# Effects of deforestation and afforestation on regional weather conditions

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# Methods

- **Model:**

COSMO-CLM — Module TERRA: daily update of root depth, leaf area index (LAI)

- **Configuration:**

COSMO-Ru-NWR — Horizontal resolution ~ 6.6 km; Model domain – 1848×1452 km; Experimental area – 445×571 km

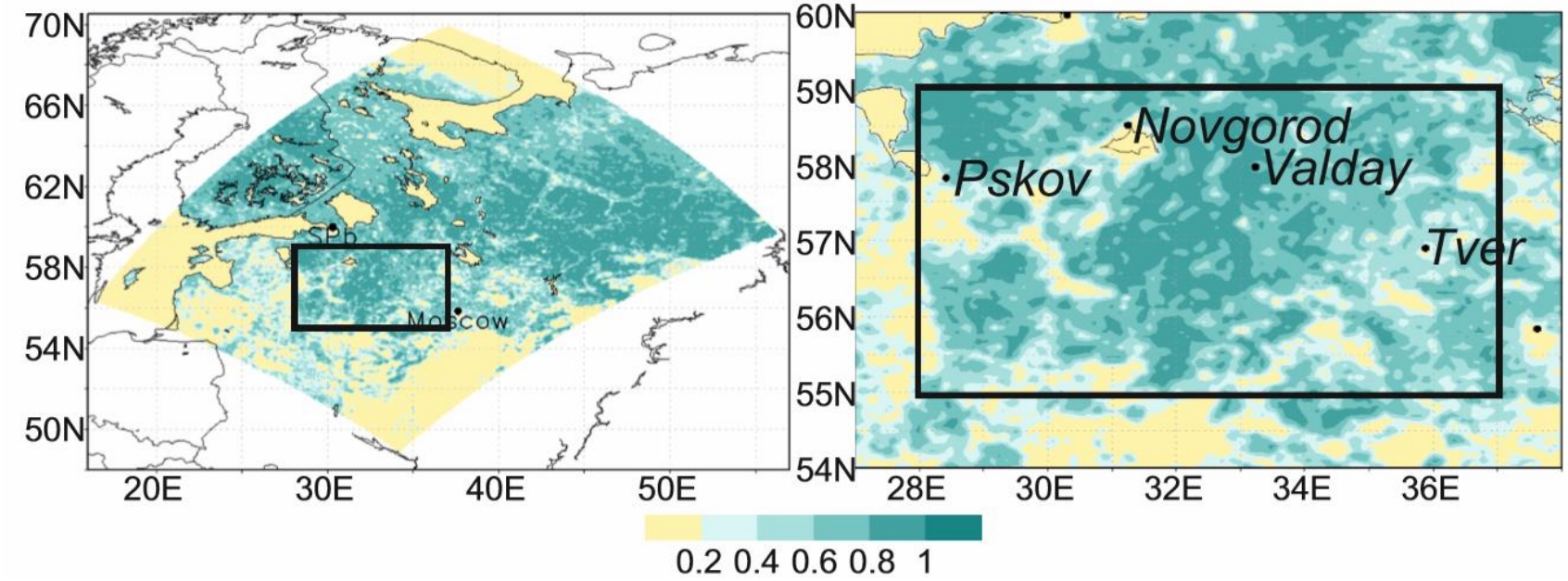
- **Period of simulation:**

1 Nov 2015 – 31 Dec 2016 — The full year + 2-month spin-up period – 'the cold start' procedure

- **Initial and boundary conditions:**

ICON (13 km grid spacing) — IC – not renewed*; BC – renewed each 3 hours

*model started once for the period of simulation




*Selected modeling domain and forest distribution within it. The depth of green color indicates the fraction of forest cover (both evergreen and broad-leaved tree species) in reference experiment.*

- **3 scenarios:**

*Within the experimental area*

**Reference** — The present distribution: coniferous 25.5%, deciduous 35.2%

LAI and root depth are specified in dependence of forest types.
LAI: in winter 0.2–1.2, in summer 3–3.5.
Root depth: 0.3–0.7 m.

**Deforestation** — Total forest clearing: grass 100%

LAI: max. 2.5 (in summer).
Root depth: 0.3 m.
FOR_E = 0 (evergreen forest). FOR_D = 0 (deciduous forest).

**Afforestation** — Forest recovery: all areas covered in reference by grass are occupied by deciduous trees

LAI: for each day of the year is determined as a max value from all available LAI values within the modeling domain.
Root depth: the same as in ref. experiment.
FOR_E + FOR_D = 1.

