Supplementary Material

Tracking the global flows of atmospheric moisture

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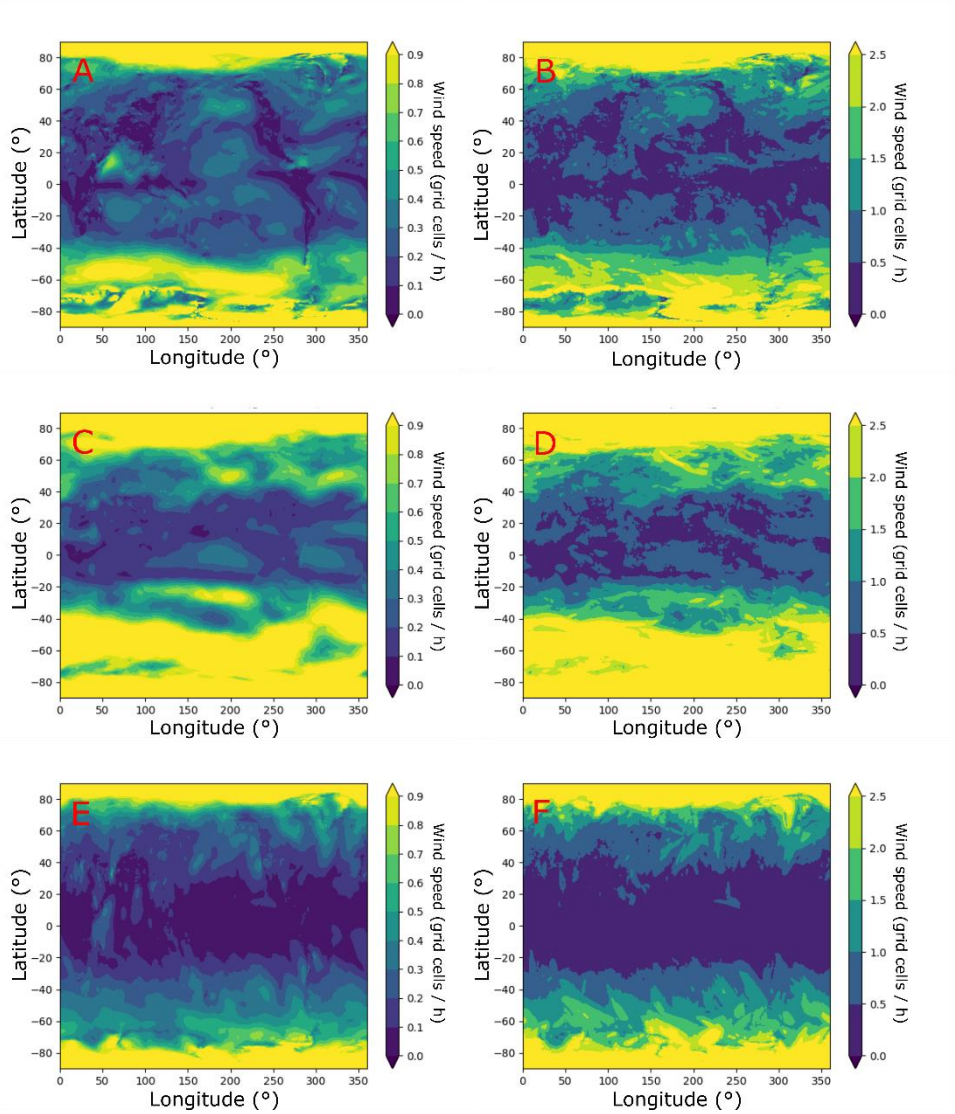

Figure S1: Eastward wind speeds in July 2012 across the globe, given in ERA5 grid cells / h (Courant number). A) Mean eastward wind speeds at 900 hPa; B) Maximum eastward wind speeds at 900 hPa; C) Mean eastward wind speeds at 500 hPa; D) Maximum eastward wind speeds at 500 hPa; E) Mean eastward wind speeds, vertically integrated divided by the precipitable water; F) Maximum eastward wind speeds, vertically integrated divided by the precipitable water.

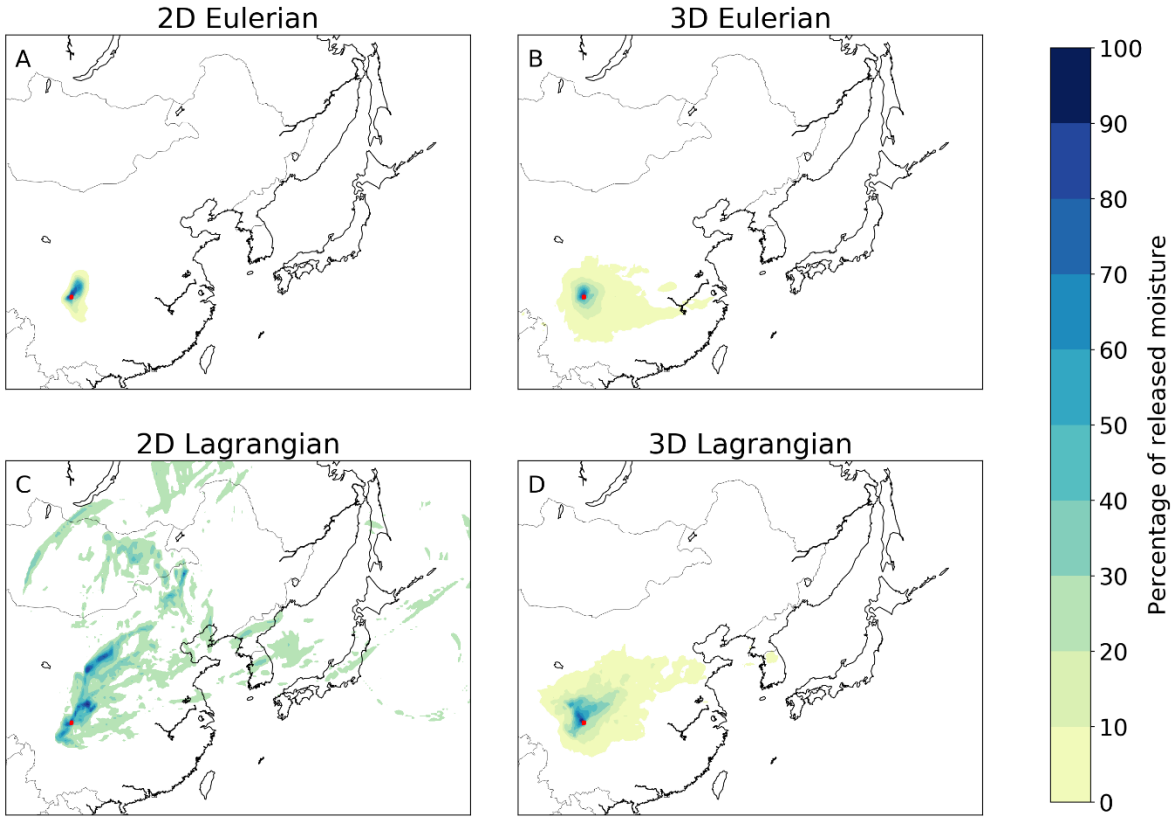

Figure S2: Different footprints of moisture releases from Chendu in July 2012 in two-dimensional and three-dimensional Eulerian and Lagrangian models. A) Two-dimensional Eulerian, with a mean latitudinal moisture flow of 0.6° in northerly direction and mean longitudinal flow of 0.6° in easterly direction; B) Three-dimensional Eulerian, with a mean latitudinal moisture flow of 0.1° in northerly direction and mean longitudinal flow of 0.9° in easterly direction; C) Two-dimensional Lagrangian, with a mean latitudinal moisture flow of 6.5° in northerly direction and mean longitudinal flow of 5.6° in easterly direction; D) Three-dimensional Lagrangian, with a mean latitudinal moisture flow of 1.8° in northerly direction and mean longitudinal flow of 1.7° in easterly direction.

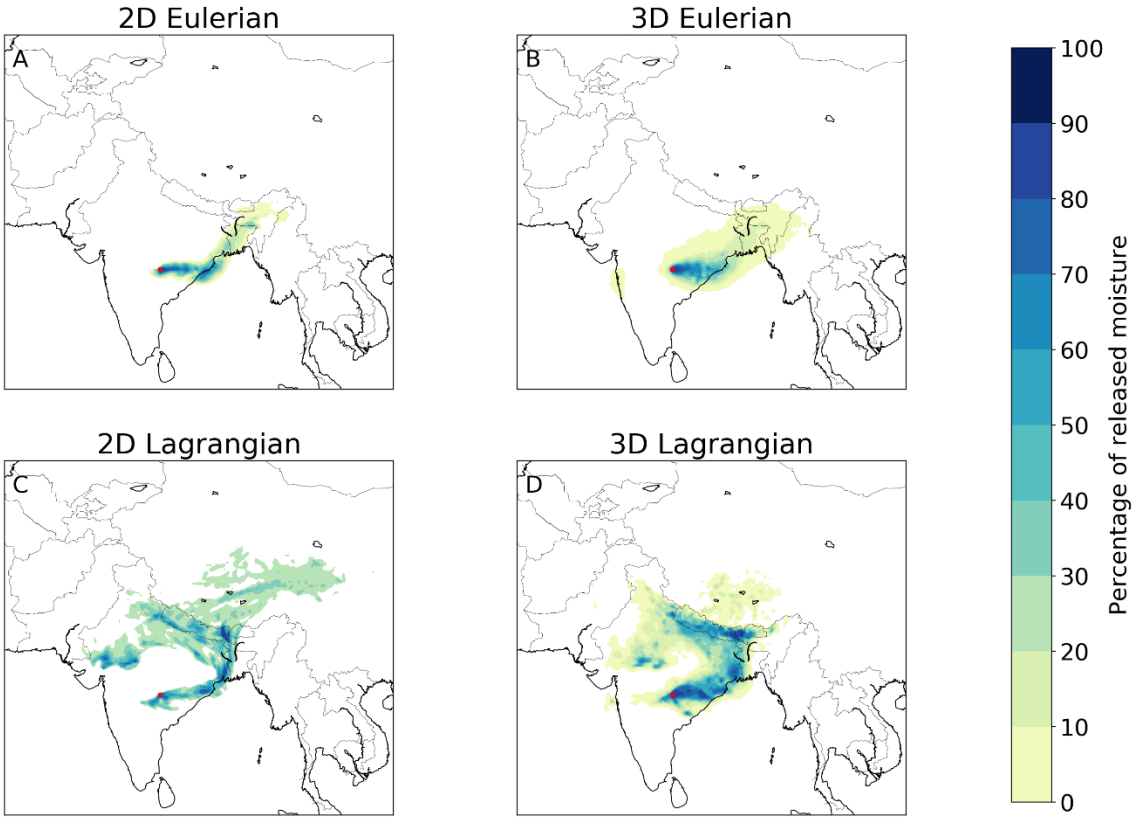

Figure S3: Different footprints of moisture releases from Nagpur in July 2012 in two-dimensional and three-dimensional Eulerian and Lagrangian models. A) Two-dimensional Eulerian, with a mean latitudinal moisture flow of 1.3° in northerly direction and mean longitudinal flow of 5.7° in easterly direction; B) Three-dimensional Eulerian, with a mean latitudinal moisture flow of 0.6° in northerly direction and mean longitudinal flow of 3.8° in easterly direction; C) Two-dimensional Lagrangian, with a mean latitudinal moisture flow of 5.5° in northerly direction and mean longitudinal flow of 4.8° in easterly direction; D) Three-dimensional Lagrangian, with a mean latitudinal moisture flow of 4.7° in northerly direction and mean longitudinal flow of 3.6° in easterly direction.

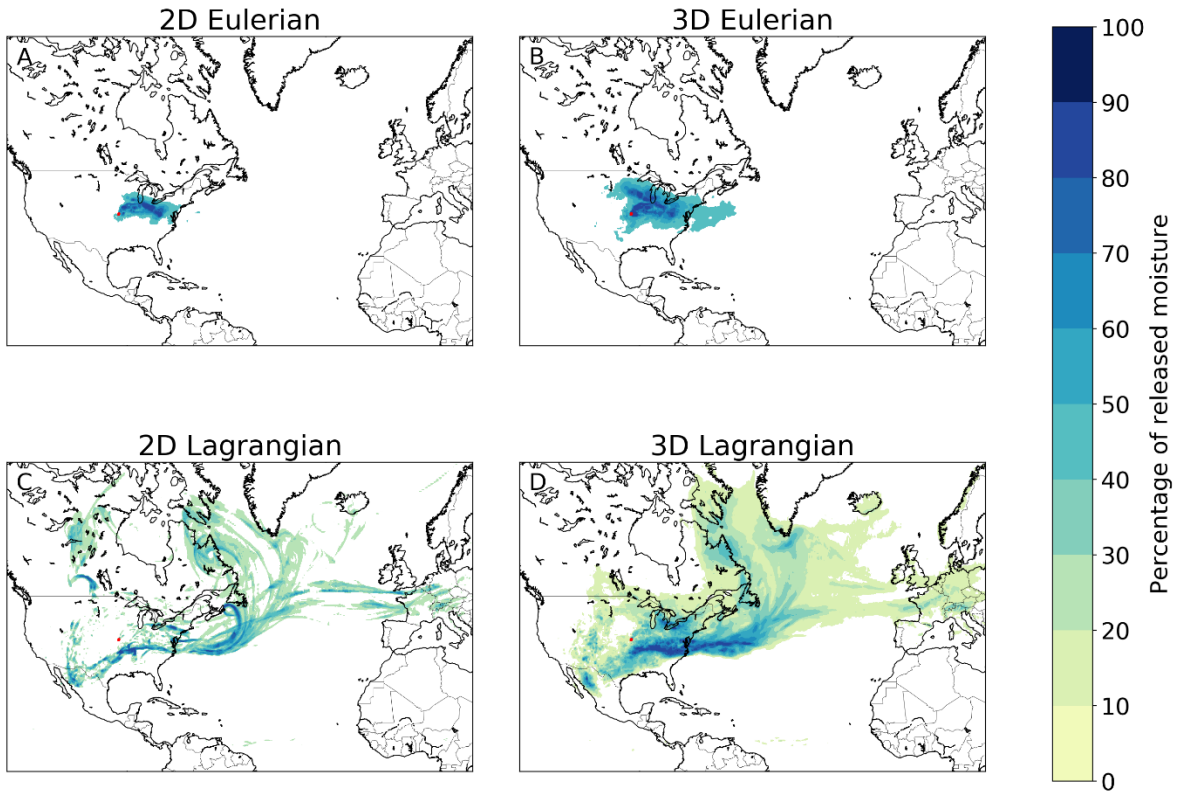

Figure S4: Different footprints of moisture releases from Kansas in July 2012 in two-dimensional and three-dimensional Eulerian and Lagrangian models. A) Two-dimensional Eulerian, with a mean latitudinal moisture flow of 1.8° in northerly direction and mean longitudinal flow of 8.5° in easterly direction; B) Three-dimensional Eulerian, with a mean latitudinal moisture flow of 1.3° in southerly direction and mean longitudinal flow of 7.1° in easterly direction; C) Two-dimensional Lagrangian, with a mean latitudinal moisture flow of 5.4° in northerly direction and mean longitudinal flow of 14.4° in easterly direction; D) Three-dimensional Lagrangian, with a mean latitudinal moisture flow of 4.1° in northerly direction and mean longitudinal flow of 15.6° in easterly direction.

