Figure 1

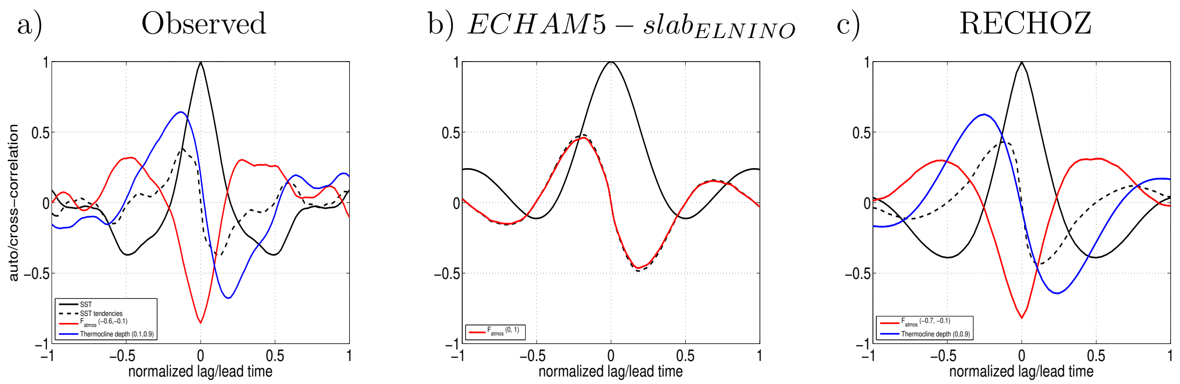

Figure 1.: Lag/lead auto- and cross-correlations with the NINO3 SST. Auto-correlation of the NINO3 SST (solid black line), cross-correlation with the NINO3 SST tendencies (dashed black line), with NINO3 F_{atmos} (red line) and tropical Pacific h (blue line). (a) for observations, (b) for the $ECHAM5 - slab_{ELNINO}$ simulation and (c) for the RECHOZ simulation. The x-axis is normalized by the El Nino oscillation period of each dataset; see methods section for details. The numbers in the legends refer to the correlation values of the forcing curves with the SST and the SST tendency curves, as defined in the methods section.

Figure 2

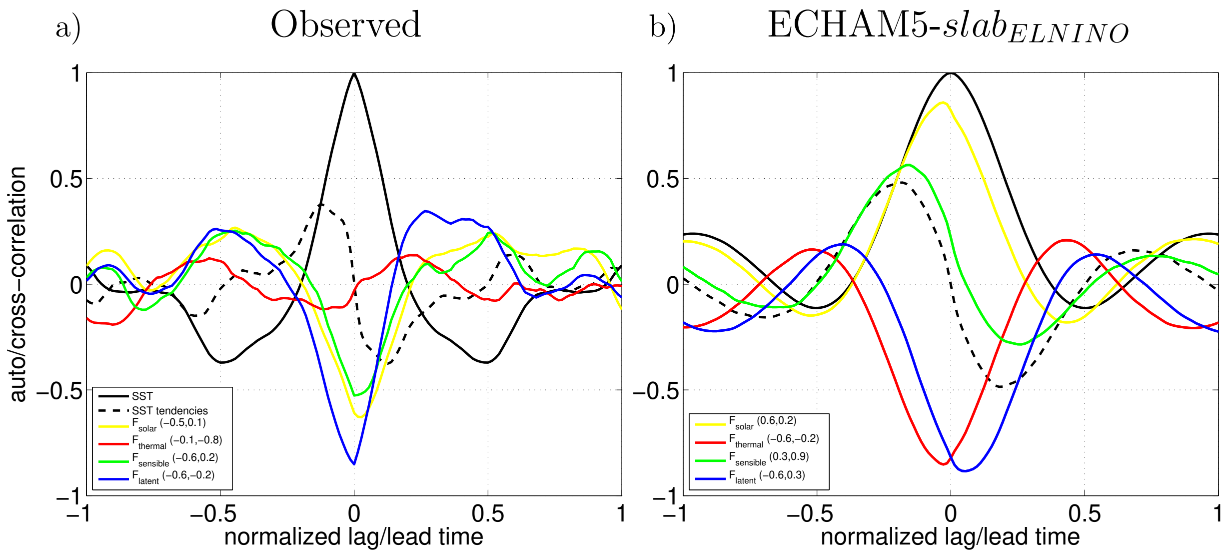

Figure 2.: Lag/lead auto- and cross-correlations with the NINO3 SST, as in Fig. 1, but for cross-correlations with the heat flux components: F_{solar} (yellow), $F_{thermal}$ (red), F_{sense} (green) and F_{latent} (blue). All heat fluxes are defined positive downward. (a) for observations and (b) $ECHAM5 - slab_{ELNINO}$. The two values in brackets are the correlations with SST autocorrelation and SST tendencies curves, respectively.