# Results: influence of forest cover change on the air temperature and precipitation

*Monthly air temperature at 2m and precipitation (experimental area)*

| Month | Air temperature at 2 m (°C) | | | Precipitation (mm month$^{-1}$) | | |
|---|---|---|---|---|---|---|
| | Reference | Deforestation | Afforestation | Reference | Deforestation | Afforestation |
| 1 | -10.6 | -10.9 (**-0.3**) | -10.4 (**+0.2**) | 76.4 | 74.4 (-2.0) | 77.6 (+1.2) |
| 2 | -2.1 | -2.3 (-0.2) | -2.0 (+0.1) | 57.4 | 53.2 (-4.2) | 59.4 (+2.0) |
| 3 | -2.2 | -2.8 (-0.6) | -1.9 (+0.3) | 46.2 | 43.1 (-3.1) | 48.1 (+1.9) |
| 4 | 5.2 | 4.8 (-0.4) | 5.3 (+0.1) | 73.0 | 69.7 (-3.3) | 74.4 (+1.4) |
| 5 | 13.6 | 13.8 (+0.2) | 13.5 (-0.1) | 50.2 | 48.3 (-1.9) | 50.7 (+0.5) |
| 6 | 17.2 | 17.8 (+0.6) | 17.0 (-0.2) | 61.7 | 57.4 (-4.3) | 63.0 (+1.3) |
| 7 | 19.0 | 19.3 (**+0.3**) | 18.9 (**-0.1**) | 138.5 | 133.5 (-5.0) | 140.0 (+1.5) |
| 8 | 17.1 | 17.2 (+0.1) | 16.9 (-0.2) | 83.5 | 81.3 (-2.2) | 84.4 (+0.9) |
| 9 | 11.2 | 11.2 (0.0) | 11.1 (-0.1) | 40.2 | 39.1 (-0.3) | 40.7 (+0.5) |
| 10 | 2.5 | 2.5 (0.0) | 2.5 (0.0) | 69.3 | 67.4 (-1.9) | 70.1 (+0.8) |
| 11 | -3.6 | -3.7 (-0.1) | -3.5 (+0.1) | 97.2 | 93.7 (-3.5) | 99.0 (+1.8) |
| 12 | -4.0 | -4.1 (-0.1) | -4.0 (0.0) | 54.6 | 52.2 (-2.4) | 56.0 (+1.4) |
| Year | 5.3 | 5.2 (-0.1) | 5.3 (0.0) | 848.2 | 813.3 (**-34.9**) | 863.3 (**+15.1**) |

**Annual air temperature range** **+0.6 °C** **-0.3 °C**

# Results: influence of forest cover change on the air temperature and precipitation

*Continentality indexes GCI and KCI*

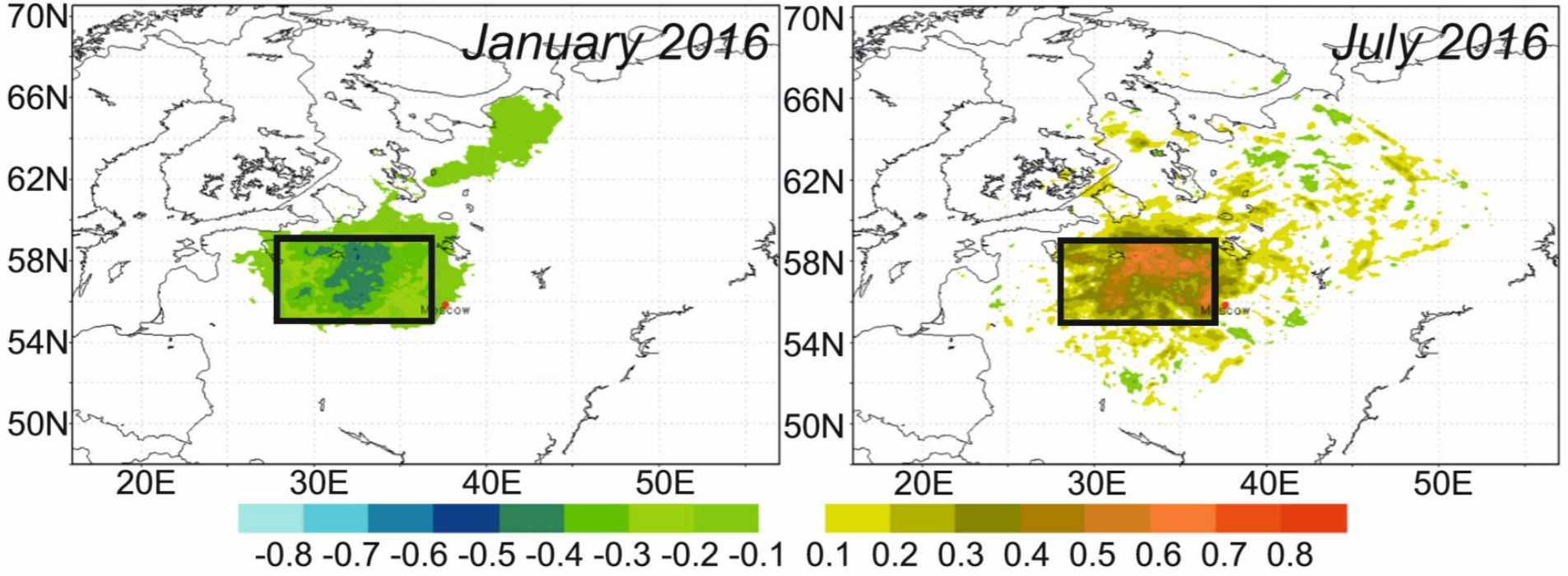
| | Reference | Deforestation | Afforestation |
|---|---|---|---|
| Gorchinsky CI | 39.62 | 40.84 | 39.01 |
| Khromov CI | 0.847 | 0.850 | 0.845 |