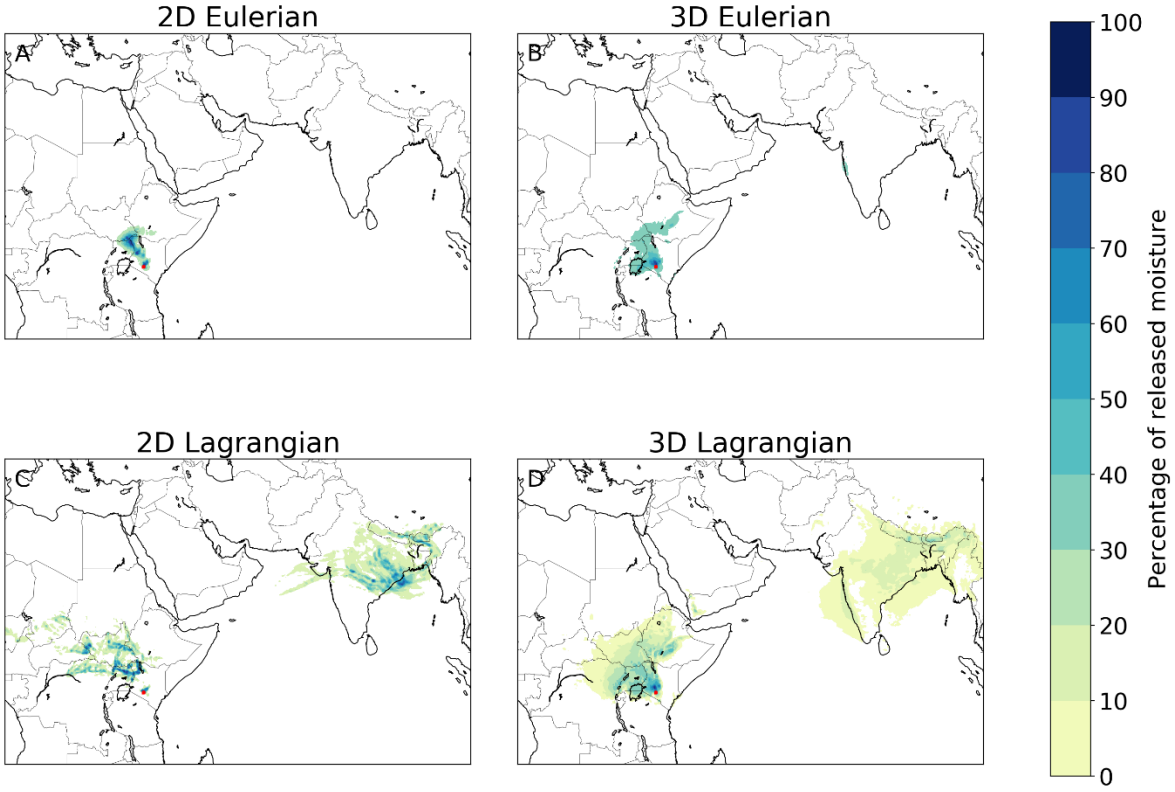

Figure S5: Different footprints of moisture releases from Nairobi in July 2012 in two-dimensional and three-dimensional Eulerian and Lagrangian models. A) Two-dimensional Eulerian, with a mean latitudinal moisture flow of 4.0° in northerly direction and mean longitudinal flow of 1.6° in westerly direction; B) Three-dimensional Eulerian, with a mean latitudinal moisture flow of 2.2° in northerly direction and mean longitudinal flow of 0.8° in easterly direction; C) Two-dimensional Lagrangian, with a mean latitudinal moisture flow of 14.0° in northerly direction and mean longitudinal flow of 3.9° in easterly direction; D) Three-dimensional Lagrangian, with a mean latitudinal moisture flow of 6.6° in northerly direction and mean longitudinal flow of 2.9° in easterly direction.

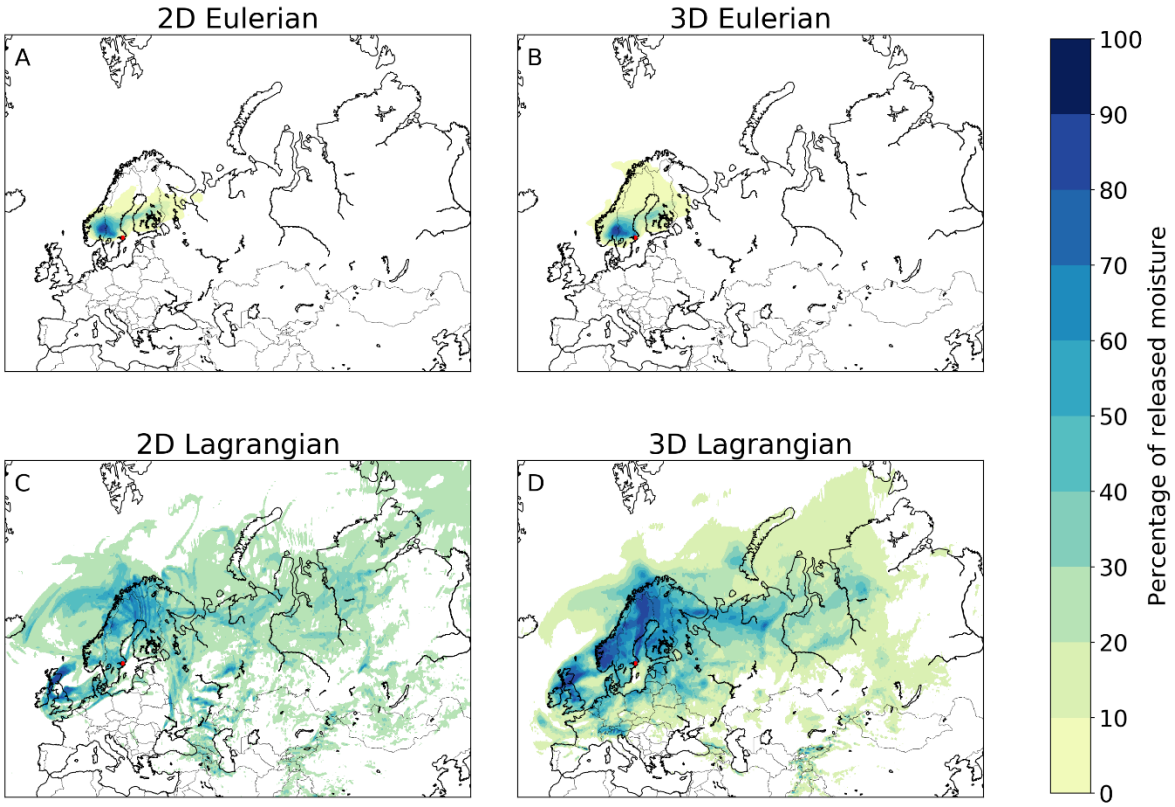

Figure S6: Different footprints of moisture releases from Stockholm in July 2012 in two-dimensional and three-dimensional Eulerian and Lagrangian models. A) Two-dimensional Eulerian, with a mean latitudinal moisture flow of 2.6° in northerly direction and mean longitudinal flow of 0.6° in westerly direction; B) Three-dimensional Eulerian, with a mean latitudinal moisture flow of 2.3° in northerly direction and mean longitudinal flow of 1.4° in westerly direction; C) Two-dimensional Lagrangian, with a mean latitudinal moisture flow of 0.0° in northerly/southerly direction and mean longitudinal flow of 13.9° in easterly direction; D) Three-dimensional Lagrangian, with a mean latitudinal moisture flow of 1.4° in northerly direction and mean longitudinal flow of 11.0° in easterly direction.

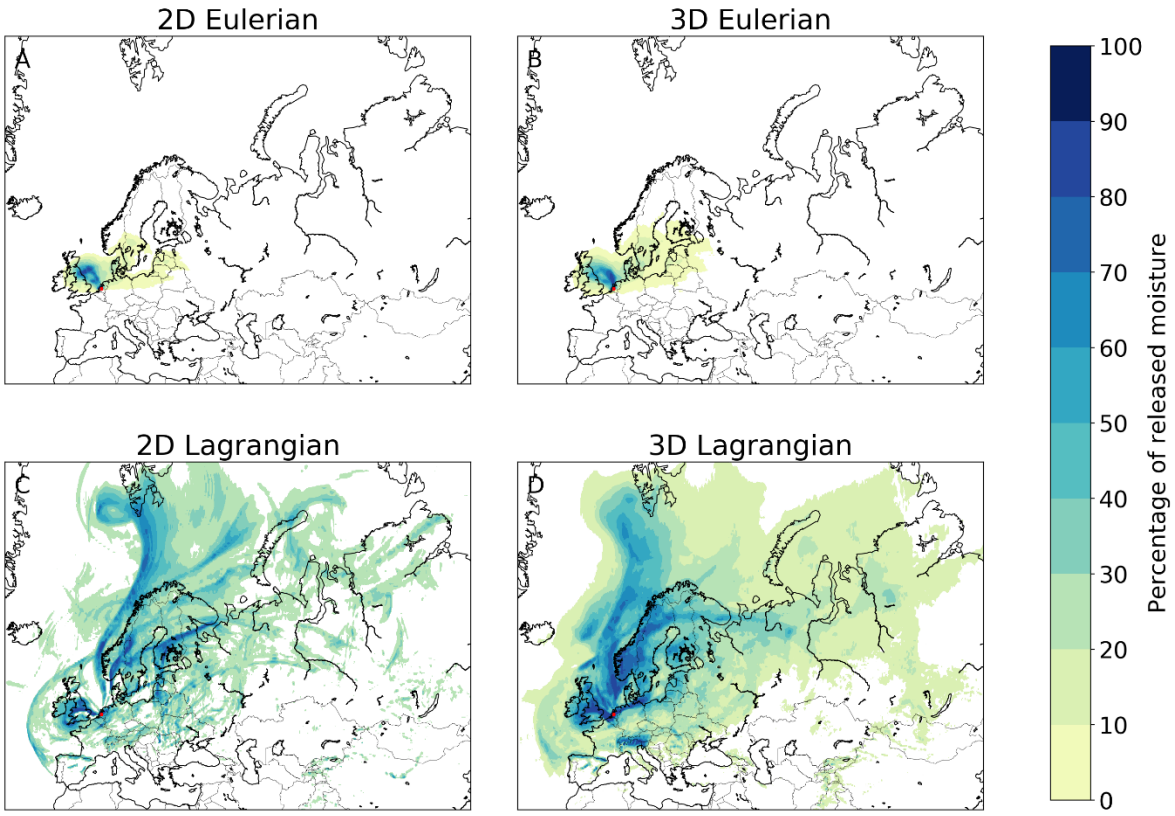

Figure S7: Different footprints of moisture releases from Utrecht in July 2012 in two-dimensional and three-dimensional Eulerian and Lagrangian models. A) Two-dimensional Eulerian, with a mean latitudinal moisture flow of 2.8° in northerly direction and mean longitudinal flow of 11.3° in easterly direction; B) Three-dimensional Eulerian, with a mean latitudinal moisture flow of 3.1° in northerly direction and mean longitudinal flow of 9.8° in easterly direction; C) Two-dimensional Lagrangian, with a mean latitudinal moisture flow of 8.7° in northerly direction and mean longitudinal flow of 18.1° in easterly direction; D) Three-dimensional Lagrangian, with a mean latitudinal moisture flow of 6.2° in northerly direction and mean longitudinal flow of 15.4° in easterly direction.

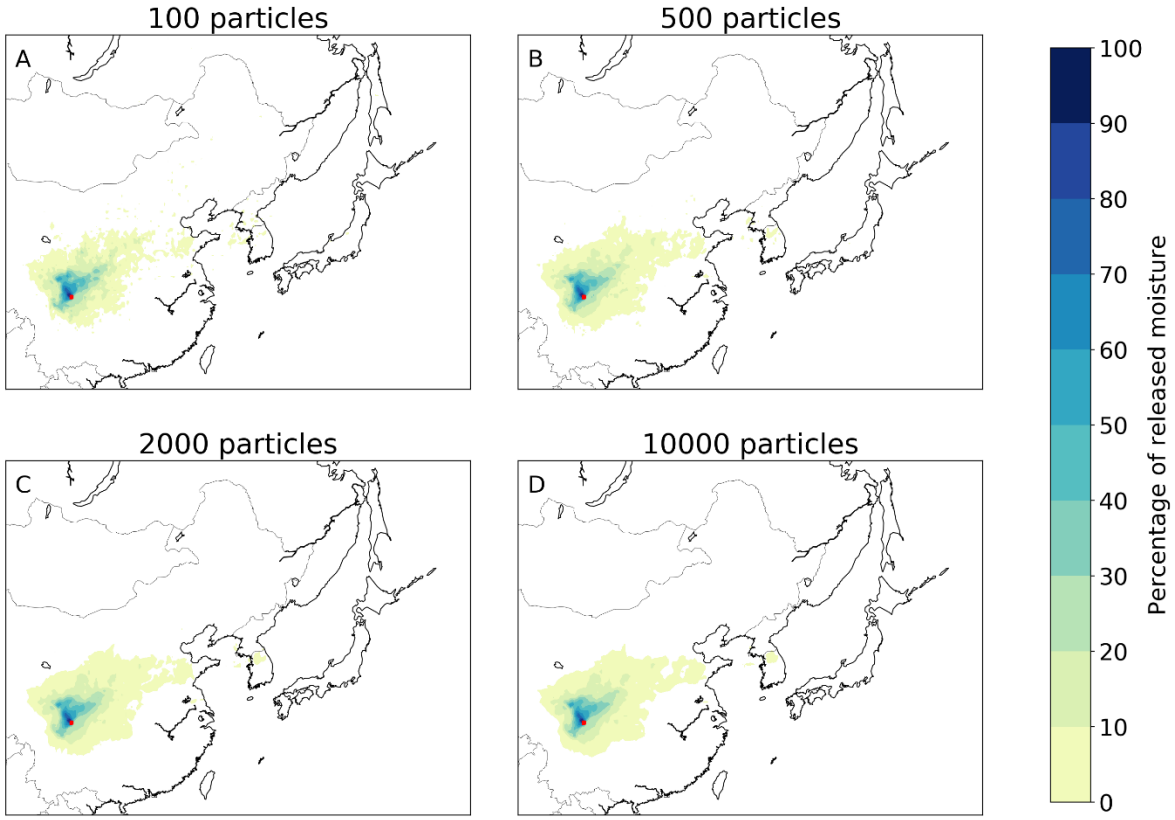

Figure S8: Different footprints of moisture releases from Chendu in July 2012 in a three-dimensional Lagrangian model with 100, 500, 2,000, and 10,000 tracked particles mm^{-1} h^{-1}). A) 100 particles, with a mean latitudinal moisture flow of 1.9° in northerly direction and mean longitudinal flow of 1.8° in easterly direction; B) 500 particles, with a mean latitudinal moisture flow of 1.9° in northerly direction and mean longitudinal flow of 1.7° in easterly direction; C) 2,000 particles, with a mean latitudinal moisture flow of 1.8° in northerly direction and mean longitudinal flow of 1.7° in easterly direction; D) 10,000 particles, with a mean latitudinal moisture flow of 1.8° in northerly direction and mean longitudinal flow of 1.7° in easterly direction.

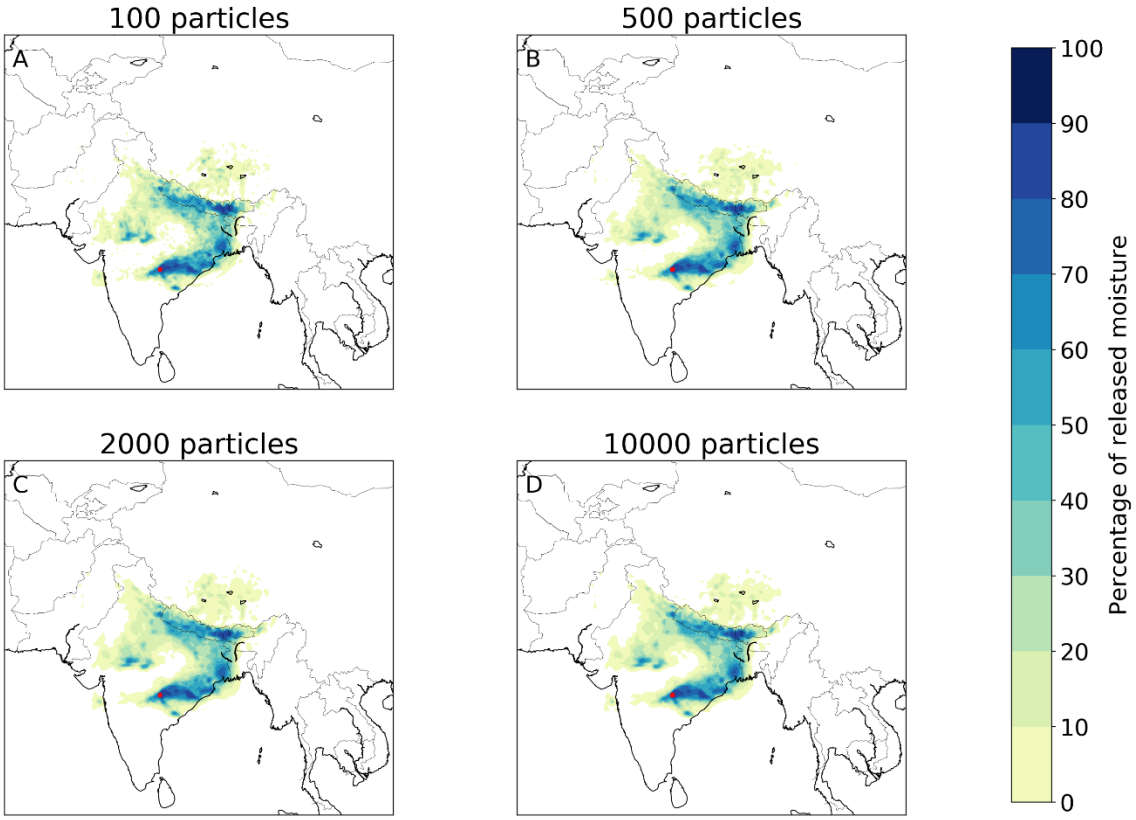

Figure S9: Different footprints of moisture releases from Nagpur in July 2012 in a three-dimensional Lagrangian model with 100, 500, 2,000, and 10,000 tracked particles mm^{-1} h^{-1}). A) 100 particles, with a mean latitudinal moisture flow of 4.7° in northerly direction and mean longitudinal flow of 3.5° in easterly direction; B) 500 particles, with a mean latitudinal moisture flow of 4.7° in northerly direction and mean longitudinal flow of 3.6° in easterly direction; C) 2,000 particles, with a mean latitudinal moisture flow of 4.7° in northerly direction and mean longitudinal flow of 3.6° in easterly direction; D) 10,000 particles, with a mean latitudinal moisture flow of 4.7° in northerly direction and mean longitudinal flow of 3.6° in easterly direction.