Figure 3

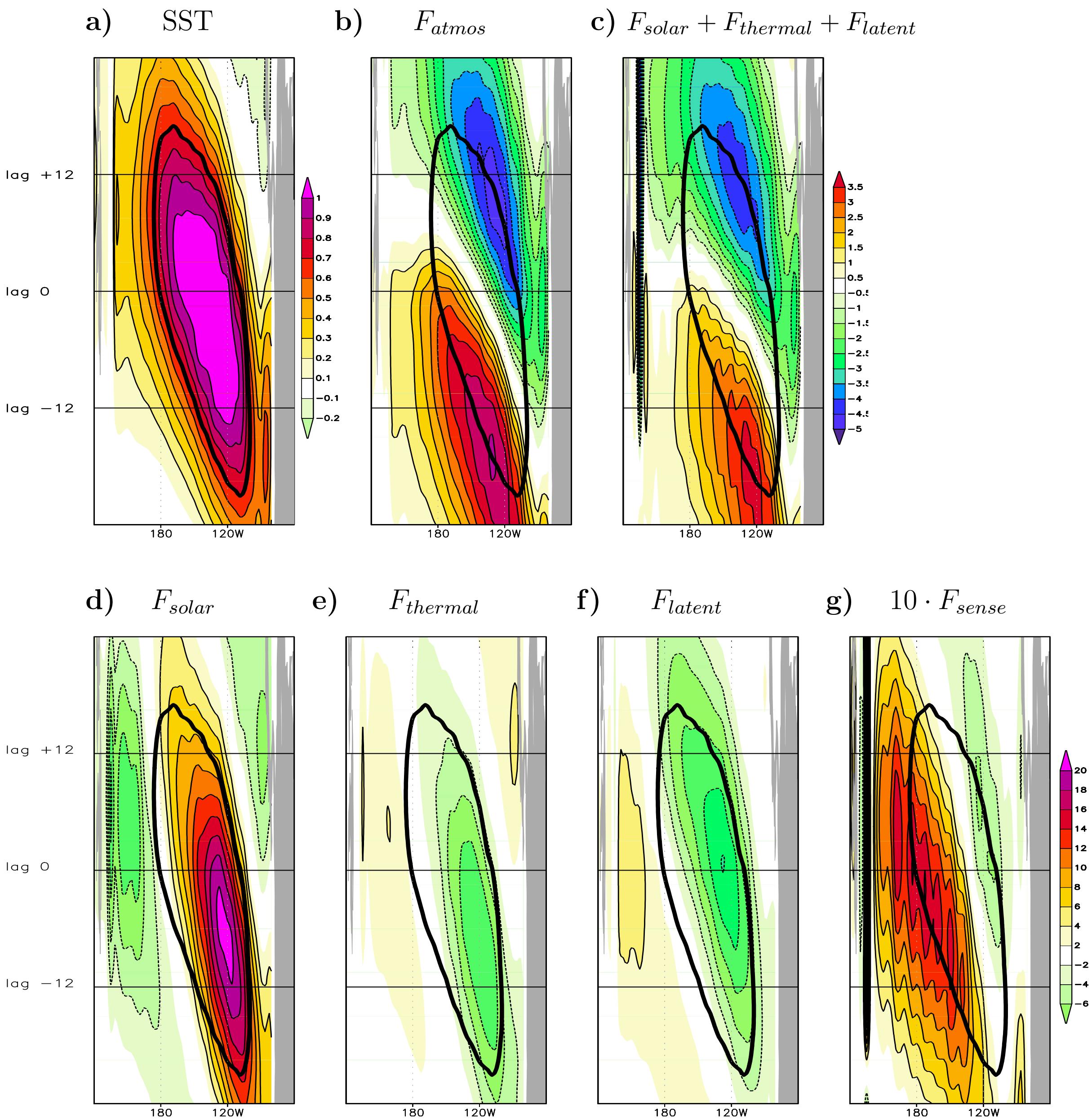

Figure 3.: Hoevmoeller diagrams along the equatorial (3^oS to 3^oN) Pacific of lag/lead regressions with the SST in the NINO3.4 region (170^oW to 120^oW / 5^oS to 5^oN) in the $ECHAM5 - slab_{ELNINO}$ simulation. (a) Auto-regression in [K/K], (b) F_{atmos}, (c) the sum $F_{solar} + F_{thermal} + F_{latent}$, (d) F_{solar}, (e) $F_{thermal}$, (f) F_{latent} and (g) F_{sense}. Values in (b)-(g) are in [W/m2/K]. The y-axis is lag/lead month. The solid thick line in all panels is the 0.7 contour line from (a).

Figure 4

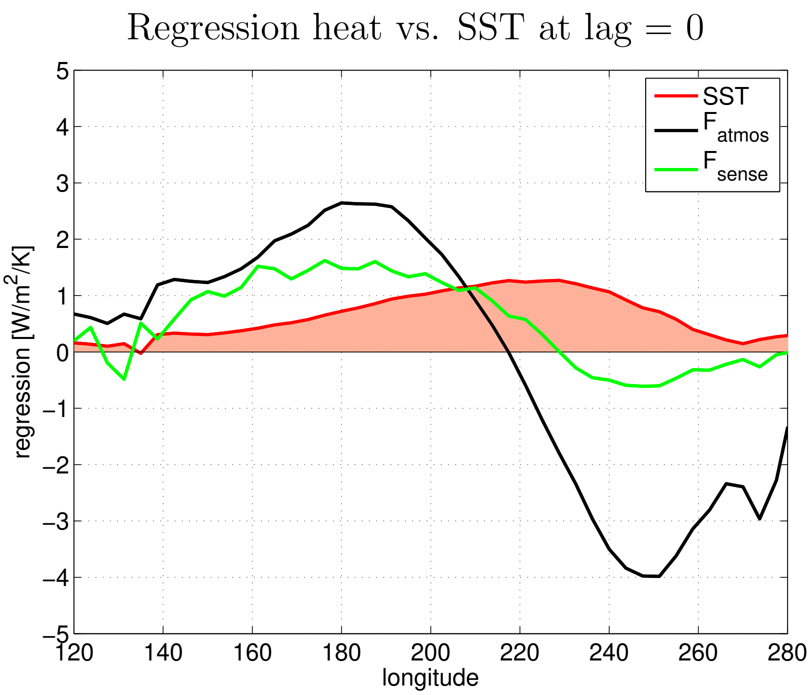

Figure 4.: Regressions of F_{atmos} and F_{sense} with the SST in the NINO3.4 region in the $ECHAM5 - slab_{ELNINO}$ simulation as in Fig. 3, but only at lag = 0. SST auto-regression in K/K.

