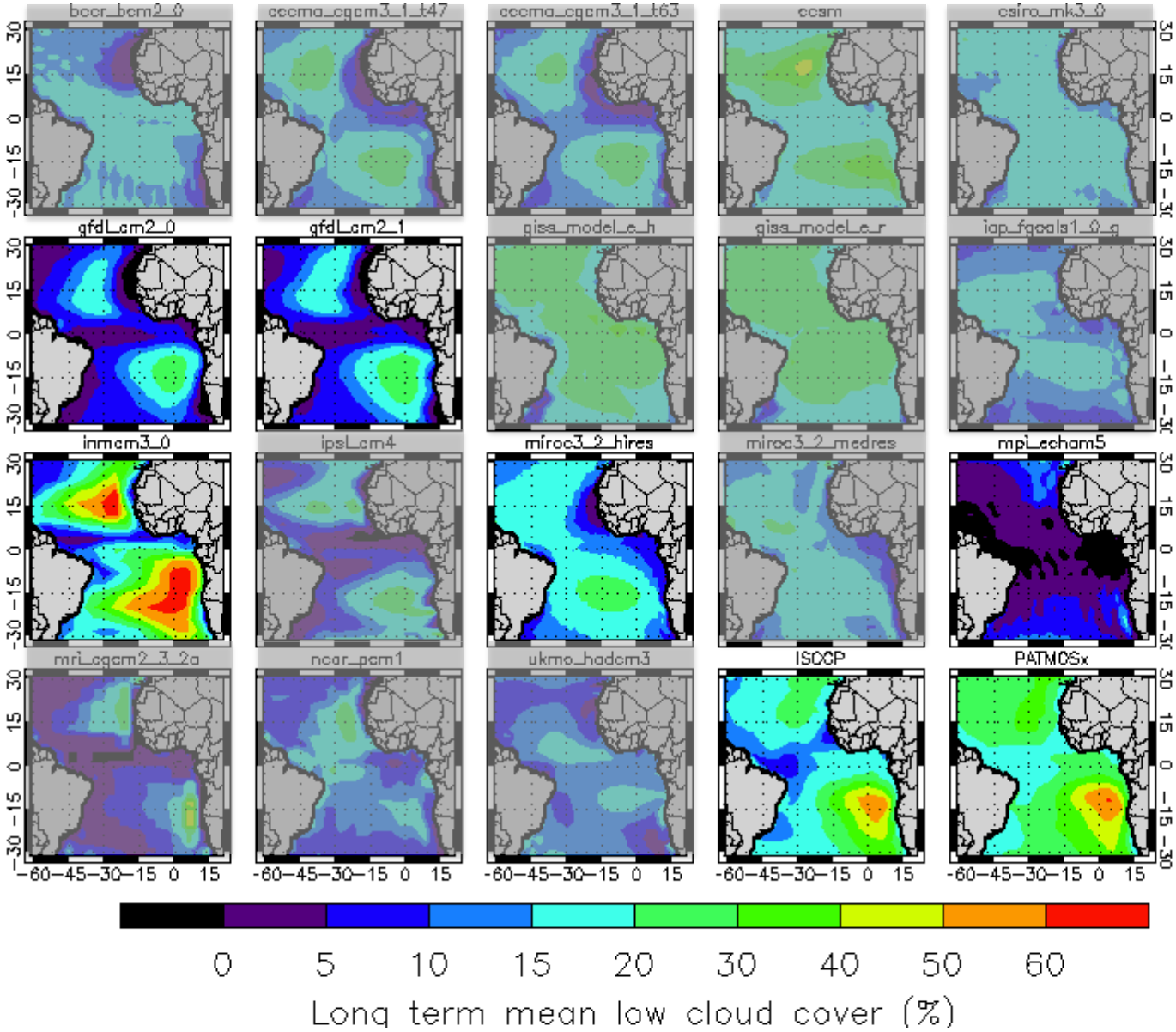
Cross-correlation function of AMM & LCC



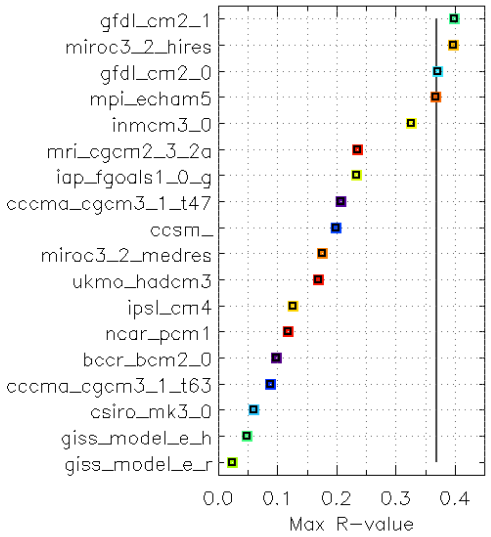


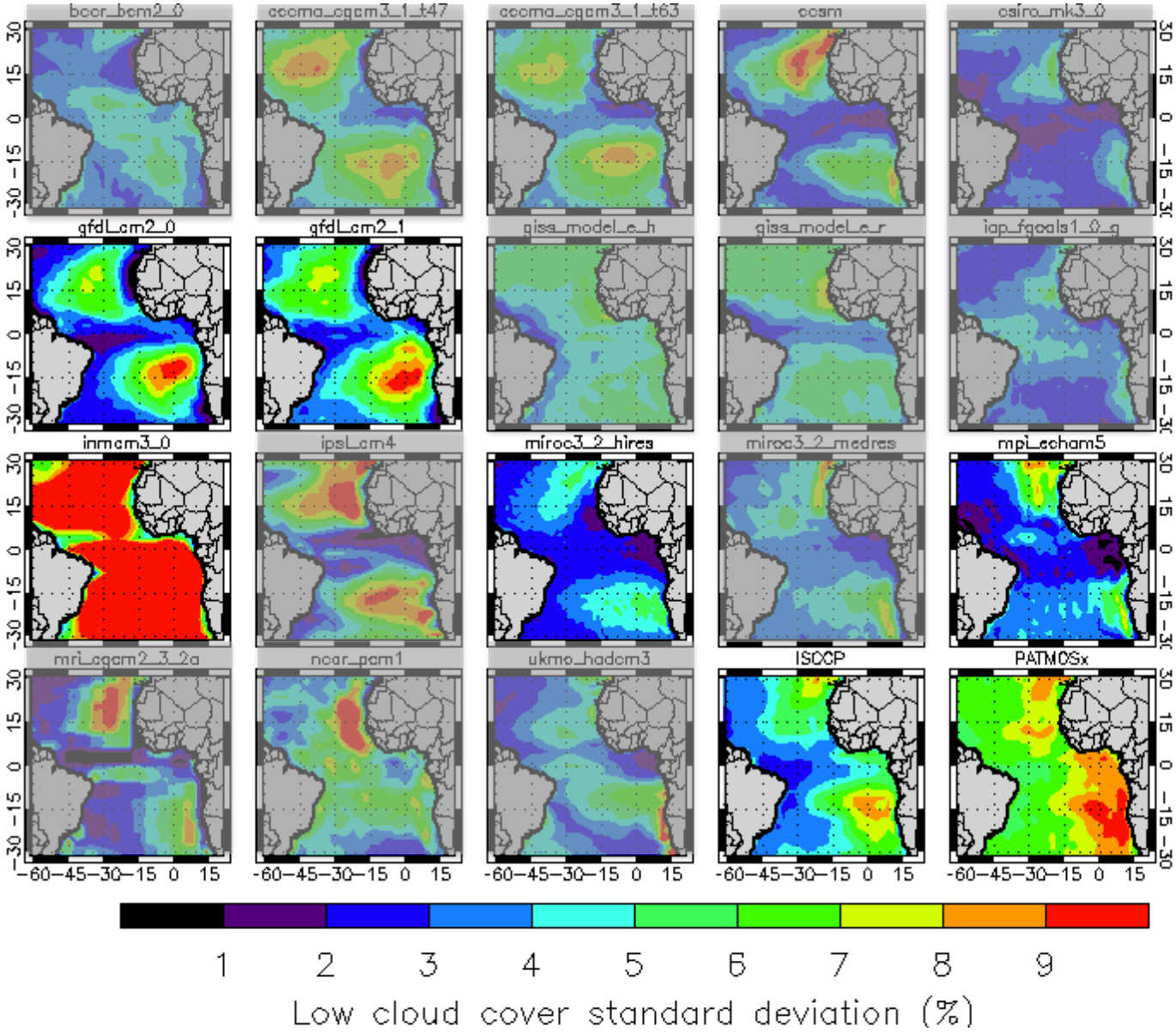
Cross-correlation function & Mean LCC