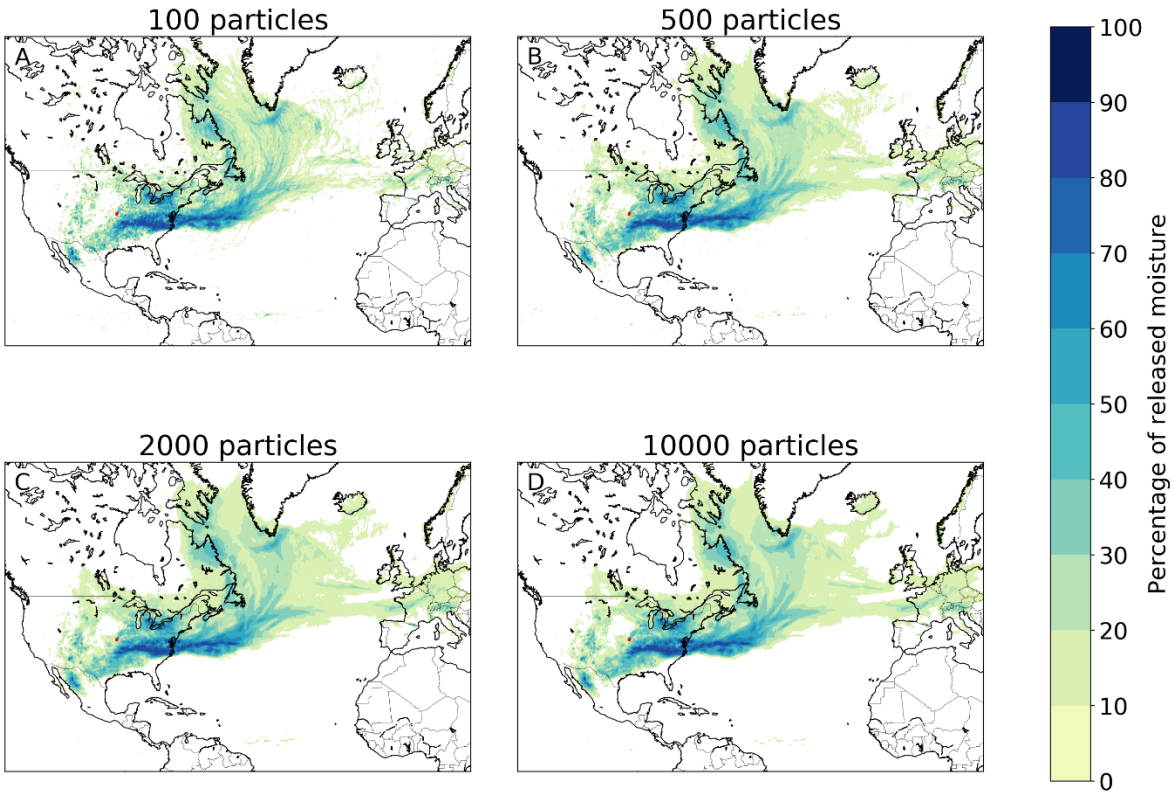

Figure S10: Different footprints of moisture releases from Kansas in July 2012 in a three-dimensional Lagrangian model with 100, 500, 2,000, and 10,000 tracked particles mm^{-1} h^{-1}). A) 100 particles, with a mean latitudinal moisture flow of 4.2° in northerly direction and mean longitudinal flow of 15.4° in easterly direction; B) 500 particles, with a mean latitudinal moisture flow of 4.1° in northerly direction and mean longitudinal flow of 15.6° in easterly direction; C) 2,000 particles, with a mean latitudinal moisture flow of 4.1° in northerly direction and mean longitudinal flow of 15.6° in easterly direction; D) 10,000 particles, with a mean latitudinal moisture flow of 4.1° in northerly direction and mean longitudinal flow of 15.6° in easterly direction.

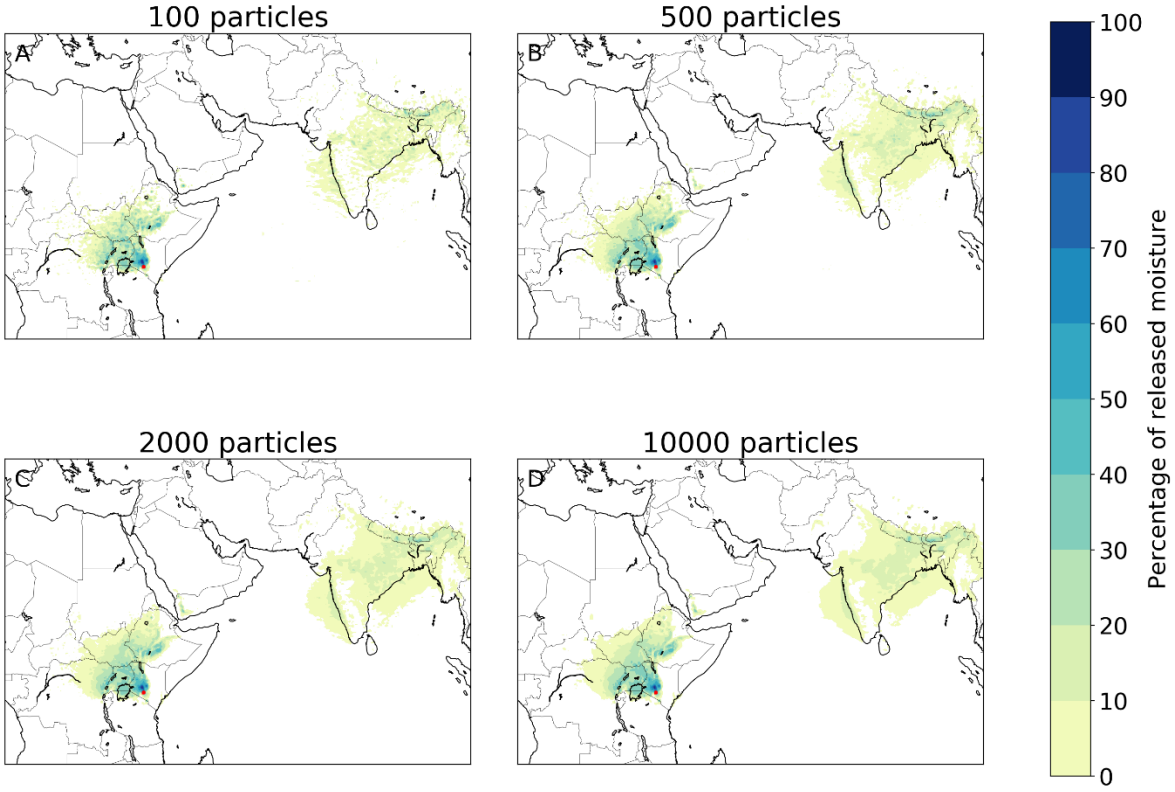

Figure S11: Different footprints of moisture releases from Nairobi in July 2012 in a three-dimensional Lagrangian model with 100, 500, 2,000, and 10,000 tracked particles mm^{-1} h^{-1}). A) 100 particles, with a mean latitudinal moisture flow of 6.7° in northerly direction and mean longitudinal flow of 2.9° in easterly direction; B) 500 particles, with a mean latitudinal moisture flow of 6.9° in northerly direction and mean longitudinal flow of 3.1° in easterly direction; C) 2,000 particles, with a mean latitudinal moisture flow of 6.5° in northerly direction and mean longitudinal flow of 2.8° in easterly direction; D) 10,000 particles, with a mean latitudinal moisture flow of 6.6° in northerly direction and mean longitudinal flow of 2.9° in easterly direction.

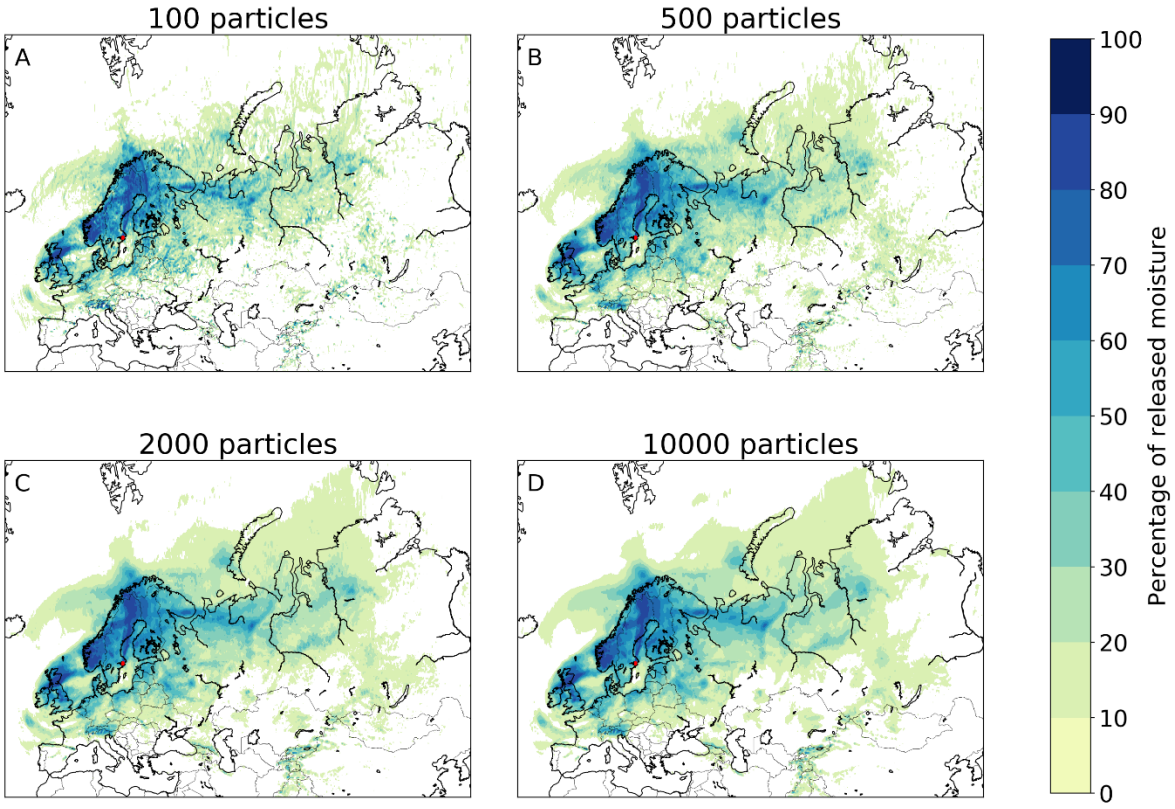

Figure S12: Different footprints of moisture releases from Stockholm in July 2012 in a three-dimensional Lagrangian model with 100, 500, 2,000, and 10,000 tracked particles mm^{-1} h^{-1}). A) 100 particles, with a mean latitudinal moisture flow of 1.3° in northerly direction and mean longitudinal flow of 11.1° in easterly direction; B) 500 particles, with a mean latitudinal moisture flow of 1.5° in northerly direction and mean longitudinal flow of 11.1° in easterly direction; C) 2,000 particles, with a mean latitudinal moisture flow of 1.5° in northerly direction and mean longitudinal flow of 11.0° in easterly direction; D) 10,000 particles, with a mean latitudinal moisture flow of 1.4° in northerly direction and mean longitudinal flow of 11.0° in easterly direction.

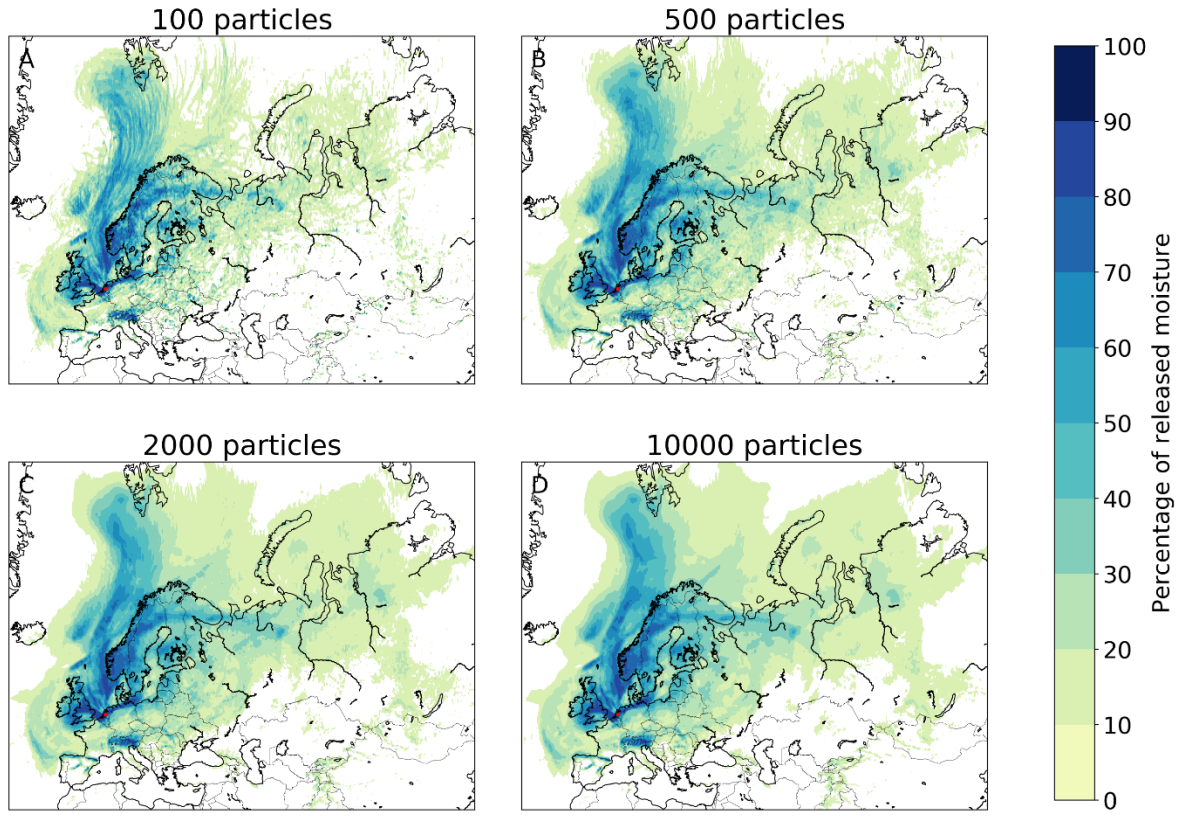

Figure S13: Different footprints of moisture releases from Utrecht in July 2012 in a three-dimensional Lagrangian model with 100, 500, 2,000, and 10,000 tracked particles mm^{-1} h^{-1}). A) 100 particles, with a mean latitudinal moisture flow of 6.1° in northerly direction and mean longitudinal flow of 15.5° in easterly direction; B) 500 particles, with a mean latitudinal moisture flow of 6.4° in northerly direction and mean longitudinal flow of 15.5° in easterly direction; C) 2,000 particles, with a mean latitudinal moisture flow of 6.3° in northerly direction and mean longitudinal flow of 15.4° in easterly direction; D) 10,000 particles, with a mean latitudinal moisture flow of 6.2° in northerly direction and mean longitudinal flow of 15.4° in easterly direction.

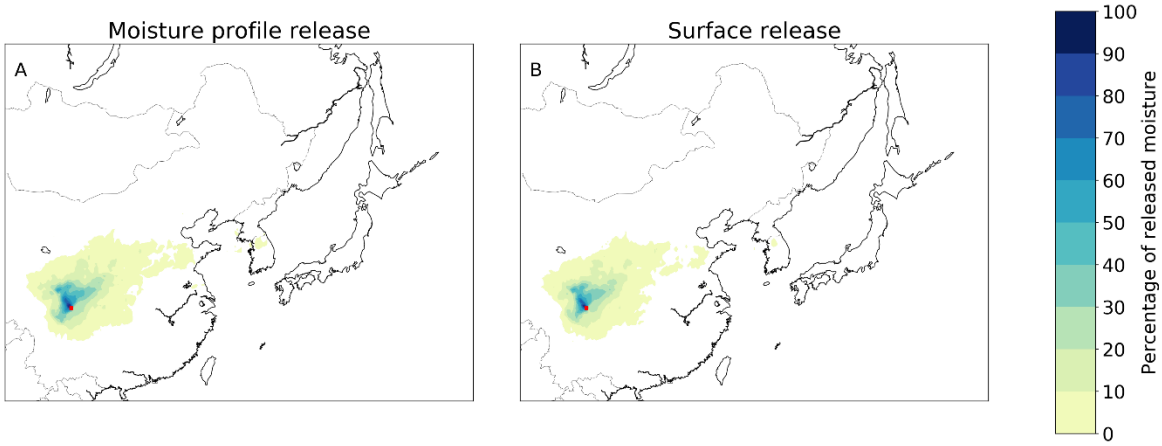

Figure S14: Different footprints of moisture releases from Chendu in July 2012 in a three-dimensional Lagrangian model with moisture released according to the vertical moisture profile of the atmosphere and moisture released at the surface. A) Release according to the moisture profile, with a mean latitudinal moisture flow of 2.3° in northerly direction and mean longitudinal flow of 2.4° in easterly direction; B) Release at the surface, with a mean latitudinal moisture flow of 2.0° in northerly direction and mean longitudinal flow of 2.1° in easterly direction.