Figure 5

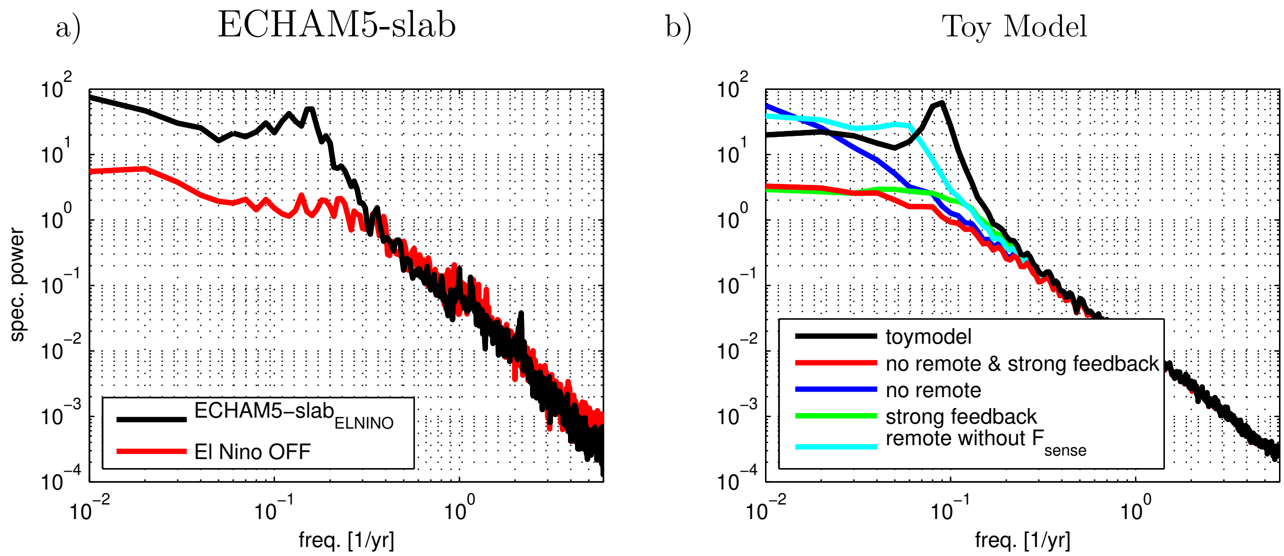

Figure 5: (a) Power spectrum of the $ECHAM5 - slab_{ELNINO}$ simulation and the mean spectrum for the ECHAM5-slab El Nino OFF simulations. (b) Power spectra of different toy models. See text for details.

Figure 6

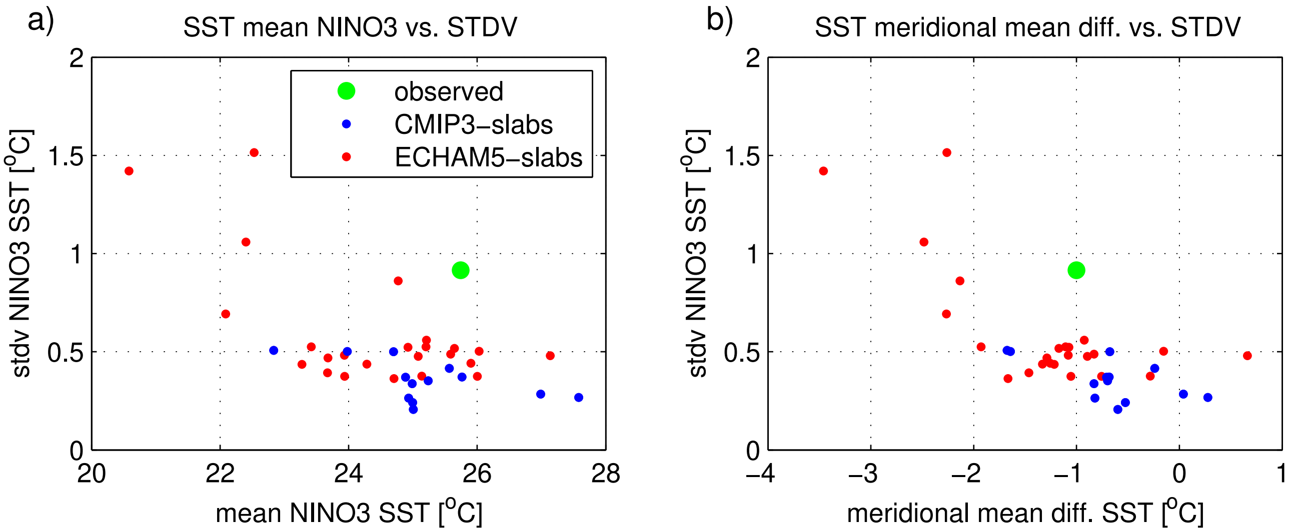

Figure 6: NINO3 SST standard deviation (STDV) as function of (a) the mean NINO3 SST and (b) the mean meridional SST difference between NINO3 region minus the mean of the regions 5^o to north and south for different simulations and observations.