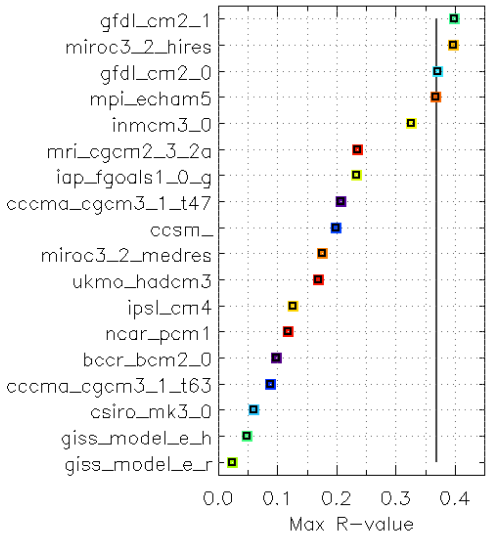


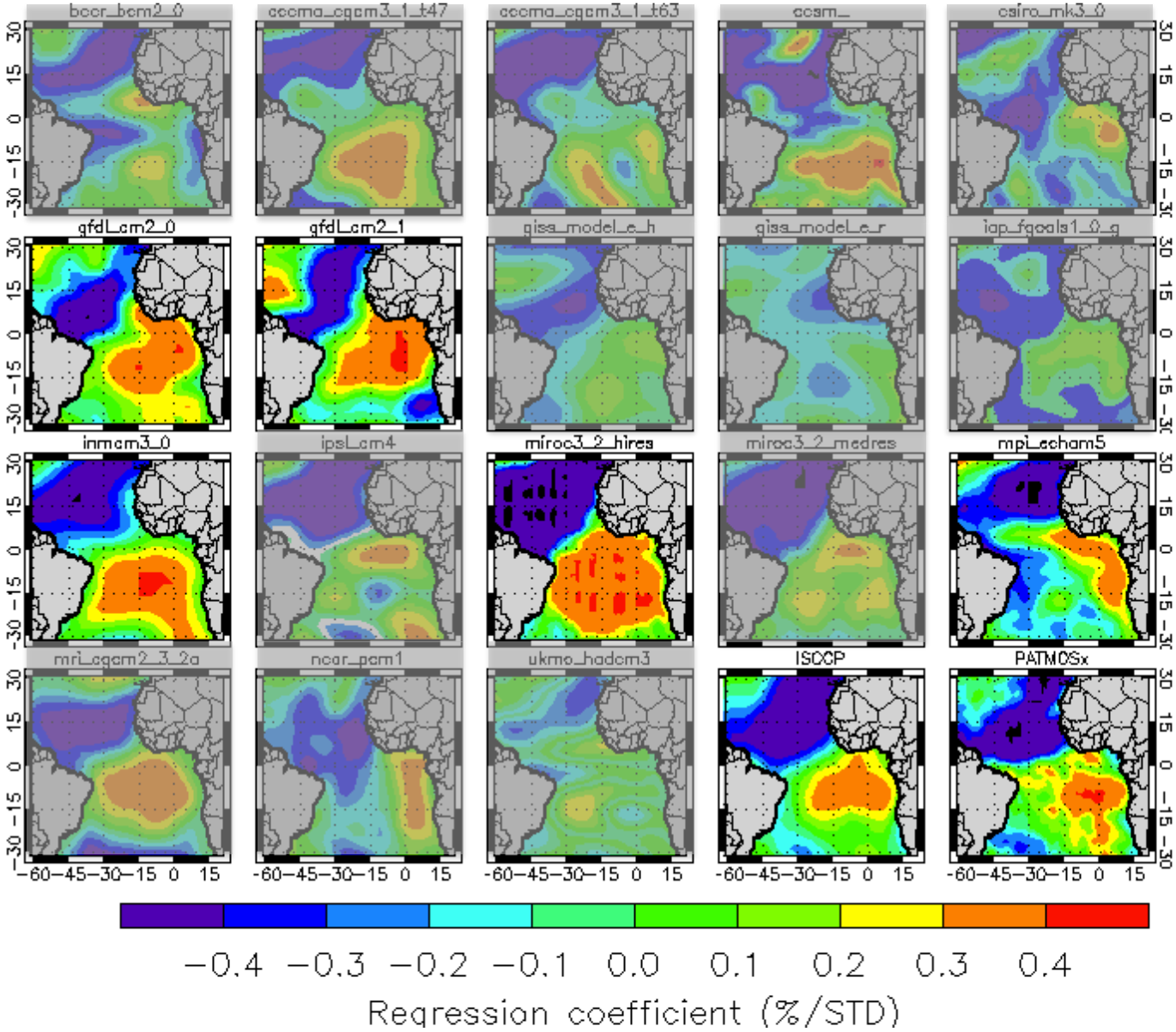
Cross-correlation function & LCC STD



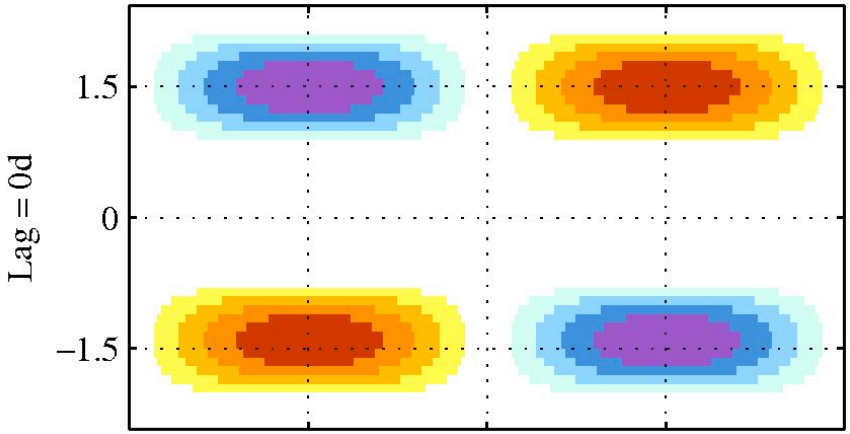


Cross-correlation function & Regression