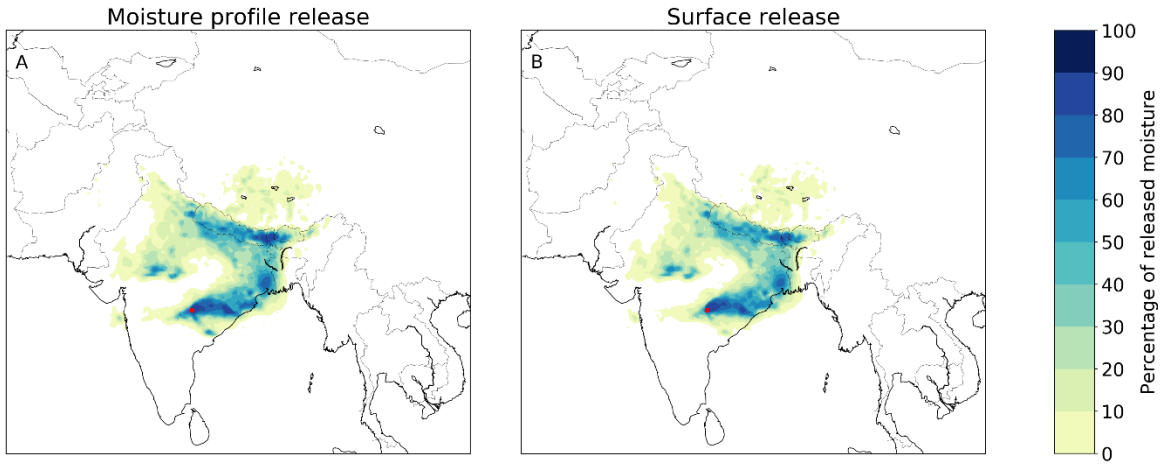

Figure S15: Different footprints of moisture releases from Nagpur in July 2012 in a three-dimensional Lagrangian model with moisture released according to the vertical moisture profile of the atmosphere and moisture released at the surface. A) Release according to the moisture profile, with a mean latitudinal moisture flow of 4.9° in northerly direction and mean longitudinal flow of 3.6° in easterly direction; B) Release at the surface, with a mean latitudinal moisture flow of 4.7° in northerly direction and mean longitudinal flow of 3.3° in easterly direction.

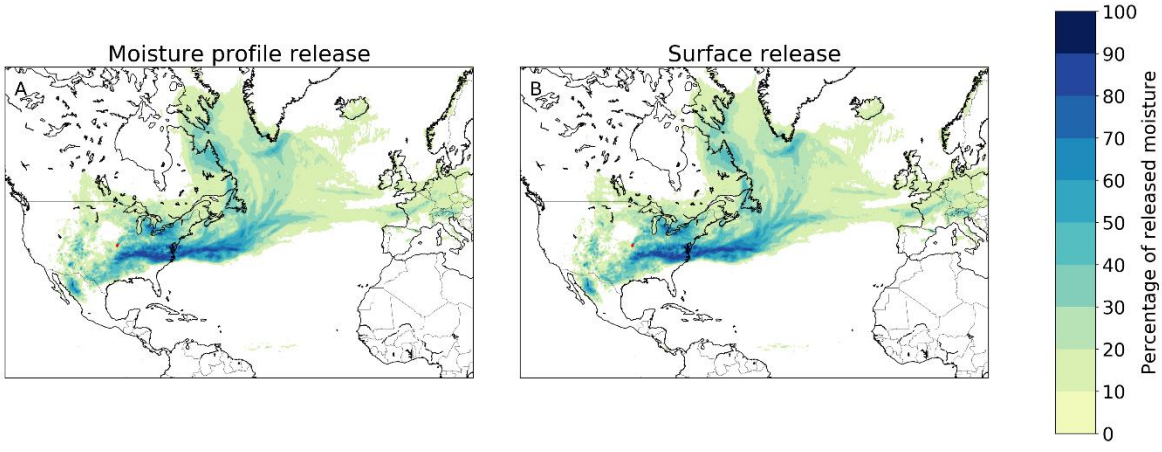

Figure S16: Different footprints of moisture releases from Kansas in July 2012 in a three-dimensional Lagrangian model with moisture released according to the vertical moisture profile of the atmosphere and

moisture released at the surface. A) Release according to the moisture profile, with a mean latitudinal moisture flow of 4.0° in northerly direction and mean longitudinal flow of 15.2° in easterly direction; B) Release at the surface, with a mean latitudinal moisture flow of 4.0° in northerly direction and mean longitudinal flow of 15.3° in easterly direction.

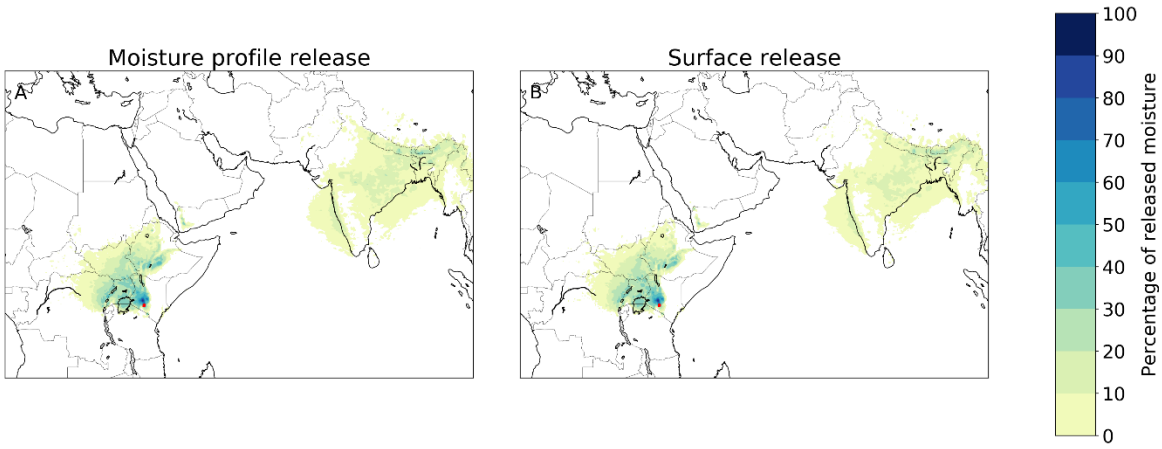

Figure S17: Different footprints of moisture releases from Nairobi in July 2012 in a three-dimensional Lagrangian model with moisture released according to the vertical moisture profile of the atmosphere and moisture released at the surface. A) Release according to the moisture profile, with a mean latitudinal moisture flow of 7.2° in northerly direction and mean longitudinal flow of 3.0° in easterly direction; B) Release at the surface, with a mean latitudinal moisture flow of 6.7° in northerly direction and mean longitudinal flow of 2.6° in easterly direction.

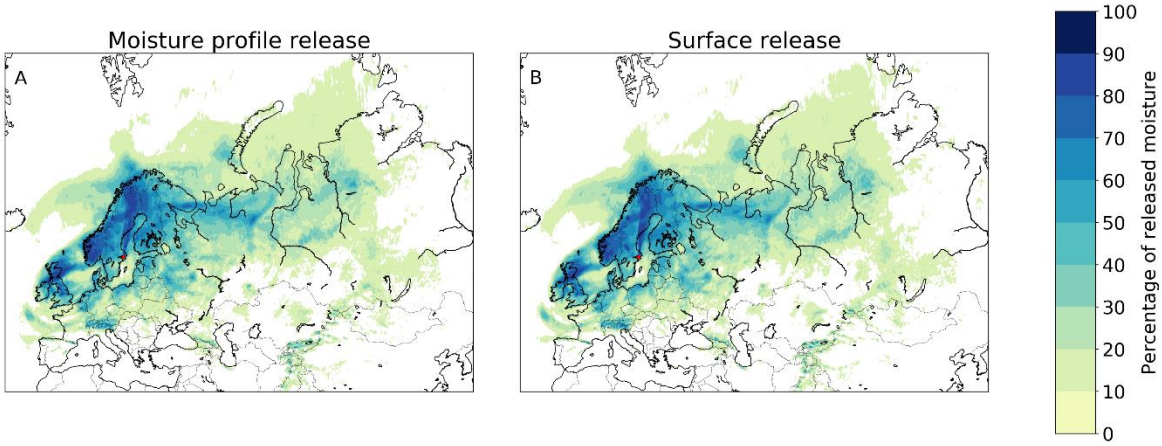

Figure S18: Different footprints of moisture releases from Stockholm in July 2012 in a three-dimensional Lagrangian model with moisture released according to the vertical moisture profile of the atmosphere and moisture released at the surface. A) Release according to the moisture profile, with a mean latitudinal moisture flow of 1.3° in northerly direction and mean longitudinal flow of 11.1° in easterly direction; B) Release at the

surface, with a mean latitudinal moisture flow of 1.3° in northerly direction and mean longitudinal flow of 10.8° in easterly direction.

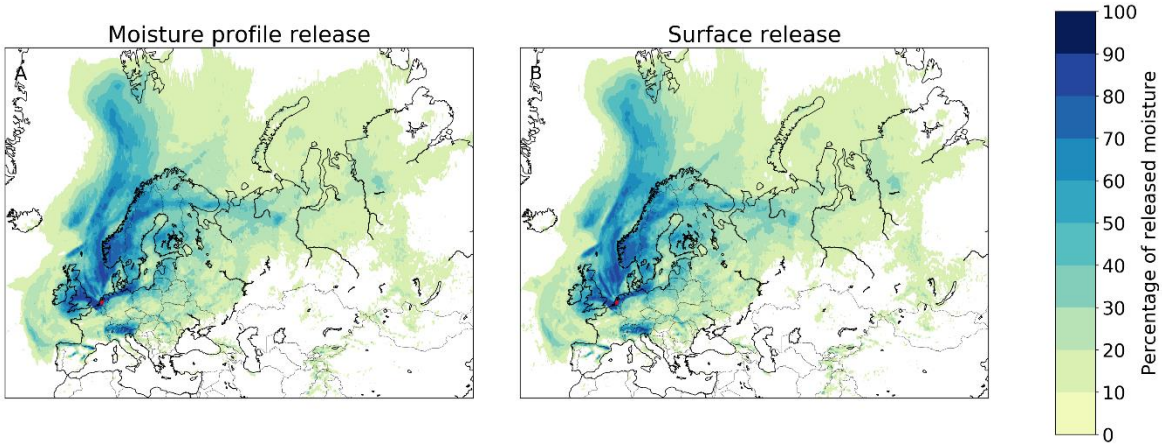

Figure S19: Different footprints of moisture releases from Utrecht in July 2012 in a three-dimensional Lagrangian model with moisture released according to the vertical moisture profile of the atmosphere and moisture released at the surface. A) Release according to the moisture profile, with a mean latitudinal moisture flow of 6.0° in northerly direction and mean longitudinal flow of 15.4° in easterly direction; B) Release at the surface, with a mean latitudinal moisture flow of 5.8° in northerly direction and mean longitudinal flow of 14.6° in easterly direction.

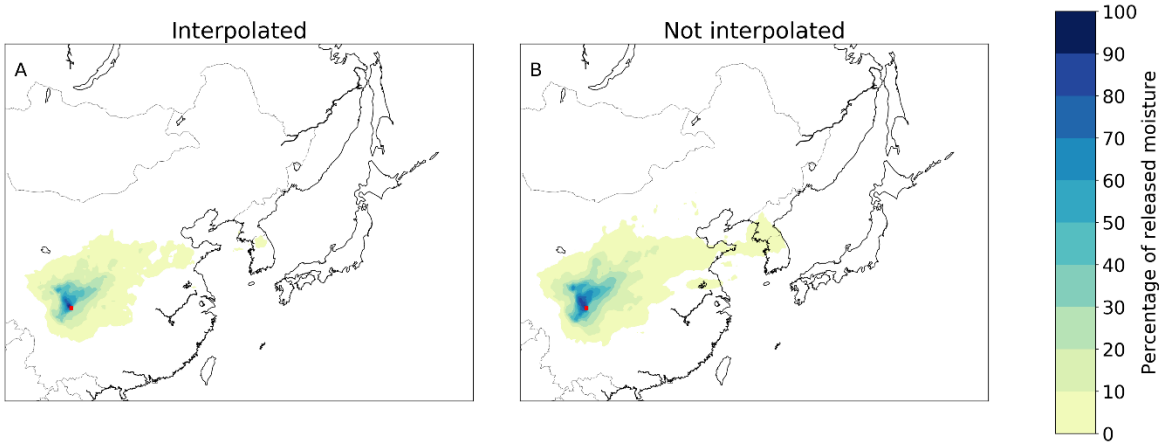

Figure S20: Different footprints of moisture releases from Chendu in July 2012 in a three-dimensional Lagrangian model with and without interpolation of wind speed and directions. A) Interpolated, with a mean latitudinal moisture flow of 1.8° in northerly direction and mean longitudinal flow of 1.7° in easterly direction; B) Not interpolated, with a mean latitudinal moisture flow of 2.3° in northerly direction and mean longitudinal flow of 2.4° in easterly direction.

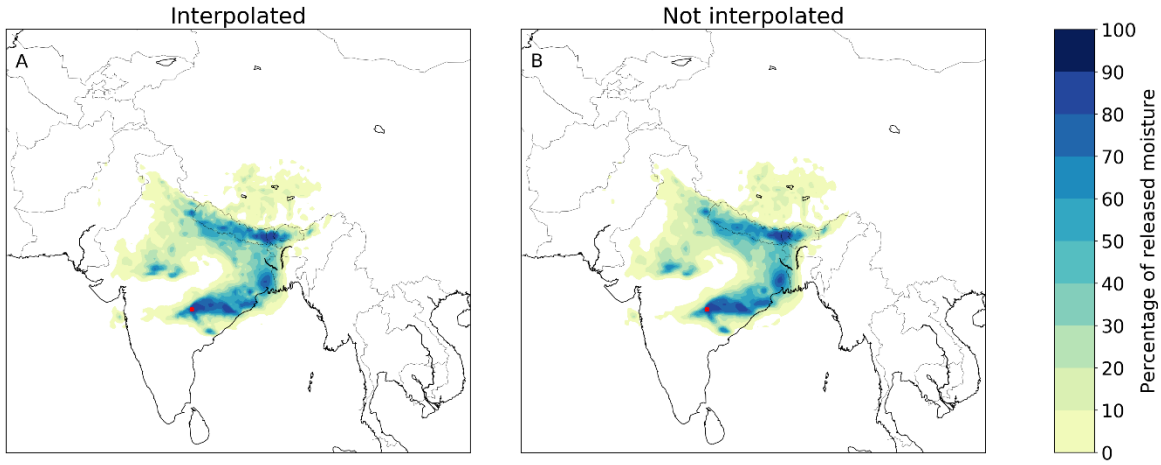

Figure S21: Different footprints of moisture releases from Nagpur in July 2012 in a three-dimensional Lagrangian model with and without interpolation of wind speed and directions. A) Interpolated, with a mean latitudinal moisture flow of 4.7° in northerly direction and mean longitudinal flow of 3.6° in easterly direction; B) Not interpolated, with a mean latitudinal moisture flow of 4.9° in northerly direction and mean longitudinal flow of 3.6° in easterly direction.

