

Table S1: Temperature in the LMS between 1995 and 2012, averaged over seasons and regions. The numbers correspond to the 1-minute mean data.

| Season | Region | Mean±stdev in K | Median in K | Number *1000 | Season | Region | Mean±stdev in K | Median in K | Number *1000 |
|--------|-------------------|--------------------|----------------|-----------------|--------|----------------------|--------------------|----------------|-----------------|
| MAM | North Canada | 222.2±4.3 | 222.8 | 42 | MAM | Greenland | 223.3±3.3 | 223.4 | 78 |
| JJA | | 226.1±2.1 | 225.8 | 28 | JJA | | 226.9±1.7 | 226.8 | 80 |
| SON | | 221.6±3.0 | 221.8 | 44 | SON | | 223.3±2.6 | 223.7 | 81 |
| DJF | | 218.4±4.2 | 218.2 | 73 | DJF | | 218.0±3.4 | 218.1 | 100 |
| MAM | Scandinavia | 221.9±3.8 | 221.3 | 28 | MAM | North Asia | 220.2±4.5 | 221.1 | 122 |
| JJA | | 226.0±2.1 | 226.1 | 22 | JJA | | 227.3±1.6 | 227.6 | 94 |
| SON | | 221.3±2.5 | 221.8 | 23 | SON | | 219.8±2.7 | 220.2 | 103 |
| DJF | | 216.4±2.6 | 216.6 | 20 | DJF | | 214.0±1.9 | 213.8 | 82 |
| MAM | North America | 222.8±1.9 | 222.8 | 145 | MAM | North Atlantic | 223.3±1.8 | 223.6 | 374 |
| JJA | | 225.2±1.2 | 225.3 | 81 | JJA | | 226.4±0.9 | 226.3 | 309 |
| SON | | 223.2±2.1 | 223.5 | 107 | SON | | 224.6±1.9 | 224.4 | 291 |
| DJF | | 221.6±1.9 | 221.3 | 185 | DJF | | 221.2±1.6 | 221.2 | 342 |
| MAM | Europe | 219.9±1.9 | 220.1 | 283 | MAM | Central Asia | 219.8±2.5 | 220.0 | 199 |
| JJA | | 224.8±1.6 | 224.7 | 209 | JJA | | 226.2±1.3 | 226.4 | 81 |
| SON | | 220.8±2.1 | 220.4 | 183 | SON | | 220.6±2.2 | 220.5 | 129 |
| DJF | | 218.1±1.7 | 217.9 | 252 | DJF | | 217.9±2.5 | 217.4 | 184 |
| MAM | Middle America | - | - | 0 | MAM | Tropical Atlantic | - | - | 0 |
| JJA | | - | - | 0 | JJA | | - | - | 0 |
| SON | | - | - | 0 | SON | | - | - | 0 |
| DJF | | - | - | 0 | DJF | | - | - | 0 |
| MAM | North Africa | - | - | 0 | MAM | Tropical Asia | - | - | 0 |
| JJA | | - | - | 0 | JJA | | - | - | 0 |
| SON | | - | - | 0 | SON | | - | - | 0 |
| DJF | | - | - | 0 | DJF | | - | - | 0 |
| MAM | South America | - | - | 0 | MAM | South Africa | - | - | 0 |
| JJA | | - | - | 0 | JJA | | - | - | 0 |
| SON | | - | - | 0 | SON | | - | - | 0 |
| DJF | | - | - | 0 | DJF | | - | - | 0 |

Table S2: Temperature in the TPL between 1995 and 2012, averaged over seasons and regions. The numbers correspond to the 1-minute mean data.