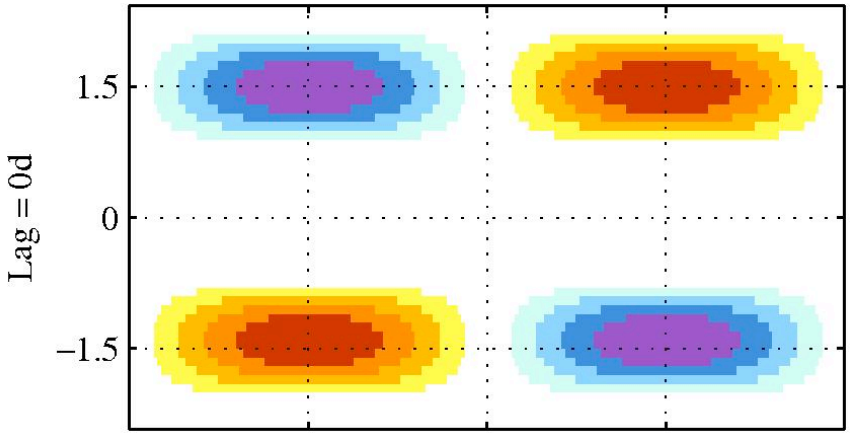




Symmetric evolution



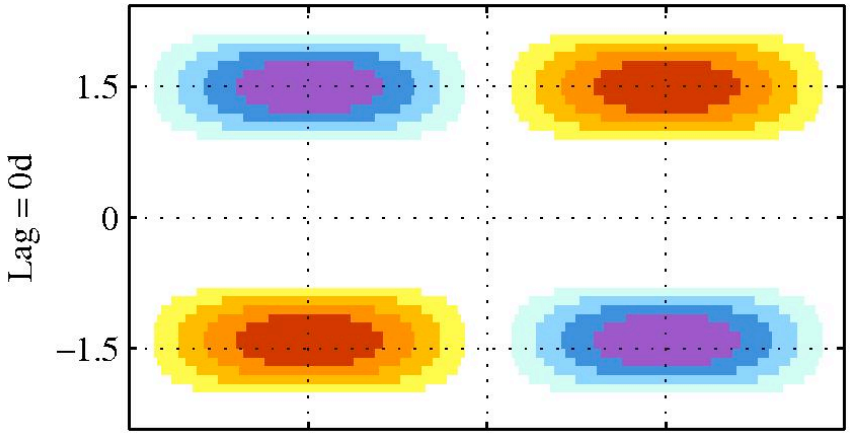
Initial Structure



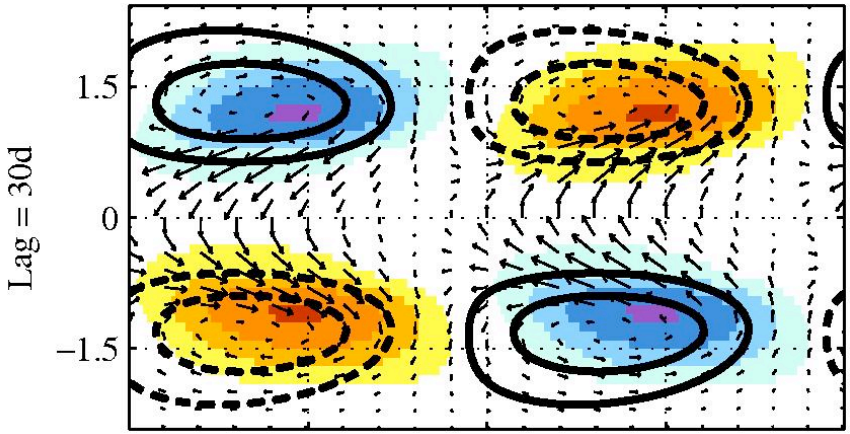
Final Structure

Vimont 2011 (*J. Clim.*)

