## Figures



**Figure 1:** Global SST anomalies of the annual mean from six different LIS experiments output compared with MARGO data-set. Background color fill: simulated global pattern of annual mean sea surface temperature changes between the LGM and PI climate. The colors fill of the circles show the temperature anomalies as recorded by different proxy records, respectively.



-10 -8 -6 -4 -2 -1 -0.5 0.5 1 2



**Figure 2:** Global reconstructed SST trends of four proxies compared to simulated annual mean SST anomalies as calculated from the ensemble median mean of the models listed in PMIP3 (a) and IPSL-CM5A-LR (b). The colors fill of the circles show the temperature anomalies as recorded by MARGO proxy records. Background color fill: simulated global pattern of annual mean sea surface temperature changes between the LGM and PI climate.



**Figure 3:** Global SST anomalies of the annual mean LGM LIS experiment output, and temperature trends based on planktonic foraminifera, Mg/Ca, dinocyst, alkenones (U<sup>k</sup><sub>37</sub>), diatoms and radiolarian reconstructions of MARGO project. Background color fill: simulated annual mean SST changes between the Tarasov\_LIS and PI. The circles localize the three different proxy records, respectively.

LGMctl vs Foraminifera Best Fit Season

LGMctl vs MgCa Best Fit Season



LGMctl vs Dinoflagellates Best Fit Season



LGMctl vs UK37 Best Fit Season



LGMctl vs UK37 Seasonal Best Fit SST



Figure 4: (a) The circles localize the foraminifera, MgCa, dinoflagellates and U<sup>k</sup><sub>37</sub> records and the colors fill of the circles 35 represent the seasonal/annual mean in which the reconstruction agrees best with model. (b) Background color fill: simulated global pattern of annual mean sea surface temperature changes between the LGM and PI climate. Colors fill of the circles show the tempera- ture trend recorded by corresponding seasonal/annual mean shown in (a) at the sample locations.

LGMctl vs Fora Seasonal Best Fit SST

LGMctl vs MgCa Seasonal Best Fit SST





LGMctl vs Foraminifera Best Fit Depth

LGMctl vs Fora Depth Best Fit SST



LGMctl vs MgCa Best Fit Depth



LGMctl vs Dinoflagellates Best Fit Depth

LGMctl vs MgCa Depth Best Fit SST



LGMctl vs Dinoflagellates Depth Best Fit SST



LGMctl vs UK37 Best Fit Depth

LGMctl vs UK37 Depth Best Fit SST



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**Figure 5:** (a) The circles localize the foraminifera, MgCa, dinoflagellates and U<sup>k</sup><sub>37</sub> records and the colors fill of the circles represent the different depth (m) mean in which the reconstruction agrees best with model. (b) Background color fill: simulated global pattern of annual mean sea surface temperature changes between the LGM and PI climate. Colors fill of the circles show the temperature change recorded by corresponding depth mean shown in (a) at the sample locations.



**Figure 6:** The colors fill of the circles represent the seasonal/annual mean in which the reconstruction of foraminifera, MgCa, dinoflagellates and U<sup>k</sup><sub>37</sub> records agree best with ensemble median of all PMIP3 models.



45 Figure 7: The colors fill of the circles represent the different depth (m) mean in which the reconstruction of foraminifera, MgCa, dinoflagellates and U<sup>k</sup><sub>37</sub> records agree best with ensemble median of all PMIP3 models.

## Tables

 Table 1: Correlation and RMSE between COSMOS LIS models annual mean SST and MARGO project dataset and

 MARGO proxies annual mean SST

|            | MARGO      | Foraminifera | MgCa       | Dinoflagellates | U <sup>k</sup> <sub>37</sub> |  |
|------------|------------|--------------|------------|-----------------|------------------------------|--|
|            | R, RMSE    |              |            |                 |                              |  |
| LGMctl     | 0.14, 3.16 | 0.43, 2.68   | 0.51, 5.93 | -0.23, 6.43     | -0.04, 3.42                  |  |
| Gowan      | 0.10, 3.10 | 0.44, 2.54   | 0.64, 5.92 | -0.26, 6.64     | -0.09, 3.48                  |  |
| Ice6g      | 0.15, 3.54 | 0.47, 2.59   | 0.61, 5.91 | -0.24, 6.61     | -0.15, 3.54                  |  |
| Lambeck    | 0.15, 3.08 | 0.44, 2.61   | 0.57, 5.93 | -0.17, 6.36     | -0.05, 3.36                  |  |
| Licc       | 0.10, 3.12 | 0.45, 2.53   | 0.72, 5.89 | -0.22, 6.72     | -0.15, 3.68                  |  |
| Tarasov    | 0.16, 3.15 | 0.48,        | 0.68,      | -0.22,          | -0.17,                       |  |
| Median_LIS | 0.15, 3.08 | 0.48, 2.58   | 0.62, 5.90 | -0.23, 6.69     | -0.12, 3.57                  |  |

Table 2: Correlation and RMSE between best-fit season of COSMOS LIS SST and proxies annual mean SST

|            | Foraminifera | MgCa       | Dinoflagellates | U <sup>k</sup> <sub>37</sub> |  |  |
|------------|--------------|------------|-----------------|------------------------------|--|--|
|            | R, RMSE      |            |                 |                              |  |  |
| LGMctl     | 0.54, 2.52   | 0.59, 5.85 | 0.01, 4.88      | 0.19, 3.28                   |  |  |
| Gowan      | 0.59, 2.18   | 0.73, 5.68 | -0.01, 5.74     | 0.19, 3.18                   |  |  |
| Ісебд      | 0.59, 2.24   | 0.67, 5.67 | 0.00, 5.72      | 0.14, 3.26                   |  |  |
| Lambeck    | 0.57, 2.15   | 0.63, 5.66 | 0.09, 5.81      | 0.21, 3.27                   |  |  |
| Licc       | 0.60, 2.26   | 0.75, 5.70 | 0.01, 5.50      | 0.15, 3.12                   |  |  |
| Tarasov    | 0.60, 2.22   | 0.67, 5.67 | 0.01, 5.78      | 0.13, 3.29                   |  |  |
| Median_LIS | 0.59, 2.22   | 0.67, 5.67 | 0.02, 5.74      | 0.16, 3.25                   |  |  |

Table 3: Correlation and RMSE between best-fit depth of COSMOS LIS SST and proxies annual mean SST

|            | Foraminifera | MgCa         | Dinoflagellates | U <sup>k</sup> <sub>37</sub> |  |  |
|------------|--------------|--------------|-----------------|------------------------------|--|--|
|            | R, RMSE      |              |                 |                              |  |  |
| LGMctl     | 0.62, 2.10   | 0.65, 5.72   | 0.16, 4.57      | 0.36, 2.90                   |  |  |
| Gowan      | 0.65, 2.06   | 0.75, 5.71   | 0.39, 4.15      | 0.38, 2.85                   |  |  |
| Ісебд      | 0.64, 2.06   | 0.72, 5.69   | 0.11, 4.70      | 0.27, 3.03                   |  |  |
| Lambeck    | 0.65, 2.05   | 0.72, 5.71   | 0.08, 4.74      | 0.31, 2.95                   |  |  |
| Licc       | 0.66, 2.04   | 0.78, , 5.69 | 0.37, 4.24      | 0.33, 2.92                   |  |  |
| Tarasov    | 0.65, 2.05   | 0.71, 5.84   | 0.08, 4.78      | 0.28, 3.02                   |  |  |
| Median_LIS | 0.65, 2.05   | 0.72, 5.70   | 0.15, 4.63      | 0.31, 2.95                   |  |  |

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