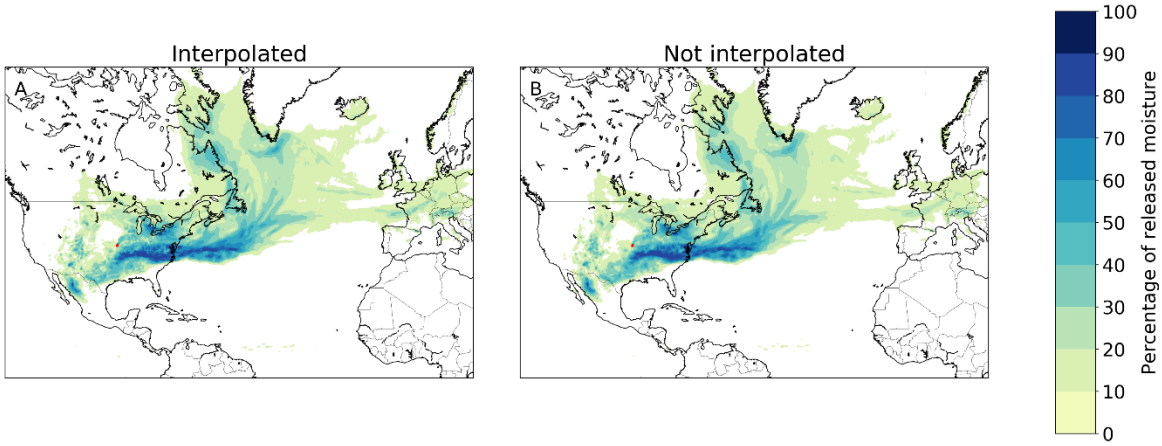

Figure S22: Different footprints of moisture releases from Kansas in July 2012 in a three-dimensional Lagrangian model with and without interpolation of wind speed and directions. A) Interpolated, with a mean latitudinal moisture flow of 4.1° in northerly direction and mean longitudinal flow of 15.6° in easterly direction; B) Not interpolated, with a mean latitudinal moisture flow of 4.0° in northerly direction and mean longitudinal flow of 15.2° in easterly direction.

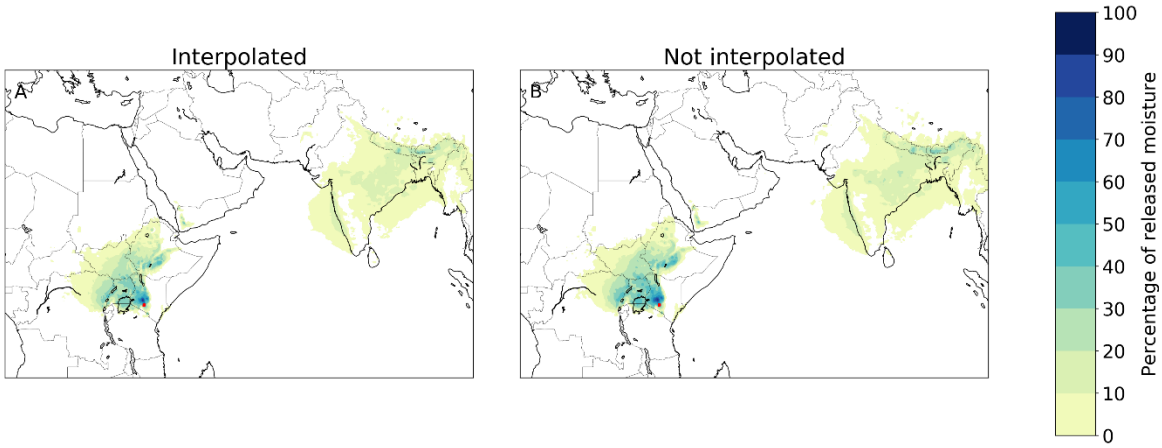

Figure S23: Different footprints of moisture releases from Nairobi in July 2012 in a three-dimensional Lagrangian model with and without interpolation of wind speed and directions. A) Interpolated, with a mean latitudinal moisture flow of 6.6° in northerly direction and mean longitudinal flow of 2.9° in easterly direction; B) Not interpolated, with a mean latitudinal moisture flow of 7.2° in northerly direction and mean longitudinal flow of 3.0° in easterly direction.

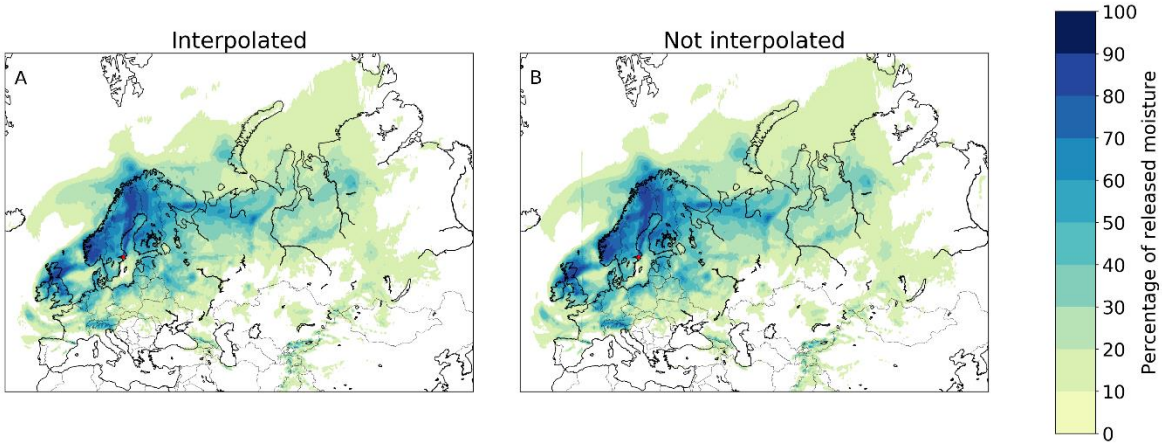

Figure S24: Different footprints of moisture releases from Stockholm in July 2012 in a three-dimensional Lagrangian model with and without interpolation of wind speed and directions. A) Interpolated, with a mean latitudinal moisture flow of 1.4° in northerly direction and mean longitudinal flow of 11.0° in easterly direction; B) Not interpolated, with a mean latitudinal moisture flow of 1.3° in northerly direction and mean longitudinal flow of 11.1° in easterly direction.

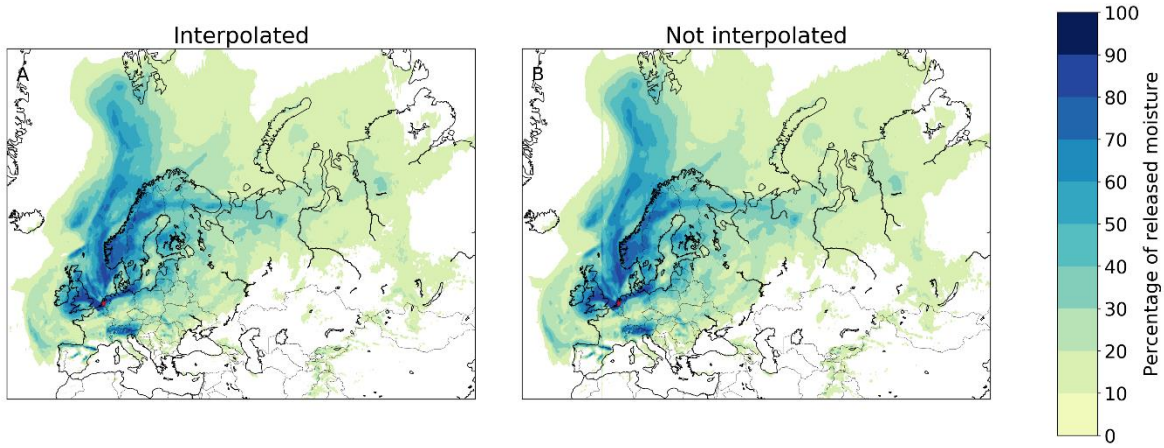

Figure S25: Different footprints of moisture releases from Utrecht in July 2012 in a three-dimensional Lagrangian model with and without interpolation of wind speed and directions. A) Interpolated, with a mean latitudinal moisture flow of 6.2° in northerly direction and mean longitudinal flow of 15.4° in easterly direction; B) Not interpolated, with a mean latitudinal moisture flow of 6.1° in northerly direction and mean longitudinal flow of 15.3° in easterly direction.

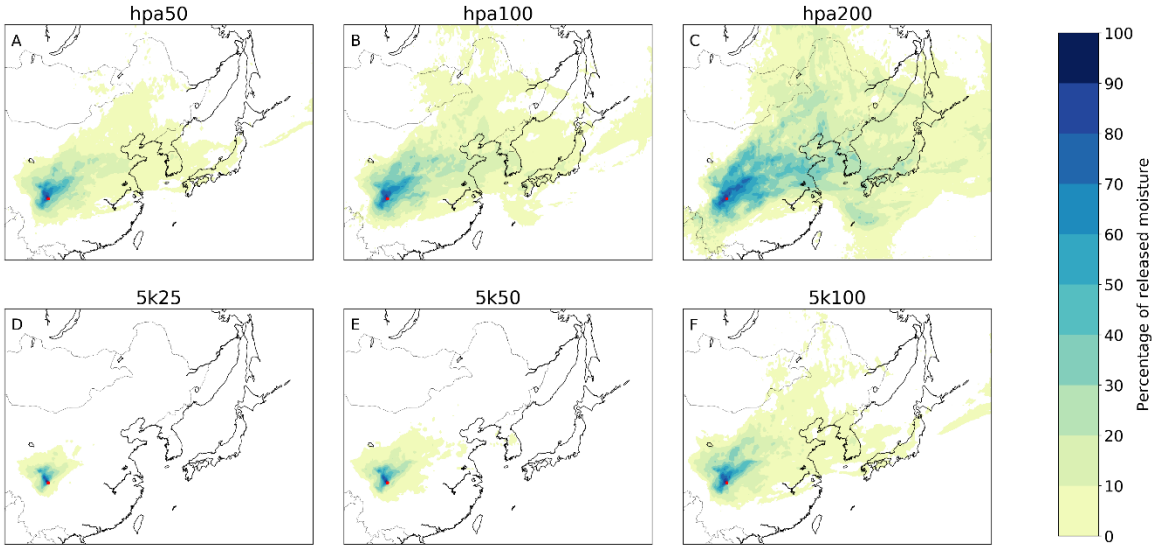

Figure S26: Different footprints of moisture releases from Chendu in July 2012 in a three-dimensional Lagrangian model with different degradations of the vertical moisture profile. A) hpa50, with a mean latitudinal moisture flow of 3.1° in northerly direction and mean longitudinal flow of 4.0° in easterly direction; B) hpa100, with a mean latitudinal moisture flow of 3.8° in northerly direction and mean longitudinal flow of 5.7° in easterly direction; C) hpa200, with a mean latitudinal moisture flow of 4.9° in northerly direction and mean longitudinal flow of 9.2° in easterly direction; D) 5k25, with a mean latitudinal moisture flow of 1.6° in northerly direction and mean longitudinal flow of 0.3° in easterly direction; E) 5k50, with a mean latitudinal moisture flow of 2.2° in northerly direction and mean longitudinal flow of 1.4° in easterly direction; F) 5k100,

with a mean latitudinal moisture flow of 3.5° in northerly direction and mean longitudinal flow of 3.6° in easterly direction.

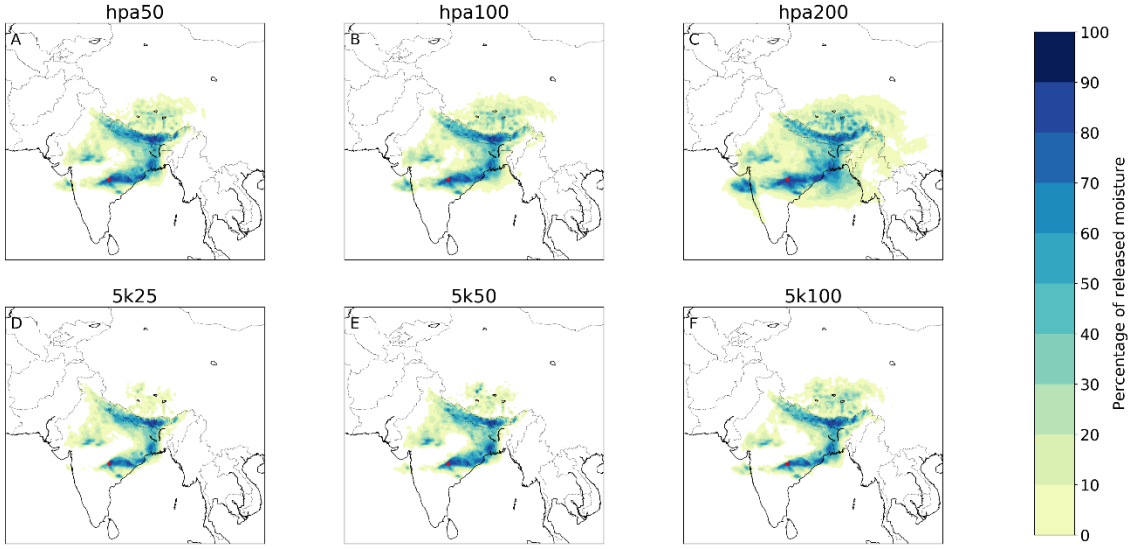

Figure S27: Different footprints of moisture releases from Nagpur in July 2012 in a three-dimensional Lagrangian model with different degradations of the vertical moisture profile. A) hpa50, with a mean latitudinal moisture flow of 4.9° in northerly direction and mean longitudinal flow of 4.6° in easterly direction; B) hpa100, with a mean latitudinal moisture flow of 4.8° in northerly direction and mean longitudinal flow of 5.1° in easterly direction; C) hpa200, with a mean latitudinal moisture flow of 3.1° in northerly direction and mean longitudinal flow of 5.1° in easterly direction; D) 5k25, with a mean latitudinal moisture flow of 5.0° in northerly direction and mean longitudinal flow of 4.0° in easterly direction; E) 5k50, with a mean latitudinal moisture flow of 4.8° in northerly direction and mean longitudinal flow of 3.8° in easterly direction; F) 5k100, with a mean latitudinal moisture flow of 5.4° in northerly direction and mean longitudinal flow of 5.6° in easterly direction.

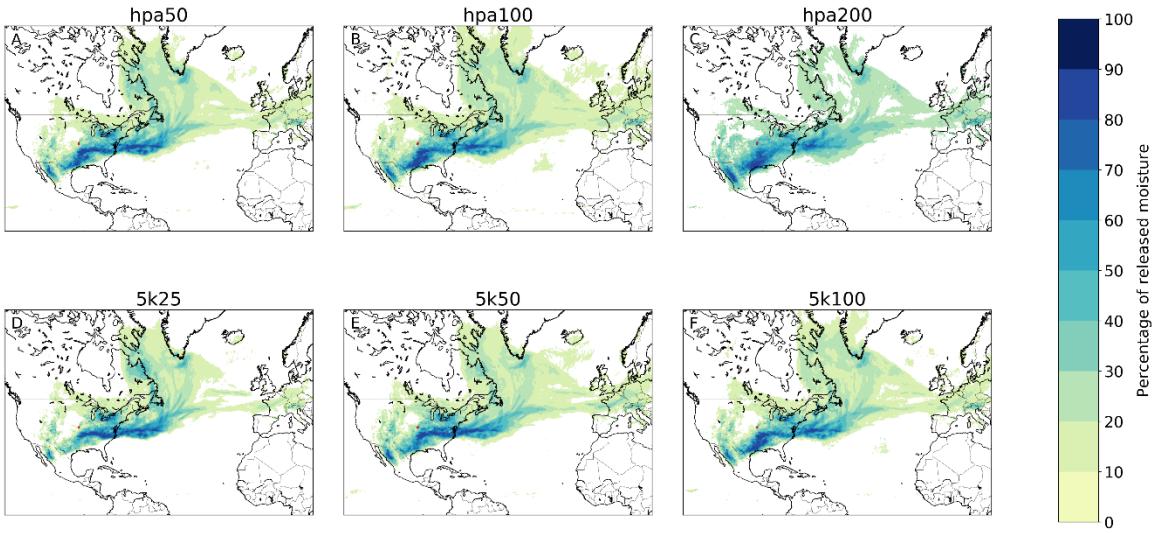

Figure S28: Different footprints of moisture releases from Kansas in July 2012 in a three-dimensional Lagrangian model with different degradations of the vertical moisture profile. A) hpa50, with a mean latitudinal moisture flow of 2.8° in northerly direction and mean longitudinal flow of 13.8° in easterly direction; B) hpa100, with a mean latitudinal moisture flow of 1.8° in northerly direction and mean longitudinal flow of 11.2° in easterly direction; C) hpa200, with a mean latitudinal moisture flow of 0.2° in southerly direction and mean longitudinal flow of 6.6° in easterly direction; D) 5k25, with a mean latitudinal moisture flow of 4.1° in northerly direction and mean longitudinal flow of 16.7° in easterly direction; E) 5k50, with a mean latitudinal moisture flow of 2.4° in northerly direction and mean longitudinal flow of 11.9° in easterly direction; F) 5k100, with a mean latitudinal moisture flow of 2.2° in northerly direction and mean longitudinal flow of 12.0° in easterly direction.