Symmetric evolution



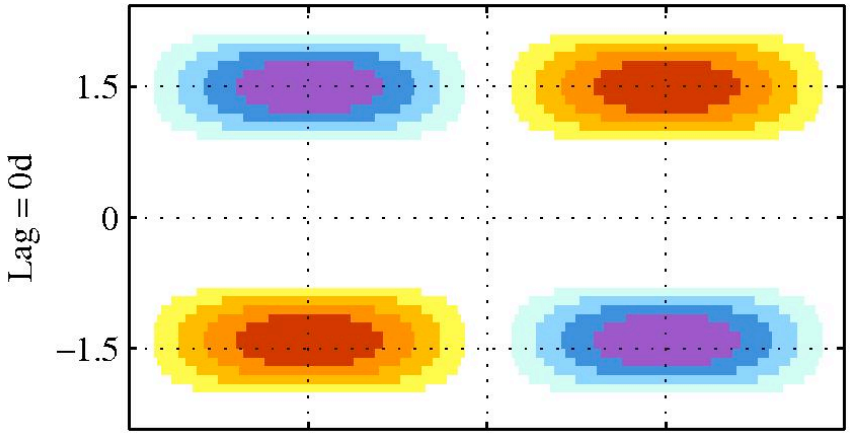
Initial Structure



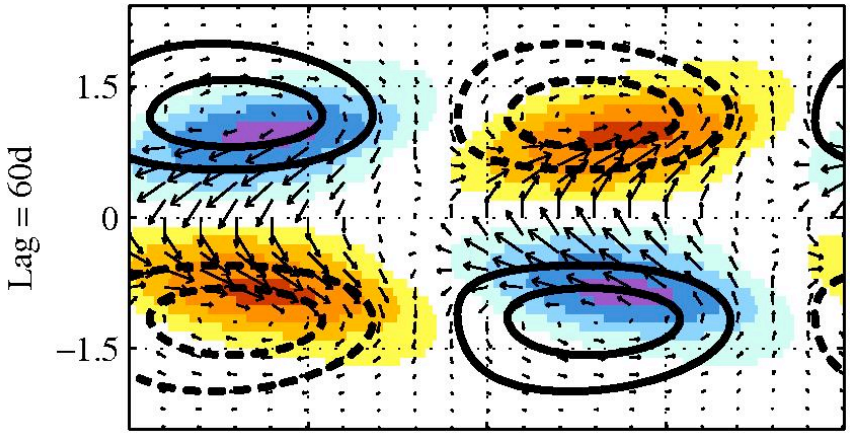
Final Structure

Vimont 2011 (*J. Clim.*)

Symmetric evolution



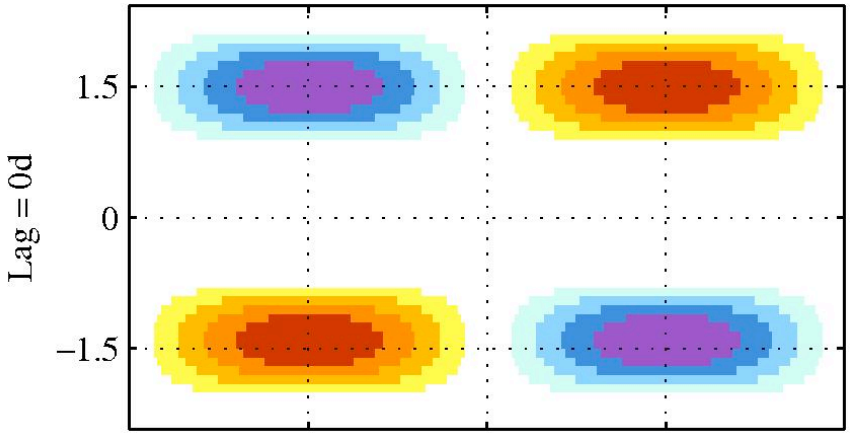
Initial Structure



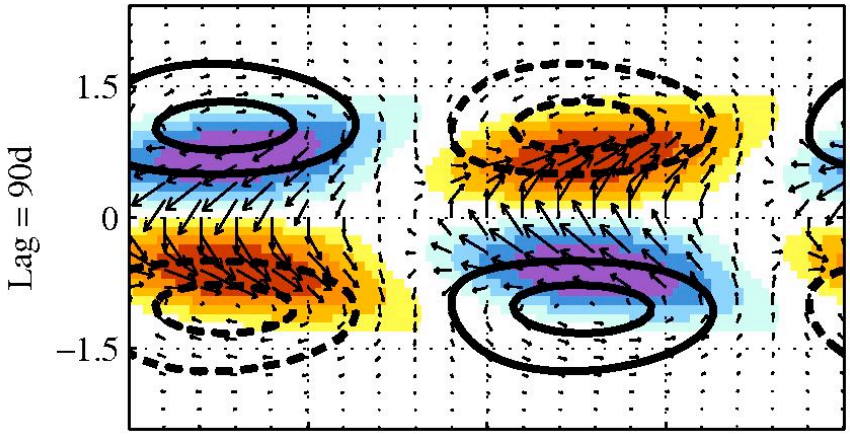
Final Structure

Vimont 2011 (*J. Clim.*)

Symmetric evolution



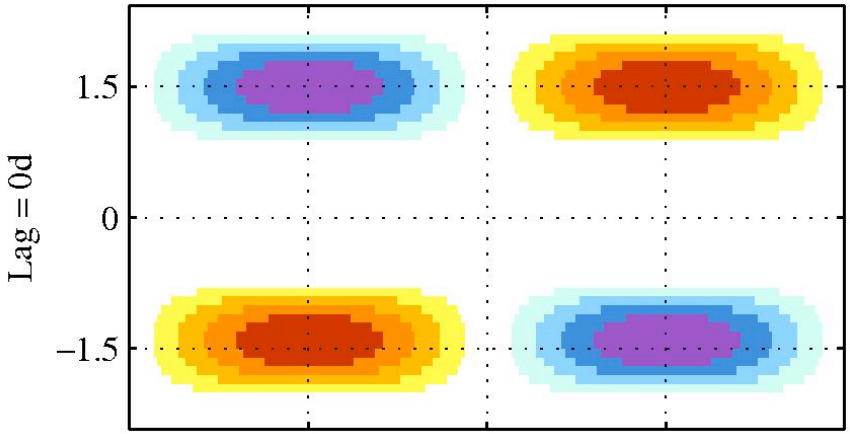
Initial Structure



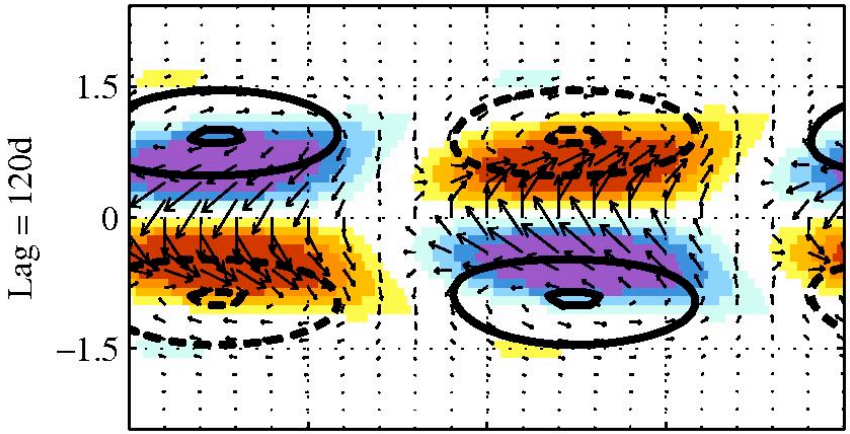
Final Structure

Vimont 2011 (*J. Clim.*)