Figure 7

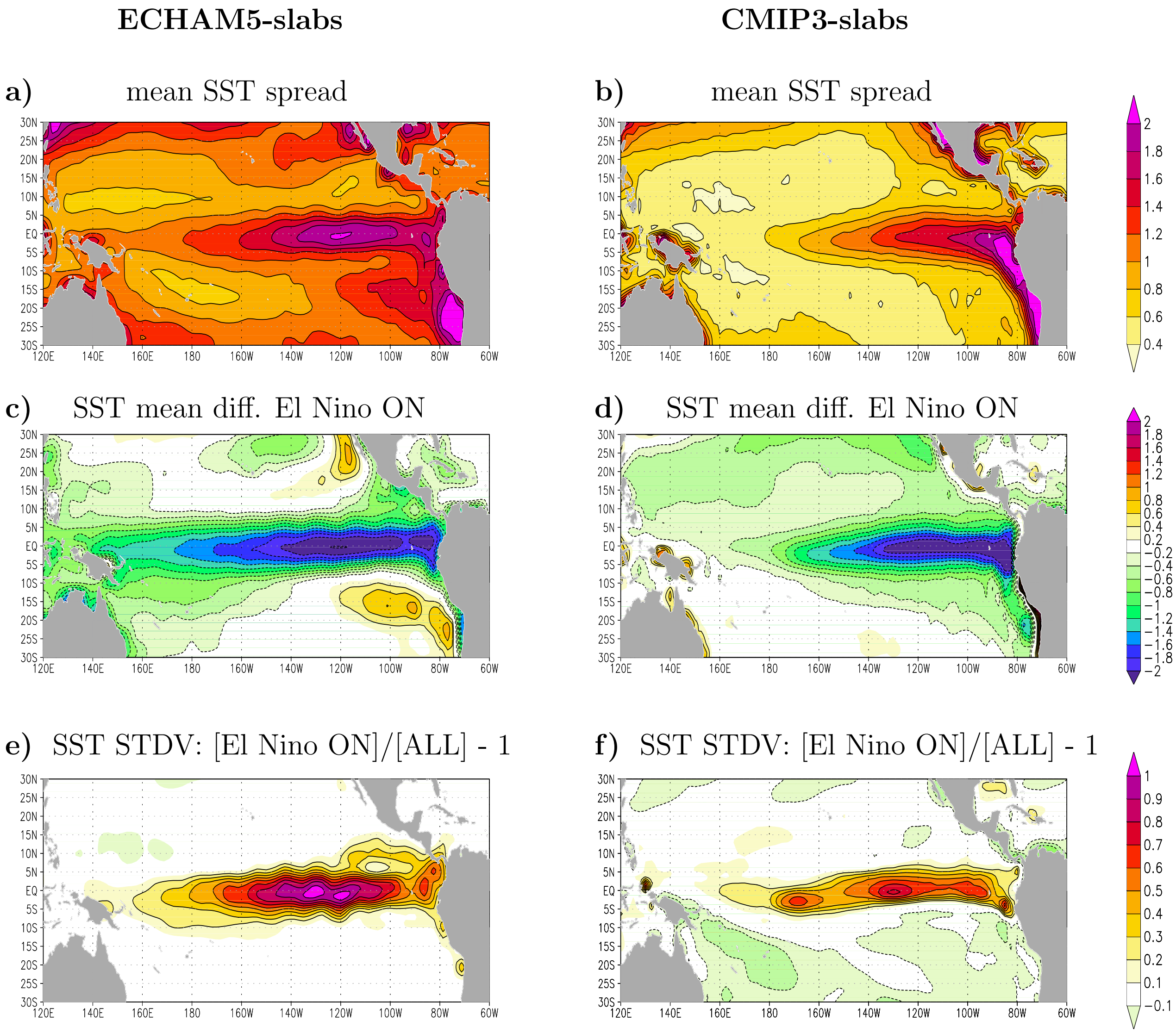

Figure 7: Spread (root-mean-square error) of the monthly mean SST climatologies in the ECHAM5-slab ensemble relative to the ensemble monthly mean SST climatologies. Units in ^oC. (b) Same as (a), but for the CMIP3-slab ensemble. (c) The mean difference in the SST of the 6 ECHAM5 simulations with the negative meridional mean SST difference $< -1.8^oC$ (as seen in Fig. 6) relative to the ensemble monthly mean SST climatologies. Units in ^oC. (d) The same as in (c), but for the 2 CMIP3-slab simulations with the negative meridional mean SST difference ¡-1.5oC. (e) The ratios of the STDV of the 6 simulations as in (c) relative to the STDV of all ECHAM5 simulations. (f) As in (e), but for the CMIP3-slab ensemble. Each model in the CMIP3-slab analysis contributes to the results with equal weight independent of the length of the simulation.