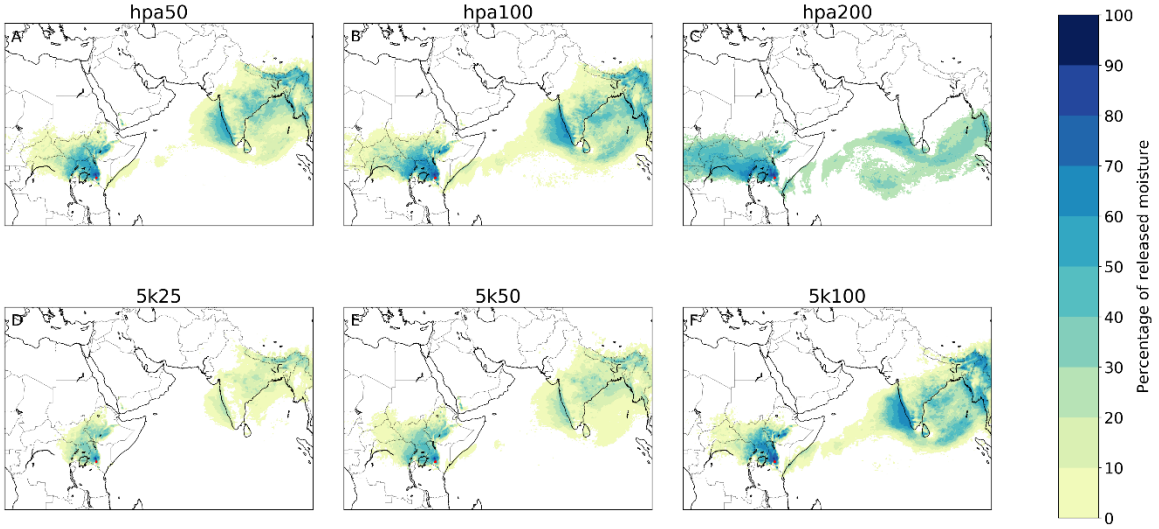

Figure S29: Different footprints of moisture releases from Nairobi in July 2012 in a three-dimensional Lagrangian model with different degradations of the vertical moisture profile. A) hpa50, with a mean latitudinal moisture flow of 11.3° in northerly direction and mean longitudinal flow of 9.8° in easterly direction; B) hpa100, with a mean latitudinal moisture flow of 11.0° in northerly direction and mean longitudinal flow of 11.0° in easterly direction; C) hpa200, with a mean latitudinal moisture flow of 4.3° in northerly direction and mean longitudinal flow of 2.7° in easterly direction; D) 5k25, with a mean latitudinal moisture flow of 8.6° in northerly direction and mean longitudinal flow of 5.4° in easterly direction; E) 5k50, with a mean latitudinal moisture flow of 8.5° in northerly direction and mean longitudinal flow of 5.9° in easterly direction; F) 5k100, with a mean latitudinal moisture flow of 13.2° in northerly direction and mean longitudinal flow of 14.1° in easterly direction.

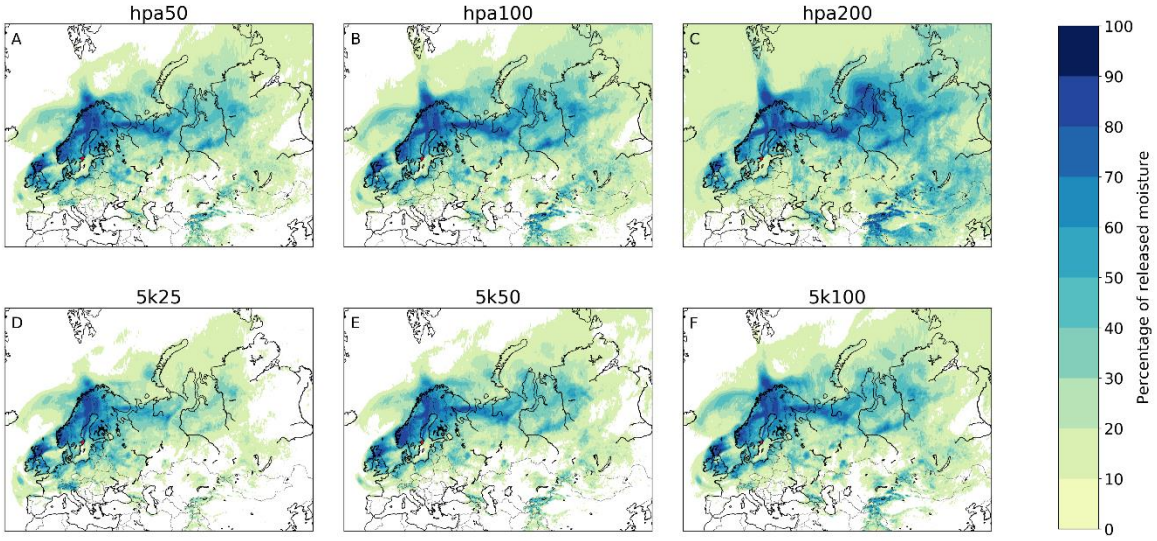

Figure S30: Different footprints of moisture releases from Stockholm in July 2012 in a three-dimensional Lagrangian model with different degradations of the vertical moisture profile. A) hpa50, with a mean latitudinal moisture flow of 1.7° in northerly direction and mean longitudinal flow of 14.0° in easterly direction; B) hpa100, with a mean latitudinal moisture flow of 1.3° in northerly direction and mean longitudinal flow of 15.4° in easterly direction; C) hpa200, with a mean latitudinal moisture flow of 0.0° in northerly/southerly direction and mean longitudinal flow of 18.1° in easterly direction; D) 5k25, with a mean latitudinal moisture flow of 1.1° in northerly direction and mean longitudinal flow of 11.1° in easterly direction; E) 5k50, with a mean latitudinal moisture flow of 2.5° in northerly direction and mean longitudinal flow of 12.9° in easterly direction; F) 5k100, with a mean latitudinal moisture flow of 1.4° in northerly direction and mean longitudinal flow of 14.4° in easterly direction.

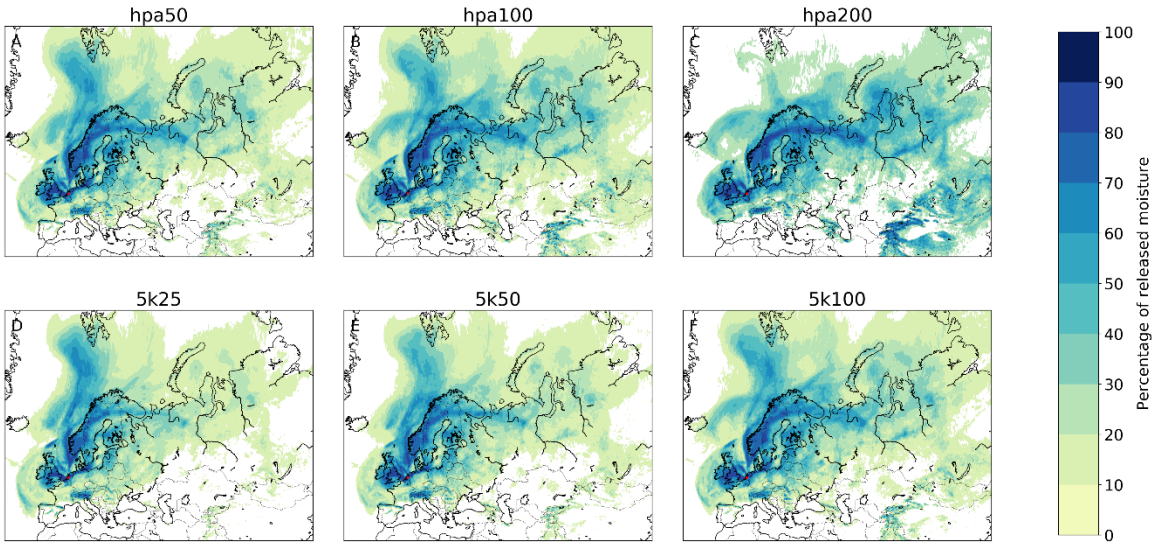

Figure S31: Different footprints of moisture releases from Utrecht in July 2012 in a three-dimensional Lagrangian model with different degradations of the vertical moisture profile. A) hpa50, with a mean latitudinal moisture flow of 7.0° in northerly direction and mean longitudinal flow of 17.9° in easterly direction; B) hpa100, with a mean latitudinal moisture flow of 6.3° in northerly direction and mean longitudinal flow of 19.1° in easterly direction; C) hpa200, with a mean latitudinal moisture flow of 3.8° in northerly direction and mean longitudinal flow of 21.0° in easterly direction; D) 5k25, with a mean latitudinal moisture flow of 6.7° in northerly direction and mean longitudinal flow of 15.7° in easterly direction; E) 5k50, with a mean latitudinal moisture flow of 7.2° in northerly direction and mean longitudinal flow of 17.0° in easterly direction; F) 5k100, with a mean latitudinal moisture flow of 6.7° in northerly direction and mean longitudinal flow of 18.7° in easterly direction.

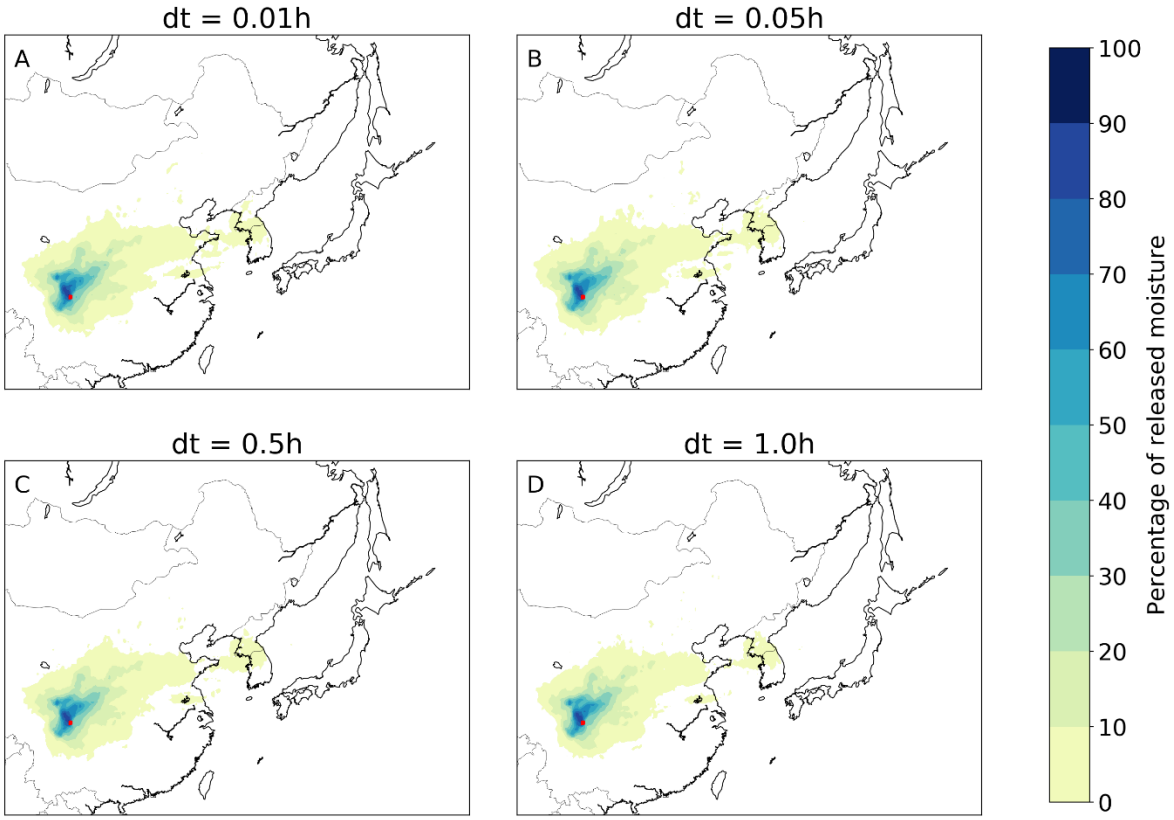

Figure S32: Different footprints of moisture releases from Chendu in July 2012 in a three-dimensional Lagrangian model with different time steps (dt): 0.01 hours, 0.05 hours, 0.5 hours, and 1.0 hours. A) 0.01h, with a mean latitudinal moisture flow of 2.3° in northerly direction and mean longitudinal flow of 2.4° in easterly direction; B) 0.05h, with a mean latitudinal moisture flow of 2.3° in northerly direction and mean longitudinal flow of 2.5° in easterly direction; C) 0.5h, with a mean latitudinal moisture flow of 2.2° in northerly direction and mean longitudinal flow of 2.3° in easterly direction; D) 1.0h, with a mean latitudinal moisture flow of 2.2° in northerly direction and mean longitudinal flow of 2.3° in easterly direction.

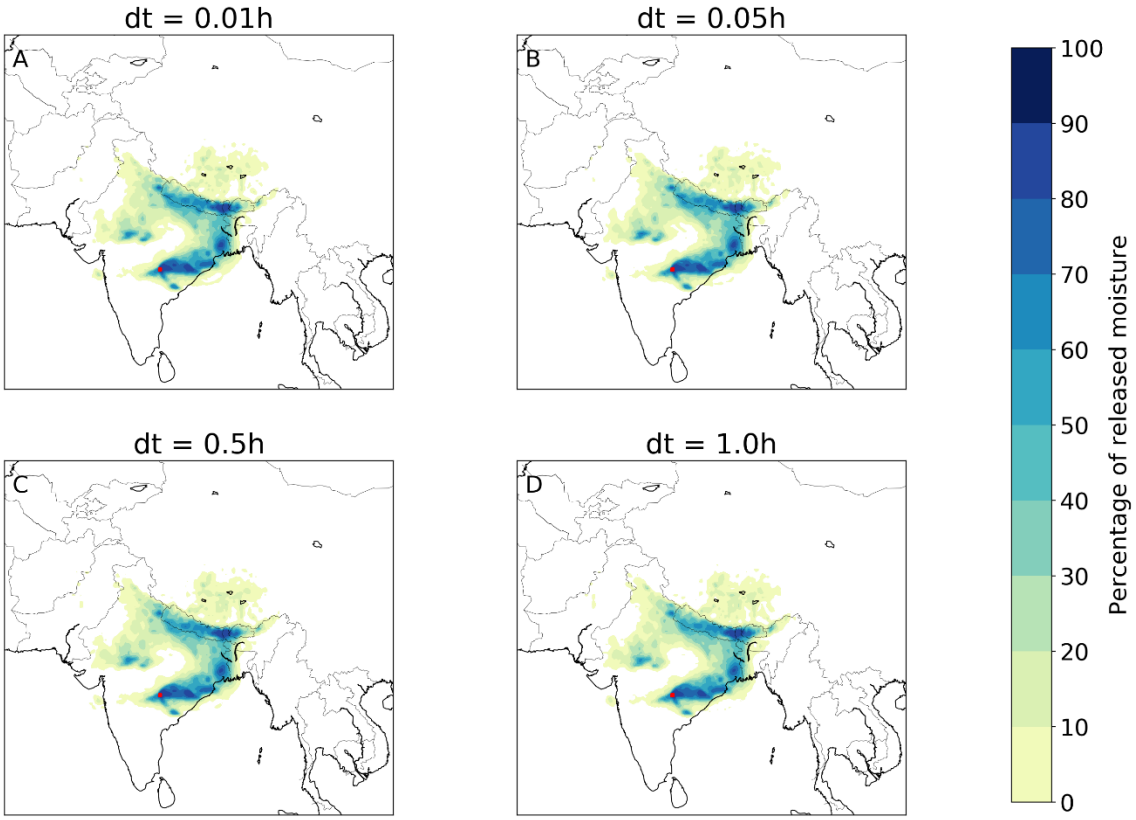

Figure S33: Different footprints of moisture releases from Nagpur in July 2012 in a three-dimensional Lagrangian model with different time steps (dt): 0.01 hours, 0.05 hours, 0.5 hours, and 1.0 hours. A) 0.01h, with a mean latitudinal moisture flow of 4.9° in northerly direction and mean longitudinal flow of 3.6° in easterly direction; B) 0.05h, with a mean latitudinal moisture flow of 4.9° in northerly direction and mean longitudinal flow of 3.6° in easterly direction; C) 0.5h, with a mean latitudinal moisture flow of 4.9° in northerly direction and mean longitudinal flow of 3.7° in easterly direction; D) 1.0h, with a mean latitudinal moisture flow of 4.9° in northerly direction and mean longitudinal flow of 3.8° in easterly direction.