Symmetric evolution



Initial Structure



Final Structure

Vimont 2011 (*J. Clim.*)

Conclusions

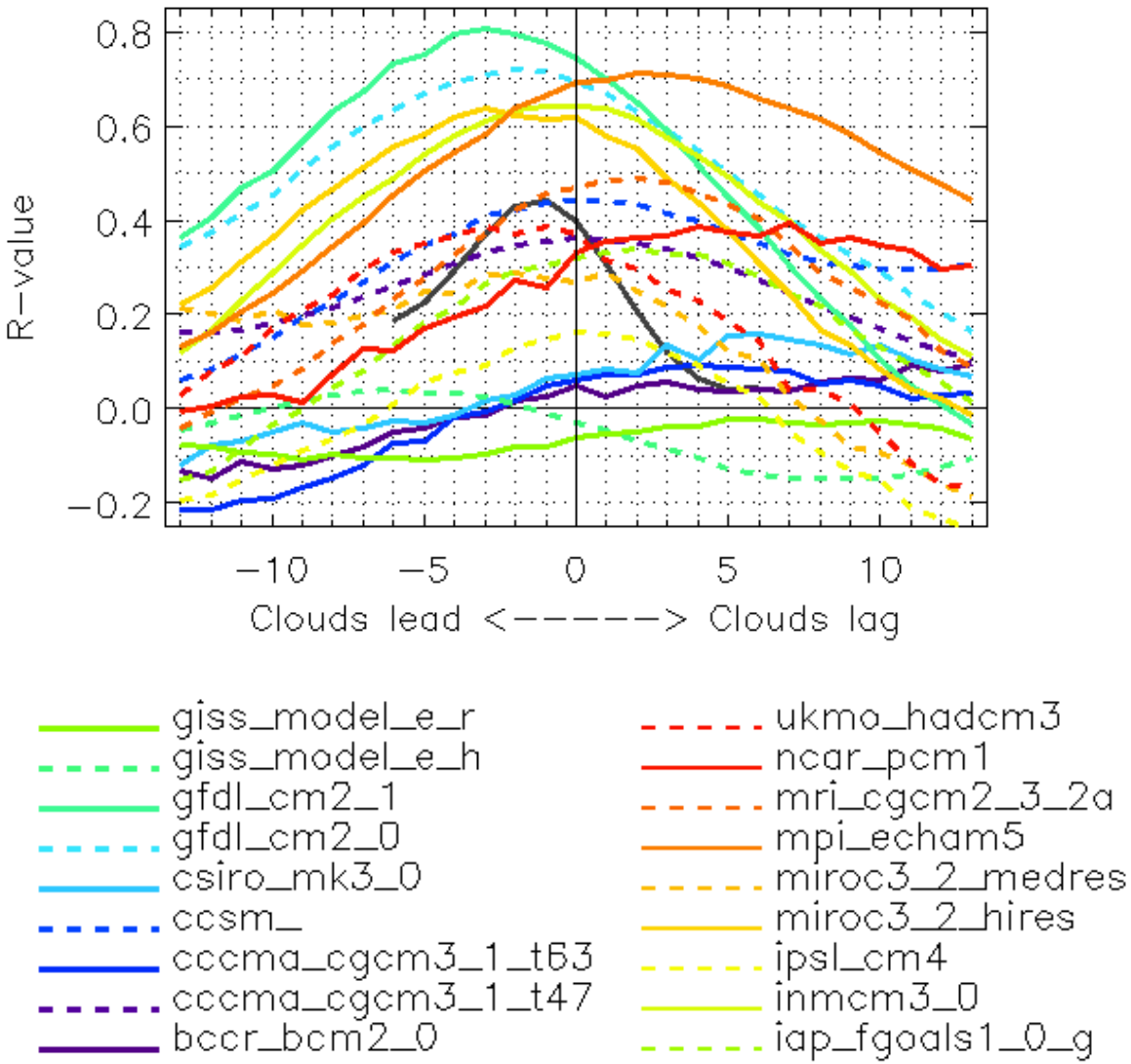
1) Observation evidence supported by theoretical arguments suggest that tropical Atlantic stratQ are an integral part of the AMM

2) Cloud cover variability may be externally exciting the AMM via CRF

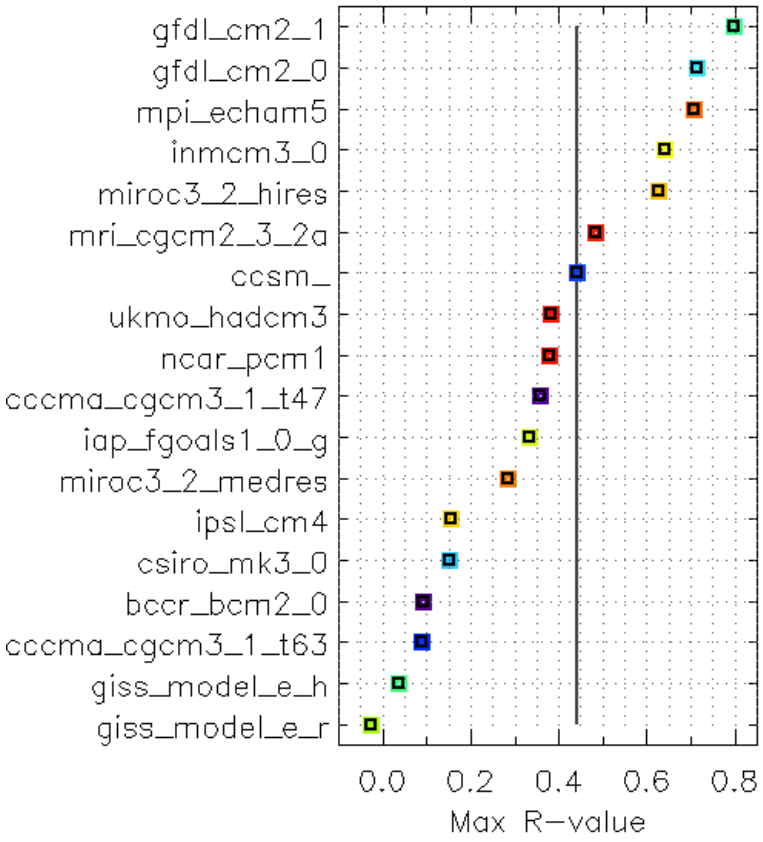
3) Some CMIP3 models are able to reproduce the observed relationship between low clouds and AMM