Figure 8

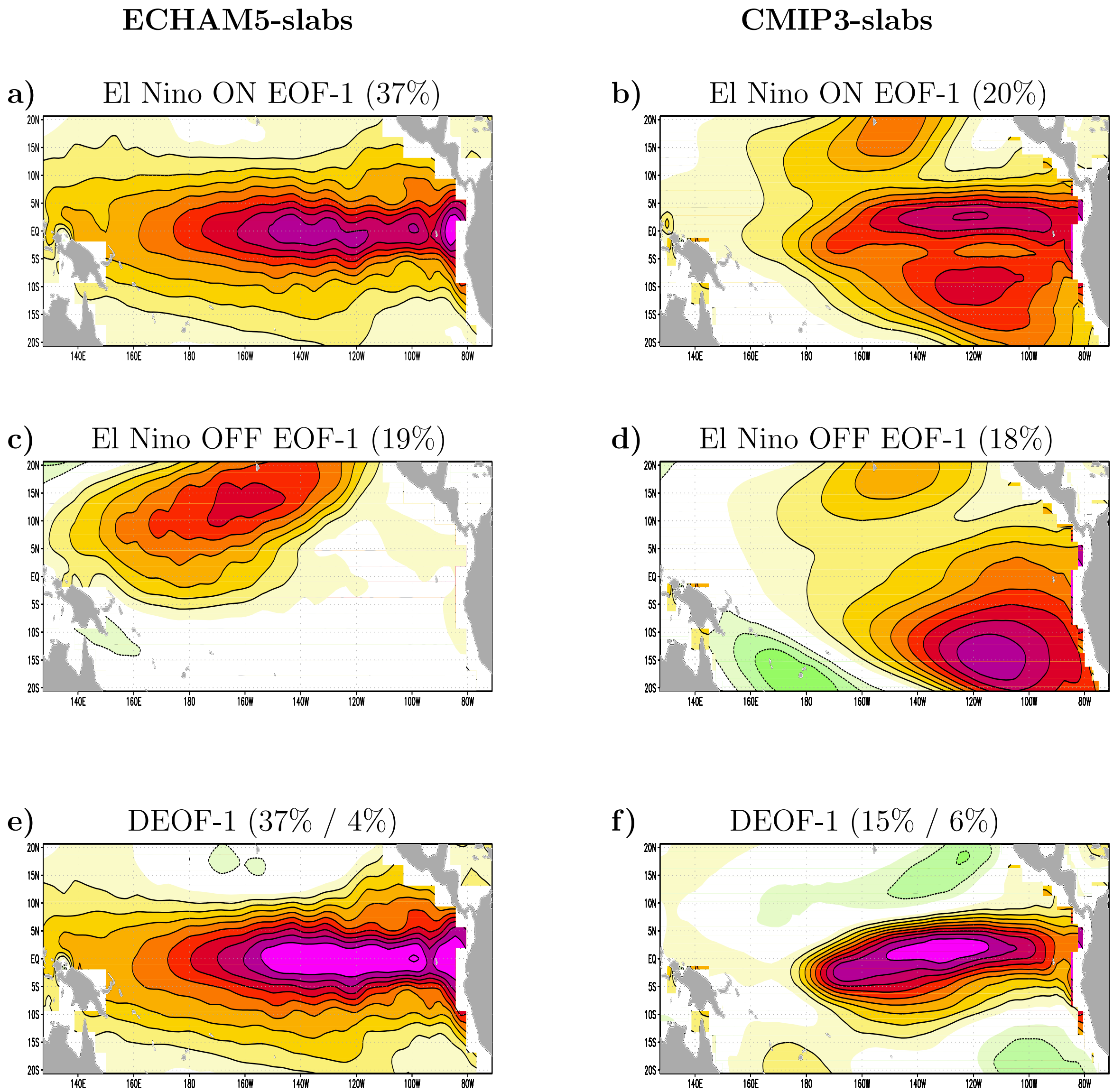

Figure 8.:(a) The EOF-1 pattern of the ECHAM5-slab El Nino ON simulations. (b) as (a) but for the CMIP3 ensemble. (c) and (d) as (a) and (b) for the El Nino OFF simulations. (e) the DEOF-1 mode of the ECHAM5-slab El Nino ON simulations relative to the El Nino OFF simulations. (f) as (e) but for the CMIP3 ensemble. The explained variances of each EOF-mode in (a) to (d) are shown in the heading. The first percentage values in (e) and (f) are the explained variances of the DEOF-1 modes in the El Nino ON simulations and the second values are for the El Nino OFF simulations.

Figure 9

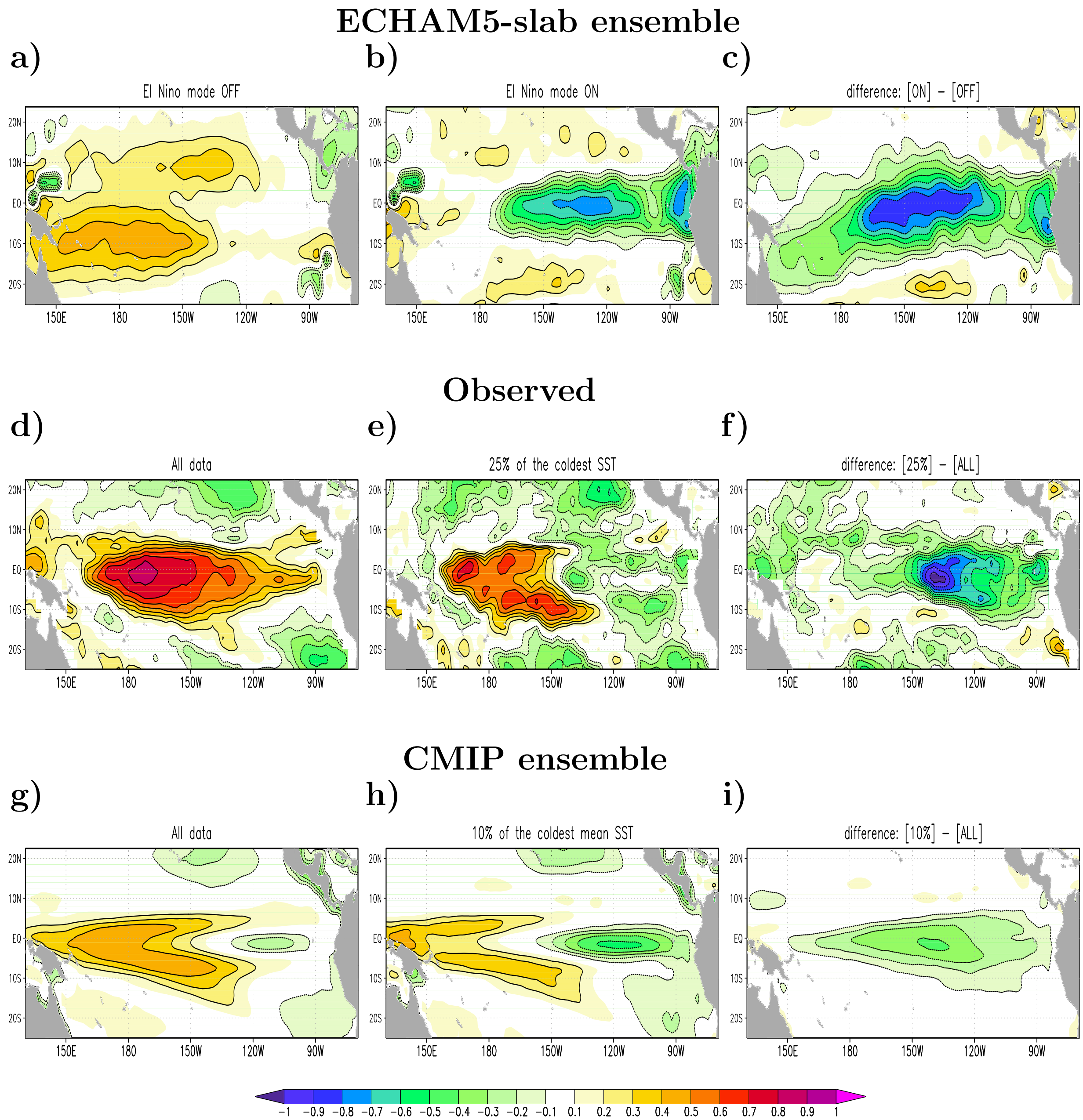

Figure 9: (a) Correlation of the total cloud cover with the SST at each grid point for the 18 ECHAM5 simulations with the meridional mean SST difference $> -1.8^oC$ (El Nino mode OFF). (b) As in (a) but for 6 ECHAM5 simulations with the meridional mean SST difference $< -1.8^oC$ (El Nino mode ON). (c) The difference between (b) minus (a). (d) As in (a) but for all observations. (e) As in (d), but only for those month that are the 25% of the coldest monthly mean NINO3 SST. (f) The difference between (e) minus (d). (g) As in (d), but for the CMIP CGCM ensemble. (h) As in (g), but only for the10% of the coldest monthly mean NINO3 SST in the whole CMIP CGCM ensemble. (i) The difference between (h) minus (g). The difference in in the central eq. Pacific in (c), (f) and (f) all pass the 99% confidence level of a students t-test.