| Season | Region | Mean±stdev in K | Median in K | Number *1000 | Season | Region | Mean±stdev in K | Median in K | Number *1000 |
|--------|-------------------|--------------------|----------------|-----------------|--------|----------------------|--------------------|----------------|-----------------|
| MAM | North Canada | 214.1±2.0 | 214.5 | 3 | MAM | Greenland | 214.1±2.5 | 214.4 | 16 |
| JJA | | 218.5±1.4 | 218.2 | 8 | JJA | | 219.7±1.1 | 219.6 | 30 |
| SON | | 215.9±2.3 | 216.5 | 4 | SON | | 216.5±2.7 | 217 | 20 |
| DJF | | 209.8±1.4 | 210 | 6 | DJF | | 210.6±2.3 | 210.6 | 23 |
| MAM | Scandinavia | 213.6±3.9 | 215.4 | 2 | MAM | North Asia | 212.4±3.3 | 212.6 | 26 |
| JJA | | 218.9±1.9 | 218.8 | 7 | JJA | | 219.2±1.3 | 219.1 | 54 |
| SON | | 215.5±2.7 | 215.4 | 4 | SON | | 213.3±2.3 | 213.5 | 34 |
| DJF | | 209.6±2.0 | 210.1 | 3 | DJF | | 208.4±1.8 | 208.5 | 17 |
| MAM | North America | 215.4±1.7 | 215.3 | 64 | MAM | North Atlantic | 214.3±1.7 | 214.4 | 197 |
| JJA | | 219.3±1.4 | 219.3 | 61 | JJA | | 219.2±1.2 | 219.4 | 229 |
| SON | | 217.2±1.9 | 217.4 | 53 | SON | | 216.9±1.9 | 217 | 453 |
| DJF | | 214.4±1.6 | 214.4 | 54 | DJF | | 212.4±1.4 | 212.2 | 136 |
| MAM | Europe | 214.2±1.5 | 214.4 | 168 | MAM | Central Asia | 214.4±2.0 | 214.4 | 113 |
| JJA | | 219.4±1.5 | 219.4 | 163 | JJA | | 219.4±1.5 | 219.4 | 103 |
| SON | | 215.3±1.9 | 215.2 | 148 | SON | | 214.9±2.0 | 215.3 | 92 |
| DJF | | 212.5±1.4 | 212.4 | 130 | DJF | | 212.7±2.4 | 212.6 | 61 |
| MAM | Middle America | - | - | 0 | MAM | Tropical Atlantic | - | - | 0 |
| JJA | | - | - | 0 | JJA | | - | - | 0 |
| SON | | - | - | 0 | SON | | - | - | 0 |
| DJF | | - | - | 0 | DJF | | - | - | 0 |
| MAM | North Africa | - | - | 0 | MAM | Tropical Asia | - | - | 0 |
| JJA | | - | - | 0 | JJA | | - | - | 0 |
| SON | | - | - | 0 | SON | | - | - | 0 |
| DJF | | - | - | 0 | DJF | | - | - | 0 |
| MAM | South America | - | - | 0 | MAM | South Africa | - | - | 0 |
| JJA | | - | - | 0 | JJA | | - | - | 0 |
| SON | | - | - | 0 | SON | | - | - | 0 |
| DJF | | - | - | 0 | DJF | | - | - | 0 |

Table S3: Temperature in the UT between 1995 and 2012, averaged over seasons and regions. The numbers correspond to the 1-minute mean data.

| Season | Region | Mean±stdev in K | Median in K | Number *1000 | Season | Region | Mean±stdev in K | Median in K | Number *1000 |
|--------|-------------------|--------------------|----------------|-----------------|--------|----------------------|--------------------|----------------|-----------------|
| MAM | North Canada | 217.2±3.1 | 218.5 | 1 | MAM | Greenland | 215.5±3.2 | 216.1 | 8 |
| JJA | | 222.5±1.6 | 221.9 | 2 | JJA | | 222.1±1.4 | 221.9 | 13 |
| SON | | 219.6±1.7 | 219.4 | 1 | SON | | 219.6±3.1 | 220.1 | 15 |
| DJF | | 210.0±3.2 | 209.5 | 1 | DJF | | 212.1±1.9 | 212.3 | 22 |
| MAM | Scandinavia | 216.3±3.5 | 217 | 2 | MAM | North Asia | 214.6±4.1 | 214.4 | 11 |
| JJA | | 223.8±1.6 | 223.4 | 7 | JJA | | 222.3±1.7 | 222.4 | 32 |
| SON | | 219.2±2.8 | 219.5 | 7 | SON | | 216.6±3.2 | 216.8 | 19 |
| DJF | | 213.5±1.7 | 213.6 | 5 | DJF | | 209.4±2.3 | 209.3 | 9 |
| MAM | North America | 221.4±1.7 | 221.3 | 136 | MAM | North Atlantic | 217.5±1.9 | 217.5 | 229 |
| JJA | | 226.3±1.3 | 226.5 | 263 | JJA | | 222.9±1.5 | 222.9 | 399 |
| SON | | 223.6±2.2 | 224 | 190 | SON | | 220.9±2.3 | 220.7 | 381 |
| DJF | | 220.3±1.8 | 220.4 | 76 | DJF | | 215.6±1.6 | 215.5 | 195 |
| MAM | Europe | 219.5±1.6 | 219.7 | 246 | MAM | Central Asia | 220.8±2.9 | 220.7 | 168 |
| JJA | | 226.5±1.9 | 226.7 | 419 | JJA | | 230.3±3.9 | 229.8 | 333 |
| SON | | 221.6±2.3 | 221.3 | 383 | SON | | 222.8±4.1 | 221.7 | 224 |
| DJF | | 217.6±1.3 | 217.5 | 217 | DJF | | 218.8±3.3 | 218.9 | 68 |
| MAM | Middle America | 229.1±4.6 | 228.5 | 6 | MAM | Tropical Atlantic | 226.0±2.3 | 225.6 | 109 |
| JJA | | 228.2±5.1 | 227.9 | 3 | JJA | | 227.6±2.4 | 228.1 | 86 |
| SON | | 227.6±5.8 | 227.8 | 3 | SON | | 226.0±2.5 | 226.2 | 87 |
| DJF | | 229.7±4.5 | 229.2 | 7 | DJF | | 225.5±2.6 | 225.9 | 98 |
| MAM | North Africa | 227.3±2.6 | 227.1 | 170 | MAM | Tropical Asia | 229.8±3.5 | 229.7 | 113 |
| JJA | | 229.5±2.9 | 229.6 | 180 | JJA | | 238.3±3.2 | 238.1 | 136 |
| SON | | 226.9±2.7 | 226.3 | 184 | SON | | 230.7±4.8 | 229.5 | 132 |
| DJF | | 225.6±2.2 | 224.9 | 161 | DJF | | 227.9±3.5 | 227.9 | 106 |
| MAM | South America | 230.2±1.7 | 229.8 | 39 | MAM | South Africa | 228.8±3.2 | 229.1 | 106 |
| JJA | | 228.8±2.9 | 228.7 | 33 | JJA | | 227.7±3.1 | 227.6 | 100 |
| SON | | 228.8±2.5 | 229.2 | 28 | SON | | 228.2±3.3 | 227.2 | 100 |
| DJF | | 229.6±2.0 | 229.3 | 40 | DJF | | 227.1±2.8 | 228.3 | 99 |