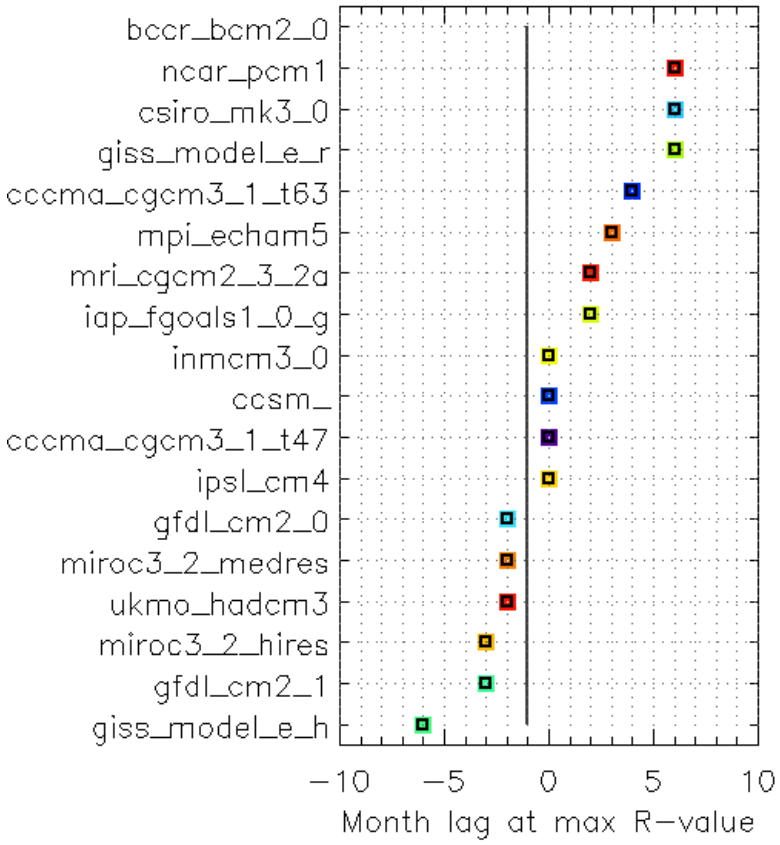
4) Next step: additional observational analysis + coupled experiments (CAM+SOM)