Figure 10

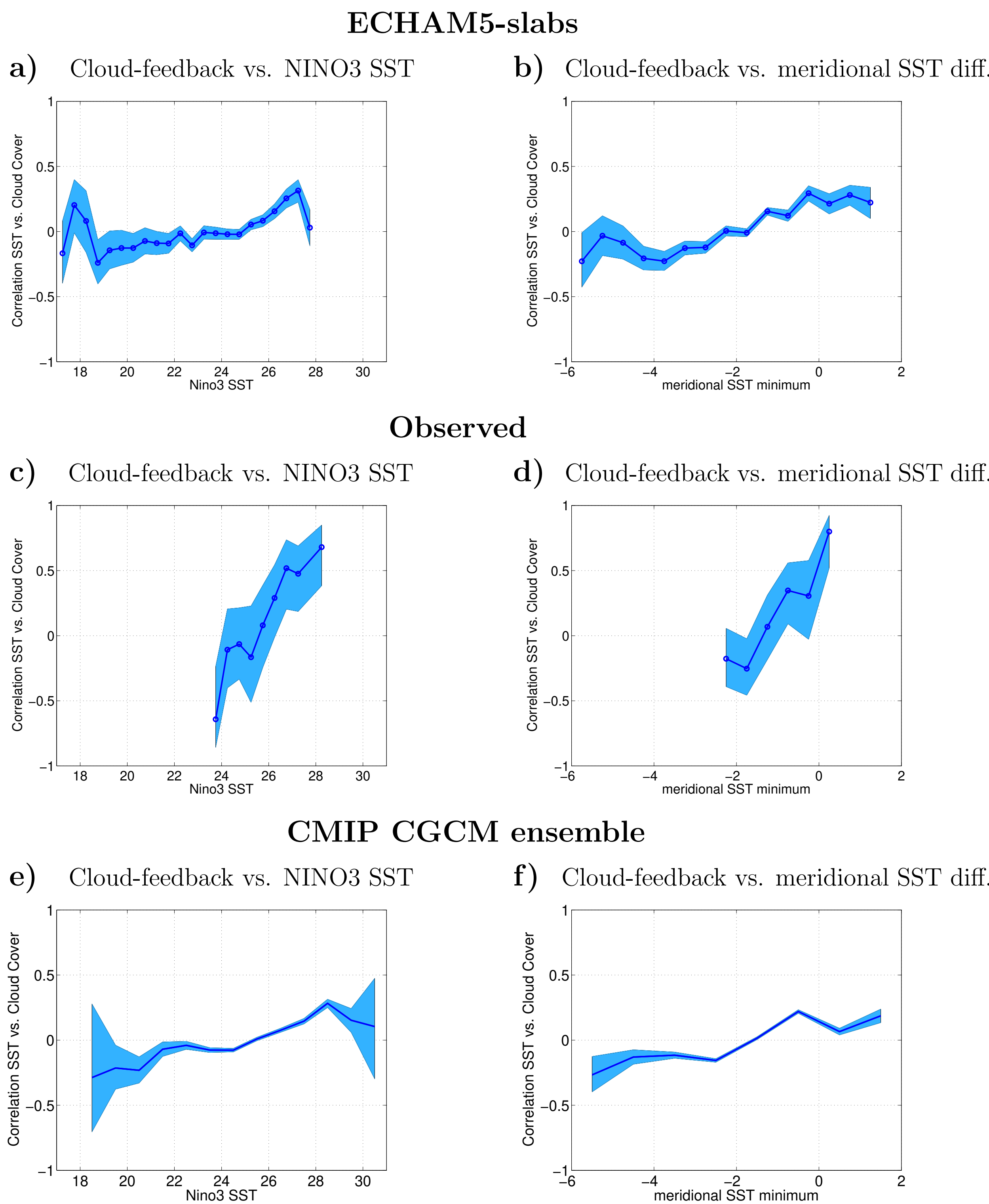

Figure 10: Correlation of the total cloud cover with SST over the NINO3 region as function of the (a) mean NINO3 SST and (b) mean meridional SST difference between NINO3 region minus the mean of the regions 5^0 to north and south for the ECHAM5 simulations. The correlation values are calculated independently for all data pairs with the SST-values within the SST-bin centered on the mean SST value of the points shown in the graph. Anomalies are defined relative to the sample space of each bin. The shaded areas mark the 90% confidence interval. (c) and (d) as in (a) and (b) but for the observations. (e) and (f) as in (a) and (b) but for the whole CMIP model ensemble.