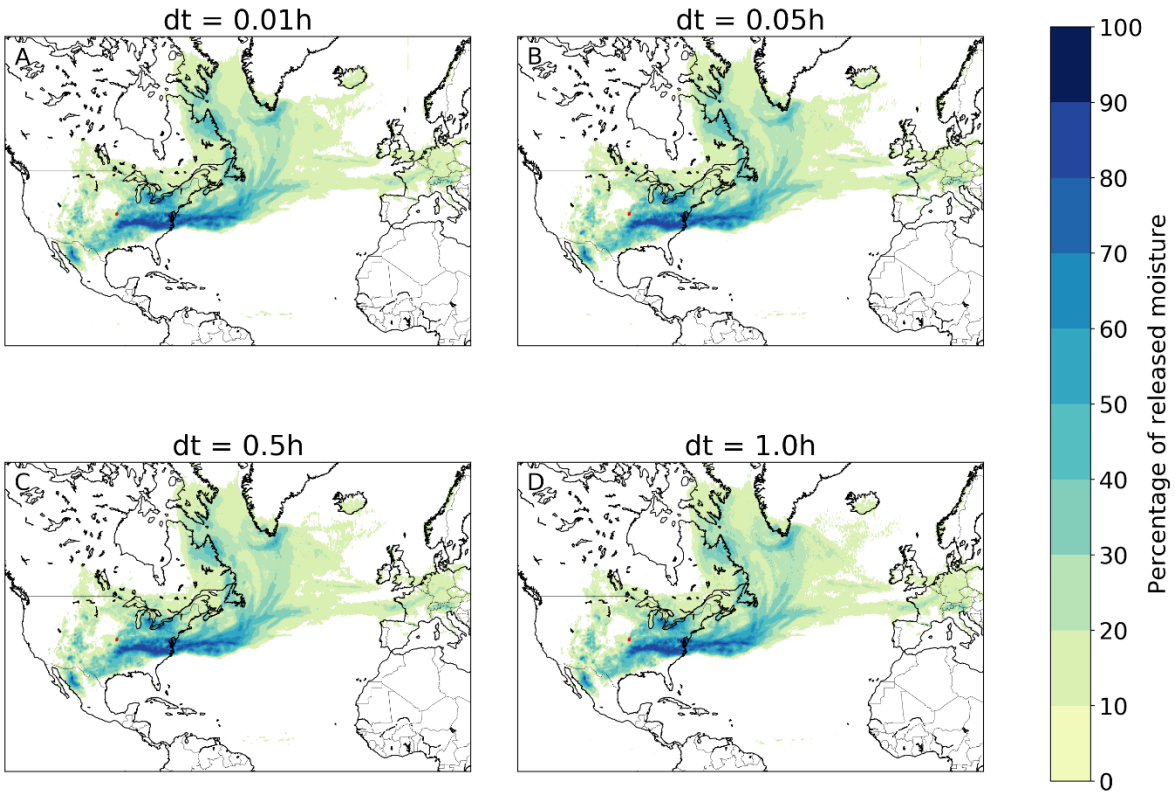

Figure S34: Different footprints of moisture releases from Kansas in July 2012 in a three-dimensional Lagrangian model with different time steps (dt): 0.01 hours, 0.05 hours, 0.5 hours, and 1.0 hours. A) 0.01h, with a mean latitudinal moisture flow of 4.0° in northerly direction and mean longitudinal flow of 15.3° in easterly direction; B) 0.05h, with a mean latitudinal moisture flow of 3.9° in northerly direction and mean longitudinal flow of 15.3° in easterly direction; C) 0.5h, with a mean latitudinal moisture flow of 3.9° in northerly direction and mean longitudinal flow of 15.3° in easterly direction; D) 1.0h, with a mean latitudinal moisture flow of 4.0° in northerly direction and mean longitudinal flow of 15.3° in easterly direction.

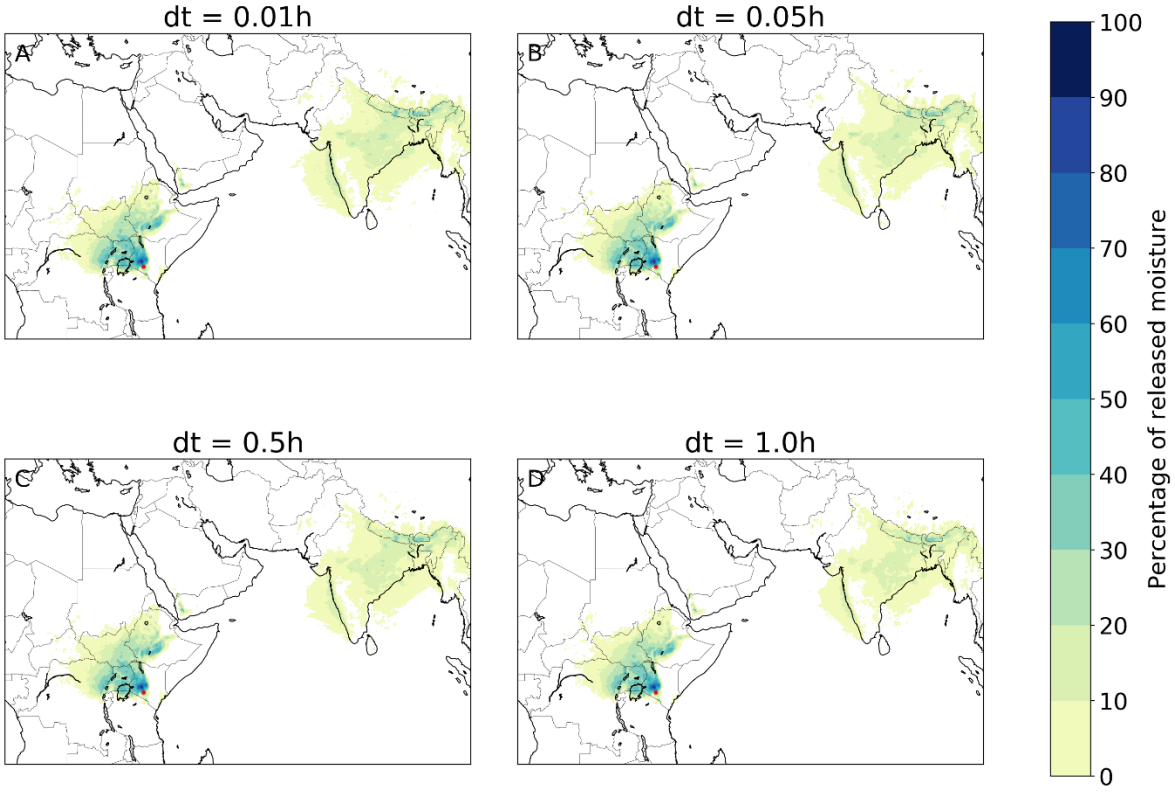

Figure S35: Different footprints of moisture releases from Nairobi in July 2012 in a three-dimensional Lagrangian model with different time steps (dt): 0.01 hours, 0.05 hours, 0.5 hours, and 1.0 hours. A) 0.01h, with a mean latitudinal moisture flow of 7.4° in northerly direction and mean longitudinal flow of 3.2° in easterly direction; B) 0.05h, with a mean latitudinal moisture flow of 7.2° in northerly direction and mean longitudinal flow of 3.0° in easterly direction; C) 0.5h, with a mean latitudinal moisture flow of 7.1° in northerly direction and mean longitudinal flow of 2.8° in easterly direction; D) 1.0h, with a mean latitudinal moisture flow of 6.9° in northerly direction and mean longitudinal flow of 2.5° in easterly direction.

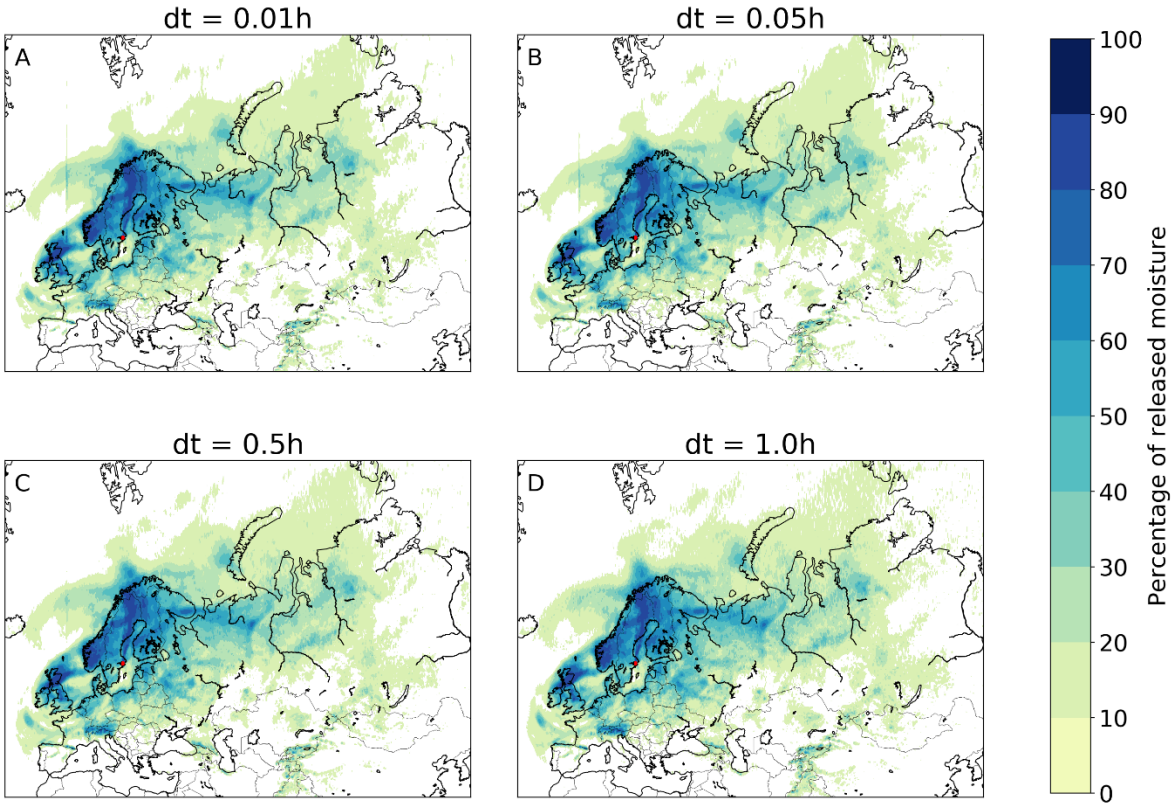

Figure S36: Different footprints of moisture releases from Stockholm in July 2012 in a three-dimensional Lagrangian model with different time steps (dt): 0.01 hours, 0.05 hours, 0.5 hours, and 1.0 hours. A) 0.01h, with a mean latitudinal moisture flow of 1.3° in northerly direction and mean longitudinal flow of 11.0° in easterly direction; B) 0.05h, with a mean latitudinal moisture flow of 1.3° in northerly direction and mean longitudinal flow of 11.1° in easterly direction; C) 0.5h, with a mean latitudinal moisture flow of 1.1° in northerly direction and mean longitudinal flow of 11.1° in easterly direction; D) 1.0h, with a mean latitudinal moisture flow of 0.8° in northerly direction and mean longitudinal flow of 11.2° in easterly direction.

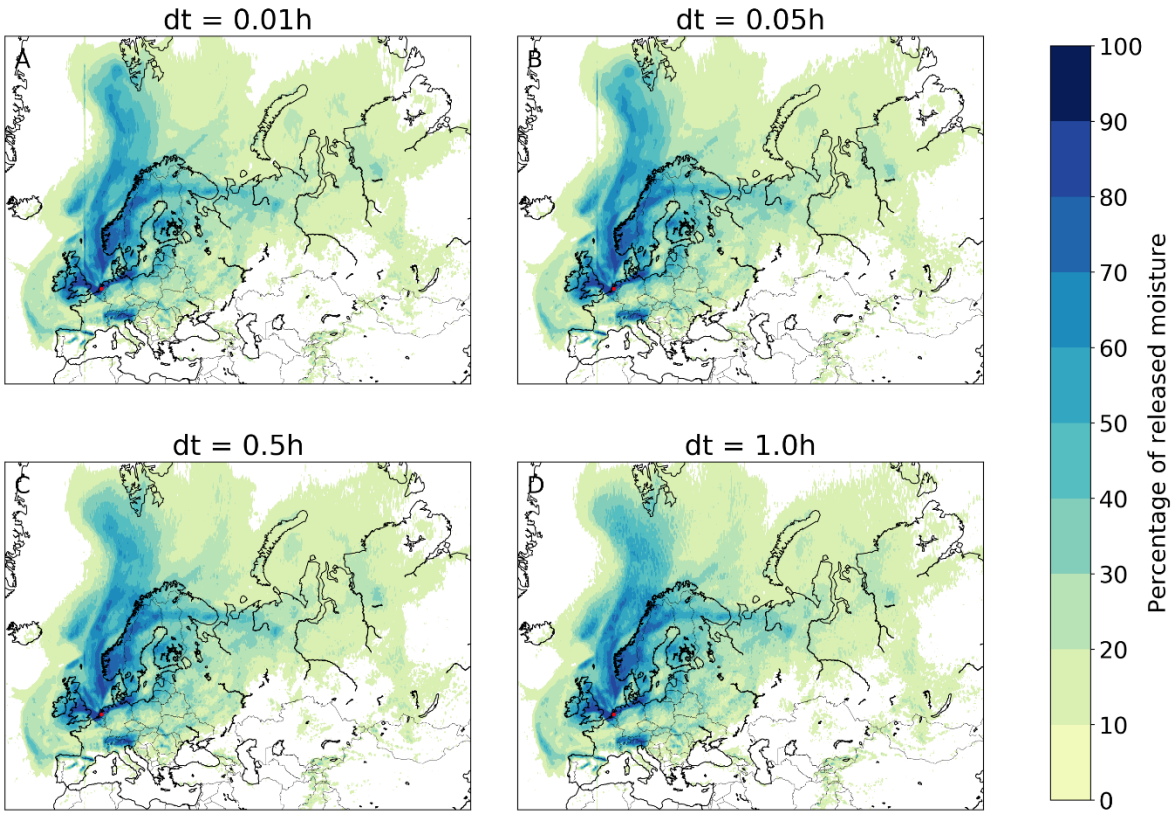

Figure S37: Different footprints of moisture releases from Utrecht in July 2012 in a three-dimensional Lagrangian model with different time steps (dt): 0.01 hours, 0.05 hours, 0.5 hours, and 1.0 hours. A) 0.01h, with a mean latitudinal moisture flow of 6.2° in northerly direction and mean longitudinal flow of 15.3° in easterly direction; B) 0.05h, with a mean latitudinal moisture flow of 6.1° in northerly direction and mean longitudinal flow of 15.3° in easterly direction; C) 0.5h, with a mean latitudinal moisture flow of 5.9° in northerly direction and mean longitudinal flow of 15.3° in easterly direction; D) 1.0h, with a mean latitudinal moisture flow of 5.9° in northerly direction and mean longitudinal flow of 15.2° in easterly direction.

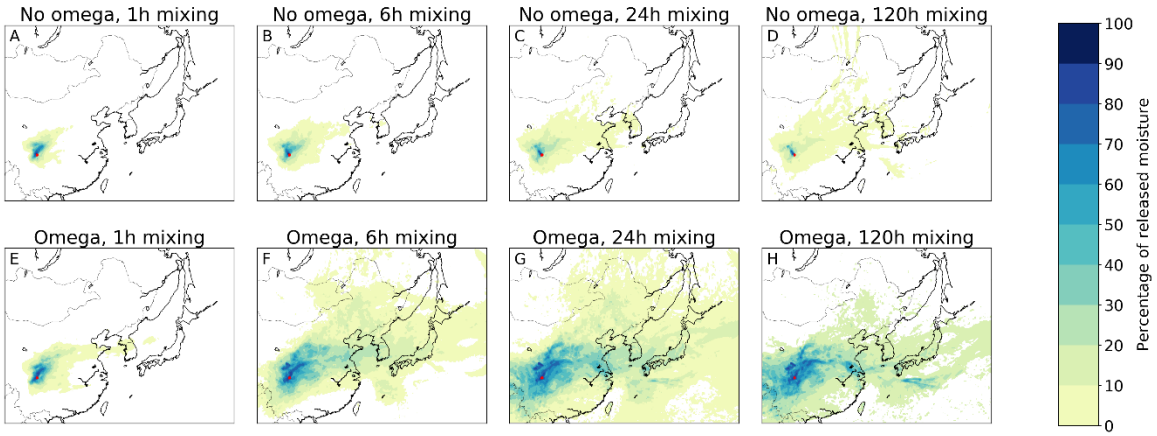

Figure S38: Different footprints of moisture releases from Chendu in July 2012 in a three-dimensional Lagrangian model with different mixing assumptions: without and with accounting for the three-dimensional

moisture flows in the ERA5 data (termed omega), and with different assumptions of additional vertical mixing speed (full mixing every 1h, every 6h, every 24, and every 120h). A) Without omega, every 1h mixing, with a mean latitudinal moisture flow of 1.6° in northerly direction and mean longitudinal flow of 1.3° in easterly direction; B) Without omega, every 6h mixing, with a mean latitudinal moisture flow of 1.8° in northerly direction and mean longitudinal flow of 1.7° in easterly direction; C) Without omega, every 24h mixing, with a mean latitudinal moisture flow of 2.0° in northerly direction and mean longitudinal flow of 1.8° in easterly direction; D) Without omega, every 120h mixing, with a mean latitudinal moisture flow of 2.0° in northerly direction and mean longitudinal flow of 1.6° in easterly direction; E) With omega, every 1h mixing, with a mean latitudinal moisture flow of 2.4° in northerly direction and mean longitudinal flow of 3.1° in easterly direction; F) With omega, every 6h mixing, with a mean latitudinal moisture flow of 3.8° in northerly direction and mean longitudinal flow of 7.1° in easterly direction; G) With omega, every 24h mixing, with a mean latitudinal moisture flow of 1.5° in northerly direction and mean longitudinal flow of 3.8° in easterly direction; H) With omega, every 120h mixing, with a mean latitudinal moisture flow of 0.6° in southerly direction and mean longitudinal flow of 1.0° in easterly direction.