Smoothed cross-correlation function

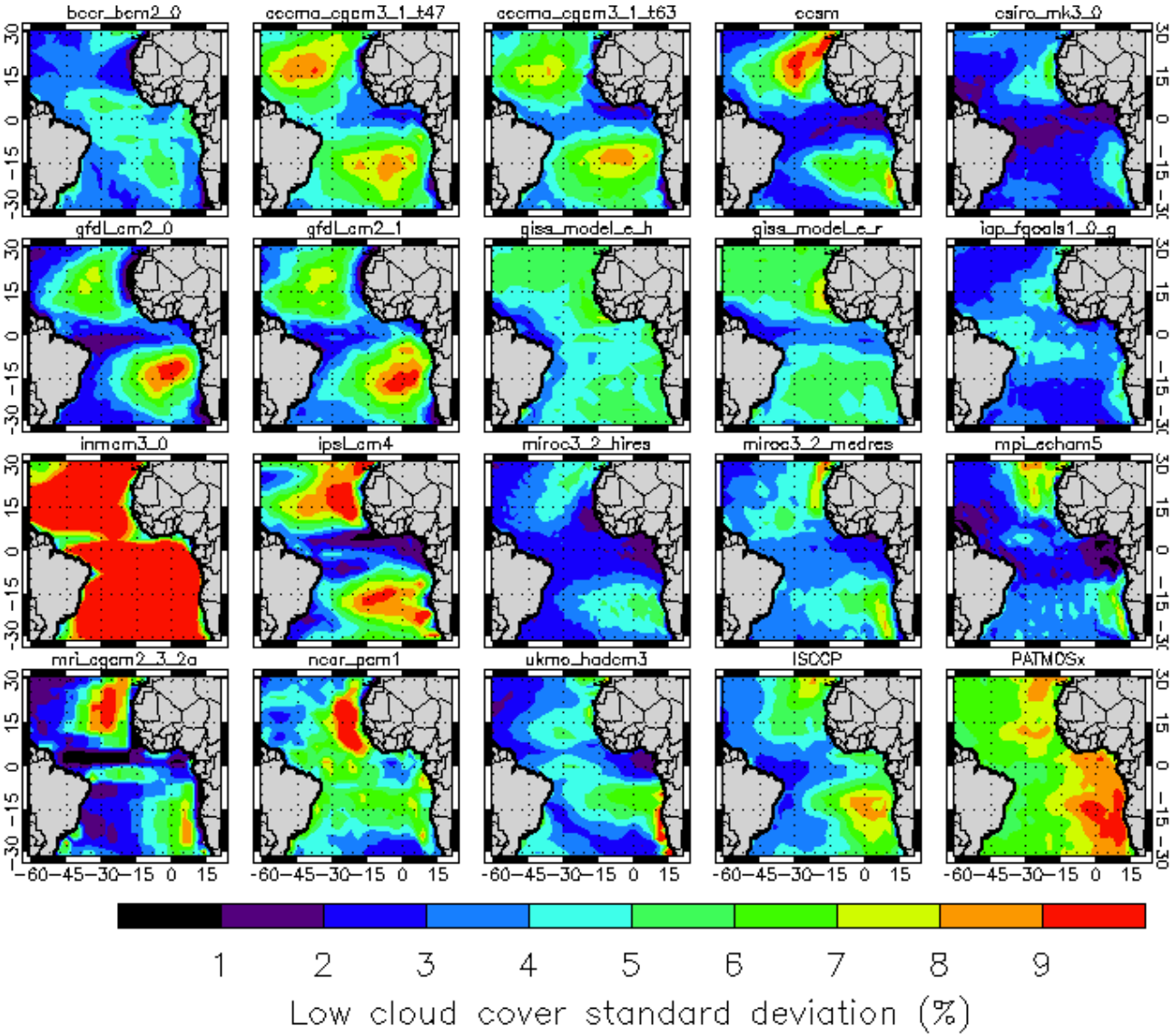


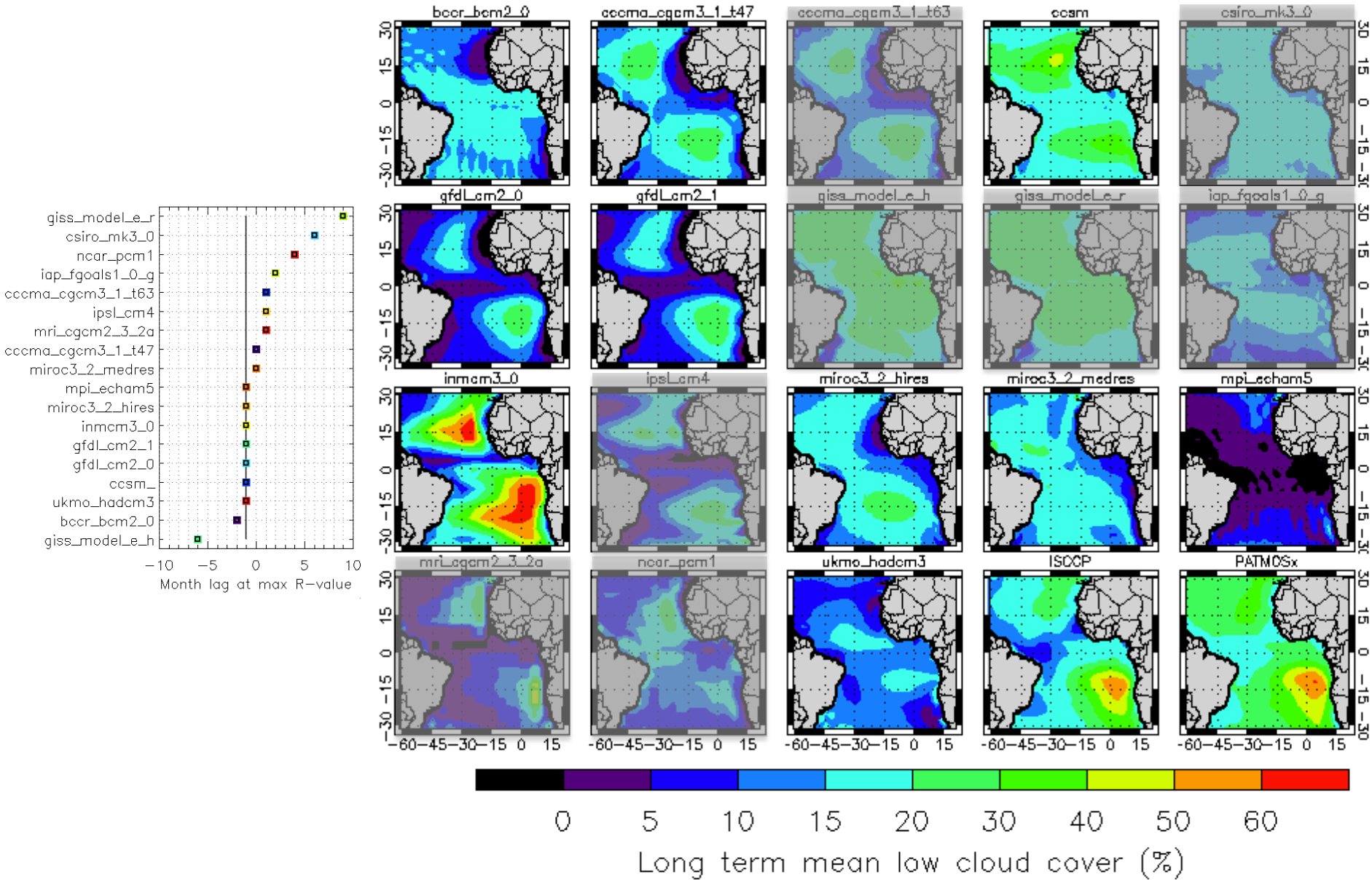
Smoothed cross-correlation function





Comparison to CMIP3 models (1950–2000)