Figure 11

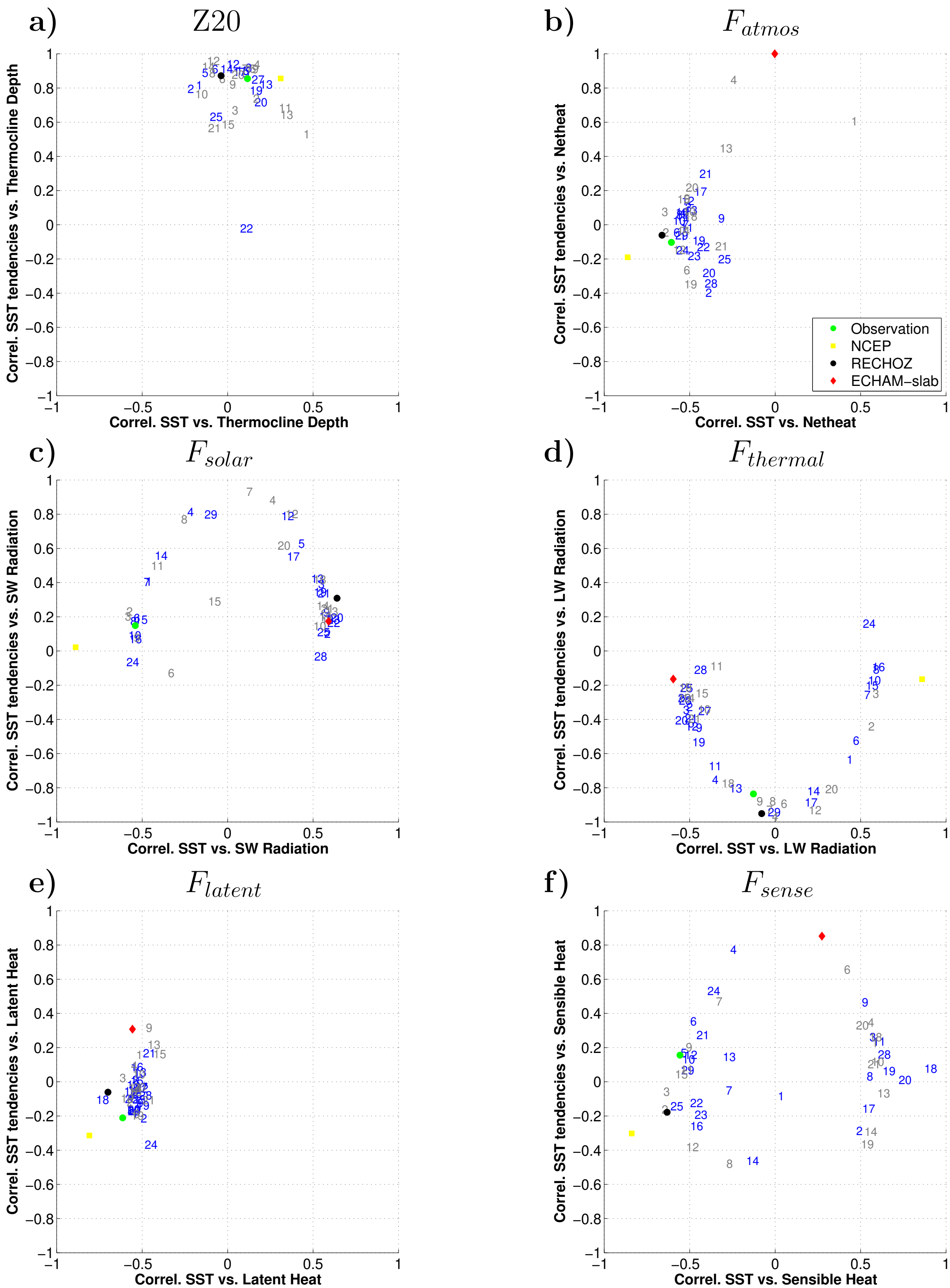

Figure 11: Correlation of CSST (x-axis) and CdSSTdt (y-axis) with (a) C_{Z20}, (b) C_{atmos}, (c) C_{solar} (d) $C_{thermal}$ (e) C_{latent} and (f) C_{sense} for the CMIP3 (grey numbers) and CMIP5 (blue numbers) simulations, the observations, the RECHOZ and the $ECHAM5 - slab_{ELNINO}$ simulation. The CMIP3 and CMIP5 model names corresponding to the numbers are listed in Tables 1 and 2. The correlations are estimated from the normalized lag -1 to 1 with lag-weighted contributions. See method section for details. Note, that some models are missing in some panels, due to missing data.