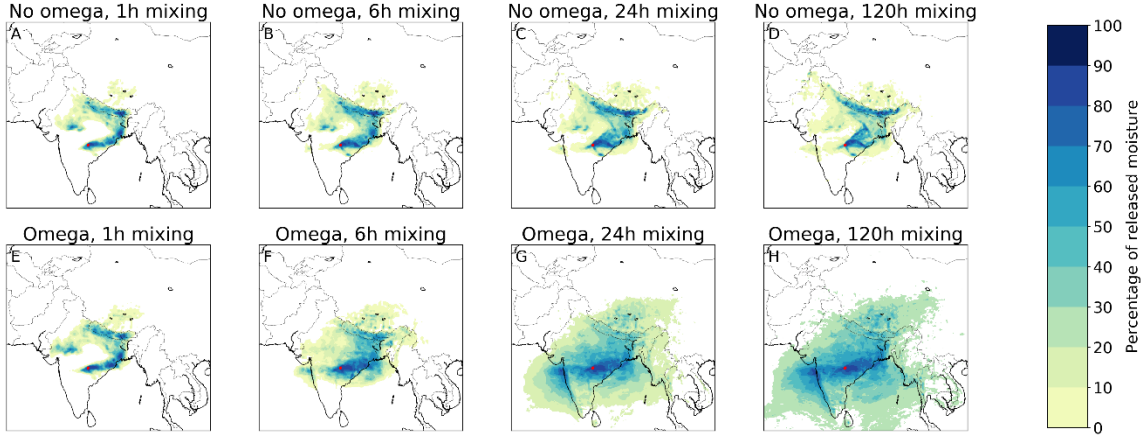

Figure S39: Different footprints of moisture releases from Nagpur in July 2012 in a three-dimensional Lagrangian model with different mixing assumptions: without and with accounting for the three-dimensional moisture flows in the ERA5 data (termed omega), and with different assumptions of additional vertical mixing speed (full mixing every 1h, every 6h, every 24, and every 120h). A) Without omega, every 1h mixing, with a mean latitudinal moisture flow of 4.9° in northerly direction and mean longitudinal flow of 3.4° in easterly direction; B) Without omega, every 6h mixing, with a mean latitudinal moisture flow of 4.7° in northerly direction and mean longitudinal flow of 3.6° in easterly direction; C) Without omega, every 24h mixing, with a mean latitudinal moisture flow of 4.6° in northerly direction and mean longitudinal flow of 3.8° in easterly direction; D) Without omega, every 120h mixing, with a mean latitudinal moisture flow of 4.5° in northerly direction and mean longitudinal flow of 3.9° in easterly direction; E) With omega, every 1h mixing, with a mean latitudinal moisture flow of 4.6° in northerly direction and mean longitudinal flow of 3.4° in easterly direction; F) With omega, every 6h mixing, with a mean latitudinal moisture flow of 2.7° in northerly direction and mean longitudinal flow of 3.9° in easterly direction; G) With omega, every 24h mixing, with a mean latitudinal

moisture flow of 1.1° in southerly direction and mean longitudinal flow of 1.1° in westerly direction; H) With omega, every 120h mixing, with a mean latitudinal moisture flow of 3.7° in southerly direction and mean longitudinal flow of 0.5° in westerly direction.

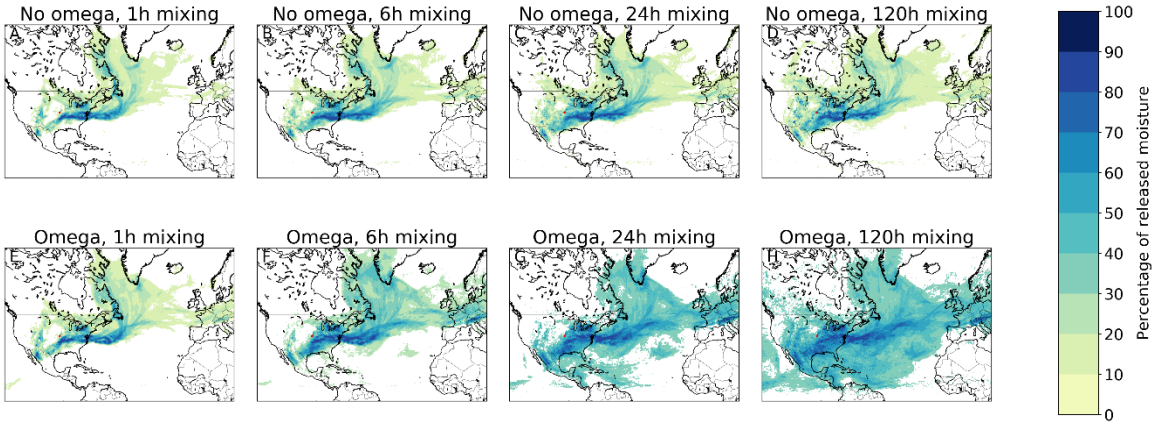

Figure S40: Different footprints of moisture releases from Kansas in July 2012 in a three-dimensional Lagrangian model with different mixing assumptions: without and with accounting for the three-dimensional moisture flows in the ERA5 data (termed omega), and with different assumptions of additional vertical mixing speed (full mixing every 1h, every 6h, every 24, and every 120h). A) Without omega, every 1h mixing, with a mean latitudinal moisture flow of 4.3° in northerly direction and mean longitudinal flow of 16.4° in easterly direction; B) Without omega, every 6h mixing, with a mean latitudinal moisture flow of 4.1° in northerly direction and mean longitudinal flow of 15.6° in easterly direction; C) Without omega, every 24h mixing, with a mean latitudinal moisture flow of 3.7° in northerly direction and mean longitudinal flow of 14.6° in easterly direction; D) Without omega, every 120h mixing, with a mean latitudinal moisture flow of 3.3° in northerly direction and mean longitudinal flow of 13.4° in easterly direction; E) With omega, every 1h mixing, with a mean latitudinal moisture flow of 4.0° in northerly direction and mean longitudinal flow of 15.4° in easterly direction; F) With omega, every 6h mixing, with a mean latitudinal moisture flow of 5.1° in northerly direction and mean longitudinal flow of 12.5° in easterly direction; G) With omega, every 24h mixing, with a mean latitudinal moisture flow of 2.3° in northerly direction and mean longitudinal flow of 9.2° in easterly direction; H) With omega, every 120h mixing, with a mean latitudinal moisture flow of 1.1° in southerly direction and mean longitudinal flow of 6.0° in easterly direction.

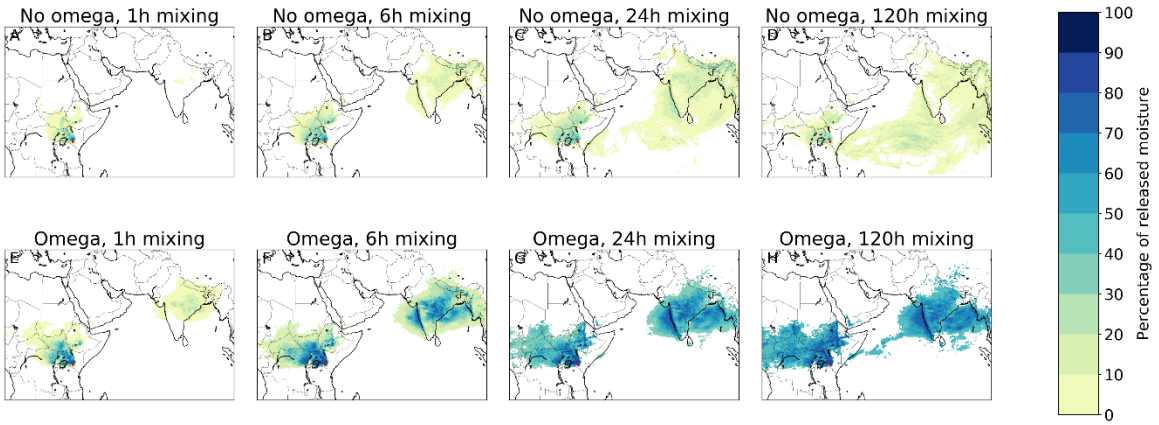

Figure S41: Different footprints of moisture releases from Nairobi in July 2012 in a three-dimensional Lagrangian model with different mixing assumptions: without and with accounting for the three-dimensional moisture flows in the ERA5 data (termed omega), and with different assumptions of additional vertical mixing speed (full mixing every 1h, every 6h, every 24, and every 120h). A) Without omega, every 1h mixing, with a mean latitudinal moisture flow of 3.5° in northerly direction and mean longitudinal flow of 0.9° in westerly direction; B) Without omega, every 6h mixing, with a mean latitudinal moisture flow of 6.5° in northerly direction and mean longitudinal flow of 2.8° in easterly direction; C) Without omega, every 24h mixing, with a mean latitudinal moisture flow of 6.5° in northerly direction and mean longitudinal flow of 5.3° in easterly direction; D) Without omega, every 120h mixing, with a mean latitudinal moisture flow of 3.6° in northerly direction and mean longitudinal flow of 5.4° in easterly direction; E) With omega, every 1h mixing, with a mean latitudinal moisture flow of 6.9° in northerly direction and mean longitudinal flow of 0.1° in easterly direction; F) With omega, every 6h mixing, with a mean latitudinal moisture flow of 12.9° in northerly direction and mean longitudinal flow of 9.5° in easterly direction; G) With omega, every 24h mixing, with a mean latitudinal moisture flow of 12.5° in northerly direction and mean longitudinal flow of 10.2° in easterly direction; H) With omega, every 120h mixing, with a mean latitudinal moisture flow of 11.0° in northerly direction and mean longitudinal flow of 8.8° in easterly direction.

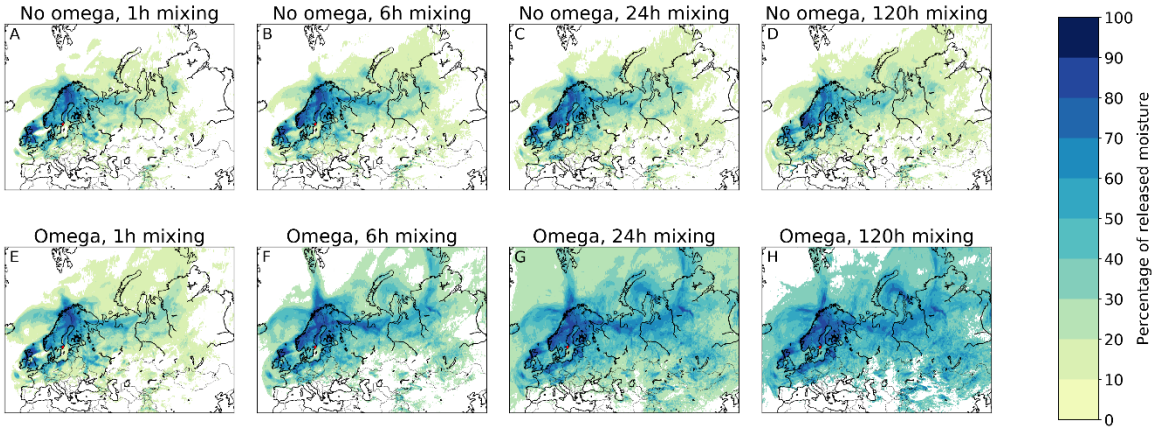

Figure S42: Different footprints of moisture releases from Stockholm in July 2012 in a three-dimensional Lagrangian model with different mixing assumptions: without and with accounting for the three-dimensional moisture flows in the ERA5 data (termed omega), and with different assumptions of additional vertical mixing speed (full mixing every 1h, every 6h, every 24, and every 120h). A) Without omega, every 1h mixing, with a mean latitudinal moisture flow of 1.5° in northerly direction and mean longitudinal flow of 11.8° in easterly direction; B) Without omega, every 6h mixing, with a mean latitudinal moisture flow of 1.5° in northerly direction and mean longitudinal flow of 11.0° in easterly direction; C) Without omega, every 24h mixing, with a mean latitudinal moisture flow of 1.0° in northerly direction and mean longitudinal flow of 10.1° in easterly direction; D) Without omega, every 120h mixing, with a mean latitudinal moisture flow of 0.4° in northerly direction and mean longitudinal flow of 8.3° in easterly direction; E) With omega, every 1h mixing, with a mean latitudinal moisture flow of 1.3° in northerly direction and mean longitudinal flow of 12.6° in easterly direction; F) With omega, every 6h mixing, with a mean latitudinal moisture flow of 1.2° in northerly direction and mean longitudinal flow of 13.6° in easterly direction; G) With omega, every 24h mixing, with a mean latitudinal moisture flow of 0.0° in northerly/southerly direction and mean longitudinal flow of 14.2° in easterly direction; H) With omega, every 120h mixing, with a mean latitudinal moisture flow of 0.8° in southerly direction and mean longitudinal flow of 14.2° in easterly direction.

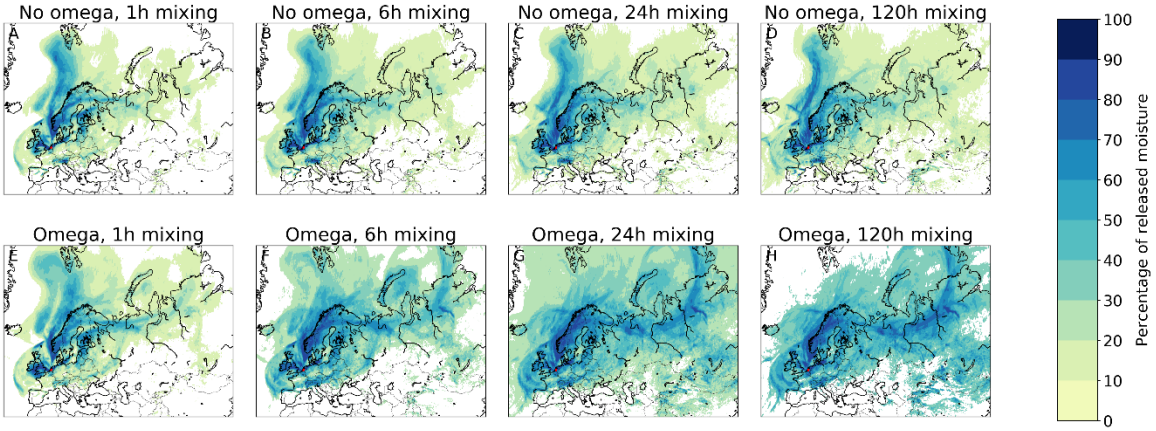

Figure S43: Different footprints of moisture releases from Utrecht in July 2012 in a three-dimensional Lagrangian model with different mixing assumptions: without and with accounting for the three-dimensional moisture flows in the ERA5 data (termed omega), and with different assumptions of additional vertical mixing speed (full mixing every 1h, every 6h, every 24, and every 120h). A) Without omega, every 1h mixing, with a mean latitudinal moisture flow of 8.1° in northerly direction and mean longitudinal flow of 14.9° in easterly direction; B) Without omega, every 6h mixing, with a mean latitudinal moisture flow of 6.3° in northerly direction and mean longitudinal flow of 15.4° in easterly direction; C) Without omega, every 24h mixing, with a mean latitudinal moisture flow of 4.7° in northerly direction and mean longitudinal flow of 15.5° in easterly direction; D) Without omega, every 120h mixing, with a mean latitudinal moisture flow of 3.6° in northerly direction and mean longitudinal flow of 15.6° in easterly direction; E) With omega, every 1h mixing, with a

mean latitudinal moisture flow of 8.8° in northerly direction and mean longitudinal flow of 17.5° in easterly direction; F) With omega, every 6h mixing, with a mean latitudinal moisture flow of 6.2° in northerly direction and mean longitudinal flow of 17.9° in easterly direction; G) With omega, every 24h mixing, with a mean latitudinal moisture flow of 4.4° in northerly direction and mean longitudinal flow of 18.1° in easterly direction; H) With omega, every 120h mixing, with a mean latitudinal moisture flow of 3.9° in northerly direction and mean longitudinal flow of 18.4° in easterly direction.