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miroc3_2_medres
mpi_echam5
miroc3_2_hires
inmcm3_0
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gfdl_cm2_0
ccsm_
ukmo_hadcm3
bccr_bcm2_0
giss_model_e_h
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Month lag at max R−value
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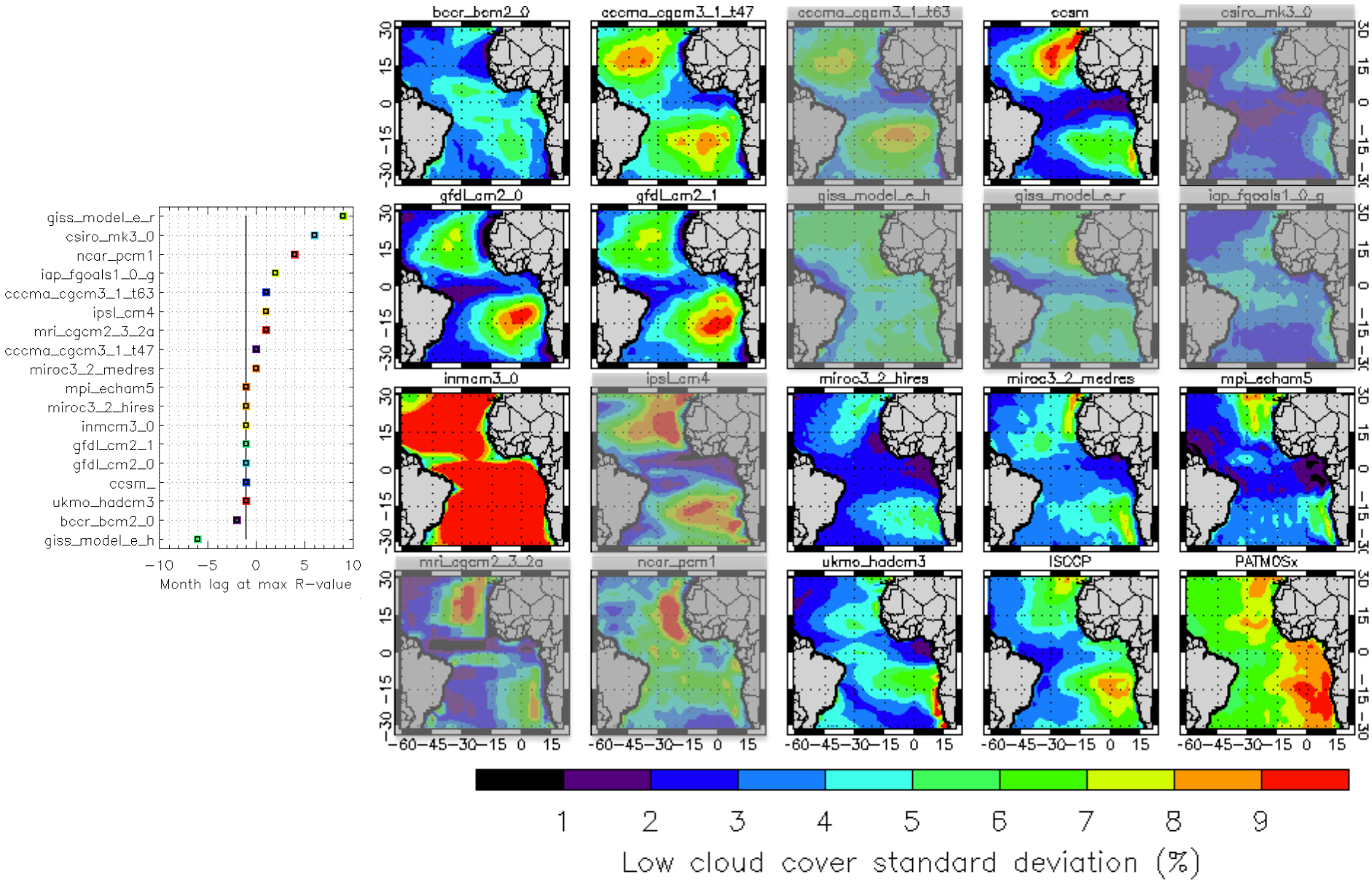
mpi_echam5
mri_cgcm2_3_2a
ncar_pcm1
ukmo_hadcm3
ISCCP
PATMOSx
30 15 0 −15 −30
−60 −45 −30 −15 0 15
0 5 10 15 20 30 40 50 60
Long term mean low cloud cover (%)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mpi_echam5
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inmcm3_0
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gfdl_cm2_0
ccsm_
ukmo_hadcm3
bccr_bcm2_0
giss_model_e_h
−10 −5 0 5 10
Month lag at max R−value
bccr_bcm2_0
cccma_cgcm3_1_t47
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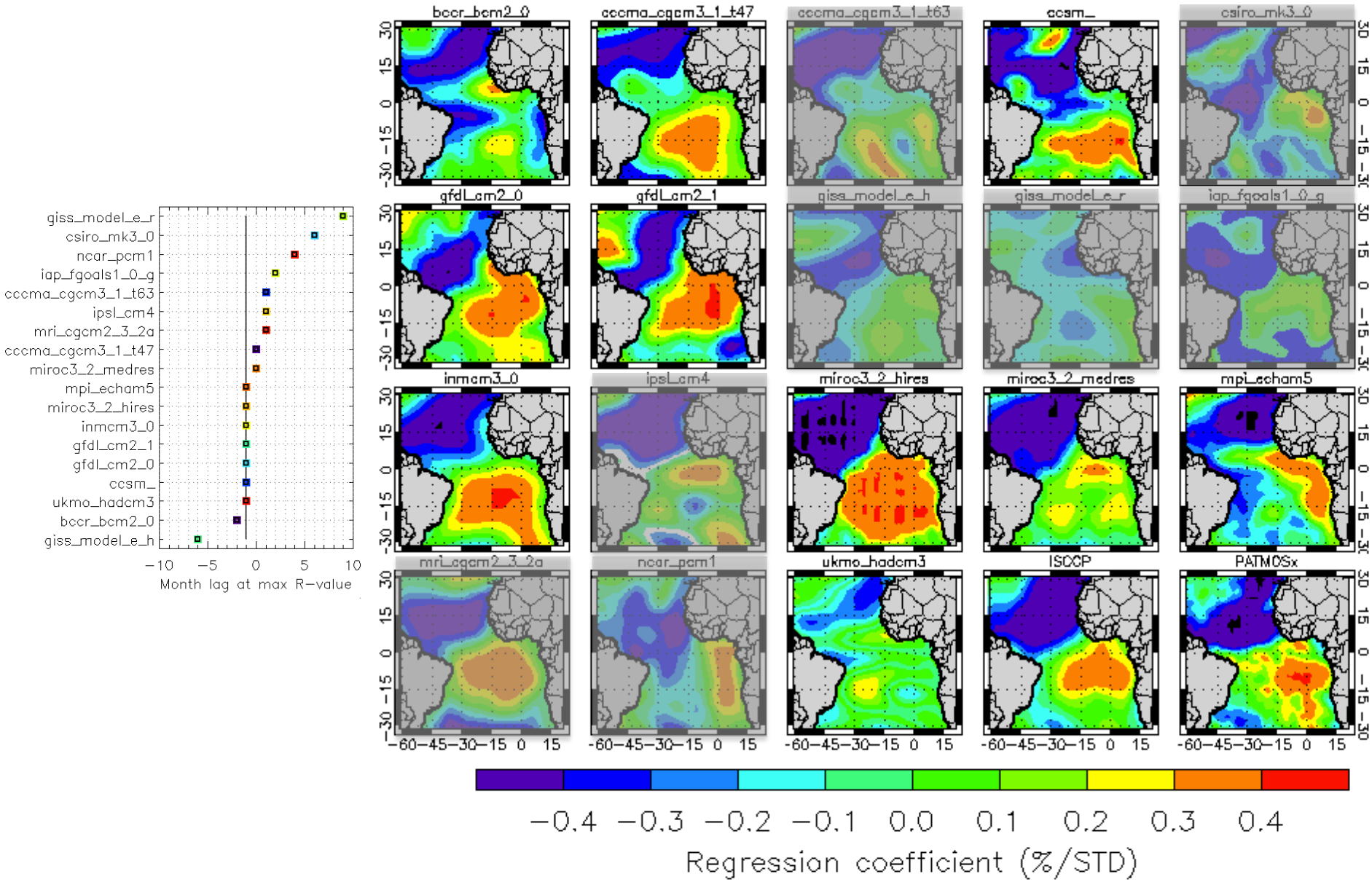
ccsm
csiro_mk3_0
gfdl_cm2_0
gfdl_cm2_1
giss_model_e_h
giss_model_e_r
iap_fgoals1_0_g
inmcm3_0
ipsl_cm4
miroc3_2_hires
miroc3_2_medres
mpi_echam5
mri_cgcm2_3_2a
ncar_pcm1
ukmo_hadcm3
ISCCP
PATMOSx
30 15 0 −15 −30
−60 −45 −30 −15 0 15
1 2 3 4 5 6 7 8 9
Low cloud cover standard deviation (%)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miroc3_2_hires
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Month lag at max R−value
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ISCCP
PATMOSx
30 15 0 −15 −30
−60 −45 −30 −15 0 15
−0.4 −0.3 −0.2 −0.1 0.0 0.1 0.2 0.3 0.4
Regression coefficient (%/STD)