Figure 12

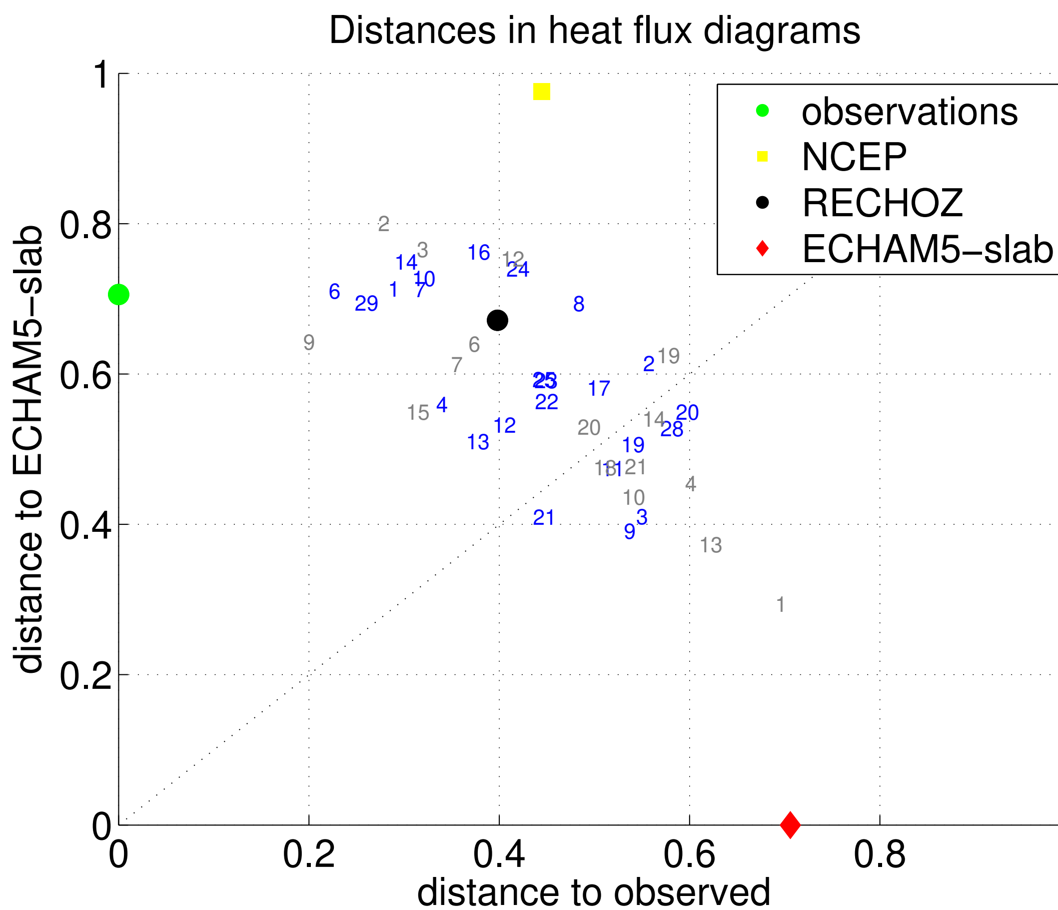

Figure 12: Distance (root-mean-square error) of the correlation values as shown in Fig. 11b-f for the CMIP3 (grey numbers) and CMIP5 (blue numbers) simulations, the observations, the RECHOZ and the $ECHAM5 - slab_{ELNINO}$ simulation relative to the observation (x-axis) and the $ECHAM5 - slab_{ELNINO}$ simulation (y-axis). Models with incomplete heat flux data are not included in this figure.

Figure 13

BCCR-BCM 2.0 model statistics

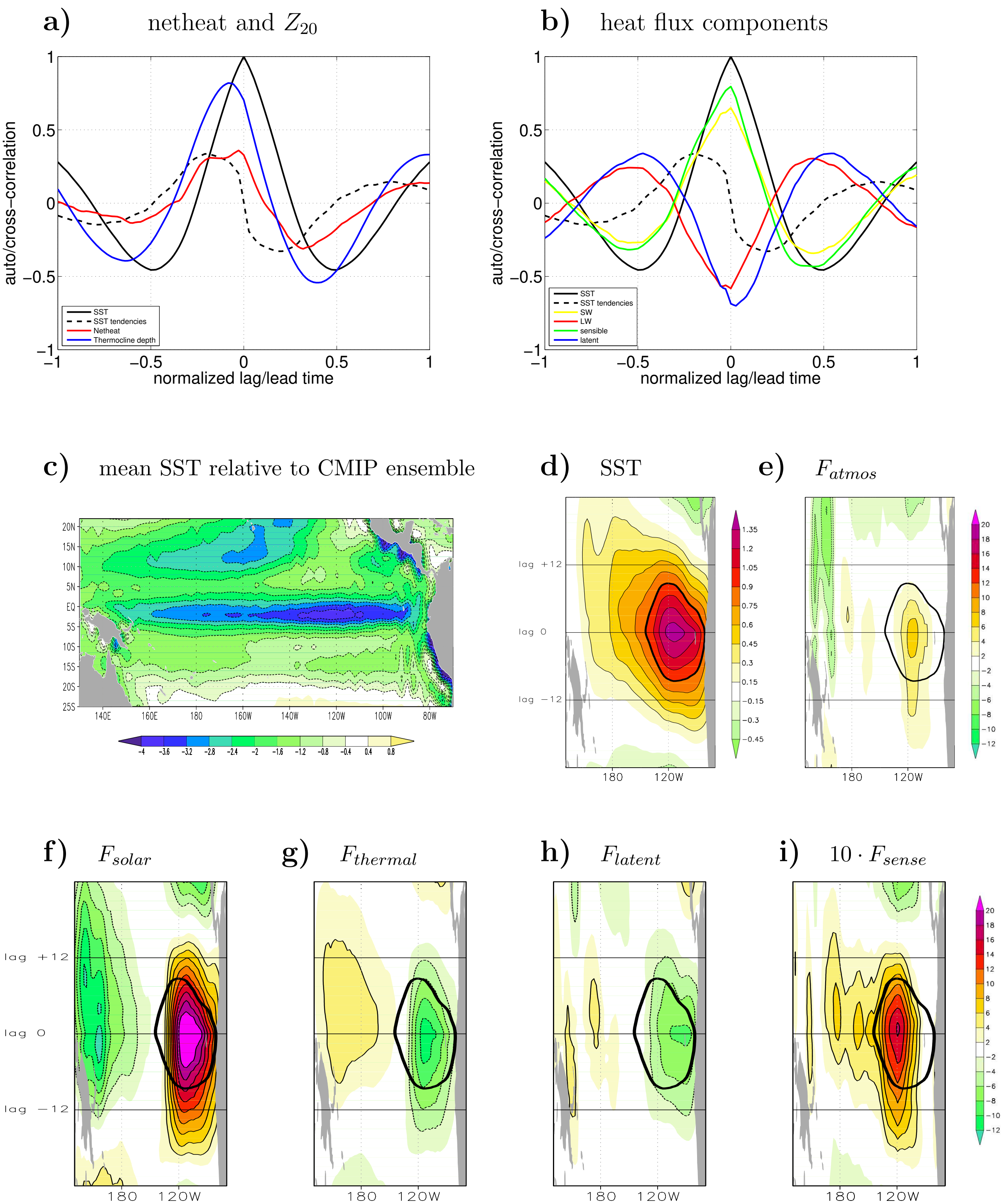

Figure 13: Statistics of the CMIP3 BCCR-BCM 2.0 model simulation: (a) and (b) lag/lead cross-correlations with SST as in Fig. 1 and 2, but relative to the NINO3 region. (c) The mean difference in the SST relative to the CMIP3 ensemble mean SST. (d) to (i) Hoevmoeller diagrams along the equatorial Pacific of lag/lead regressions with the SST as in Fig. 3, but relative to the NINO3 region.