Table S4: Temperature trends of ERA-I and from the IAGOS observations within the LMS, TPL and UT as shown in table3 and compared to temperature trends derived from 17 years skipping the first (light gray) or last year (dark gray) in the analyses.

| Region | ERA-I | | | | IAGOS | | | |
|----------------|----------------------------|-------------|-----------------------------------|----------------------------------|----------------------------|-------------|-----------------------------------|----------------------------------|
| | ΔT_{18yr} K/dec | SE K/dec | $\Delta T_{17yr, first}$ K/dec | $\Delta T_{17yr, last}$ K/dec | ΔT_{18yr} K/dec | SE K/dec | $\Delta T_{17yr, first}$ K/dec | $\Delta T_{17yr, last}$ K/dec |
| <i>LMS</i> | | | | | | | | |
| Greenland | -0.79 | 0.29 | -1.03 | -0.83 | -1.39 | 0.29 | -1.48 | -1.45 |
| North America | -0.25 | 0.21 | -0.38 | -0.21 | -0.71 | 0.21 | -0.73 | -0.76 |
| North Atlantic | +0.56 | 0.17 | +0.53 | +0.59 | -0.05 | 0.17 | +0.02 | -0.01 |
| Europe | +0.11 | 0.19 | +0.12 | +0.14 | -0.53 | 0.20 | -0.49 | -0.62 |
| <i>TPL</i> | | | | | | | | |
| North America | +0.29 | 0.19 | +0.11 | +0.45 | +0.23 | 0.20 | -0.02 | +0.42 |
| North Atlantic | +0.46 | 0.15 | +0.42 | +0.62 | +0.25 | 0.16 | +0.20 | +0.38 |
| Europe | +0.20 | 0.15 | +0.17 | +0.19 | -0.44 | 0.17 | -0.46 | -0.57 |
| <i>UT</i> | | | | | | | | |
| North America | -0.92 | 0.17 | -0.99 | -0.82 | -1.08 | 0.18 | -1.16 | -1.00 |
| North Atlantic | +0.38 | 0.18 | +0.52 | +0.58 | +0.22 | 0.20 | +0.33 | +0.43 |
| Europe | -0.24 | 0.14 | -0.21 | -0.29 | -0.59 | 0.15 | -0.55 | -0.71 |
| Central Asia | +0.66 | 0.33 | +0.55 | +0.91 | +0.32 | 0.33 | +0.27 | +0.54 |
| Tropical Asia | -0.58 | 0.39 | -0.43 | -0.24 | -0.54 | 0.04 | -0.30 | -0.21 |