1) Gochinsky *(GCI)*: $GCI = 1.7A/\sin\varphi - 20.4$,

2) Khromov (*KCI*): $KCI = (A - 5.4\sin\varphi)/A$,

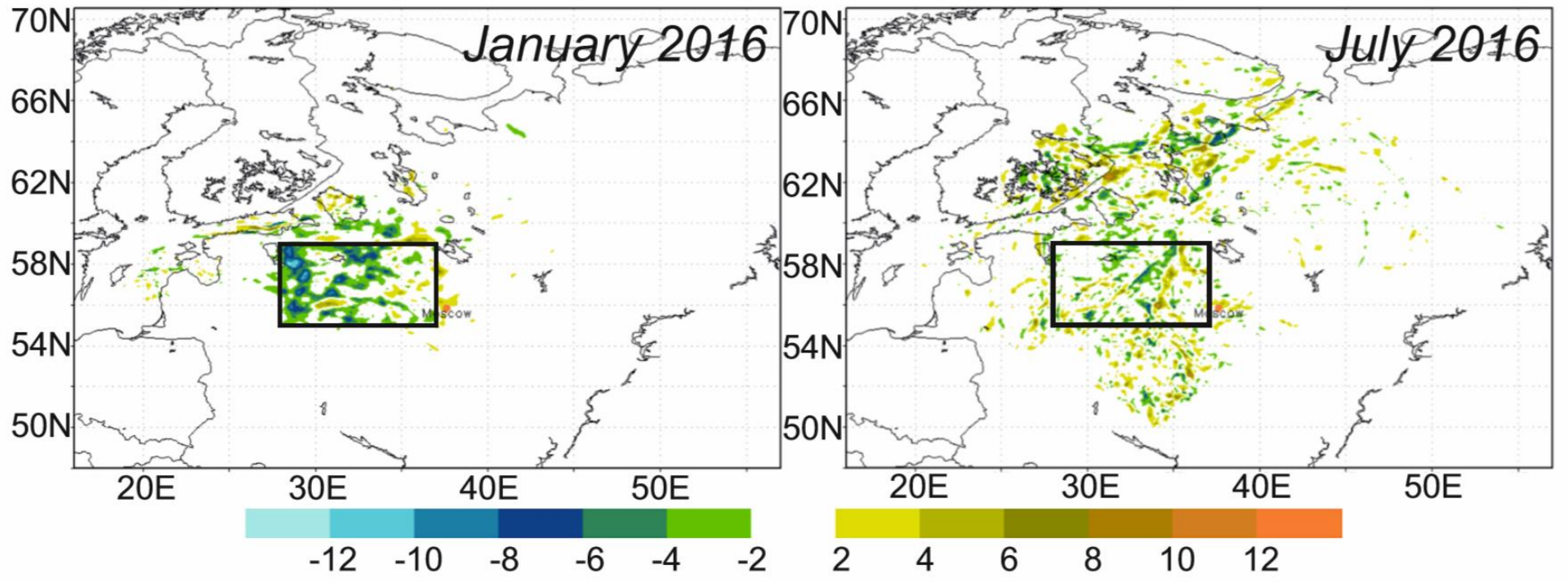
*where A — annual range of the air temperature, φ – latitude.*

# Results: influence of forest cover change on the air temperature and precipitation



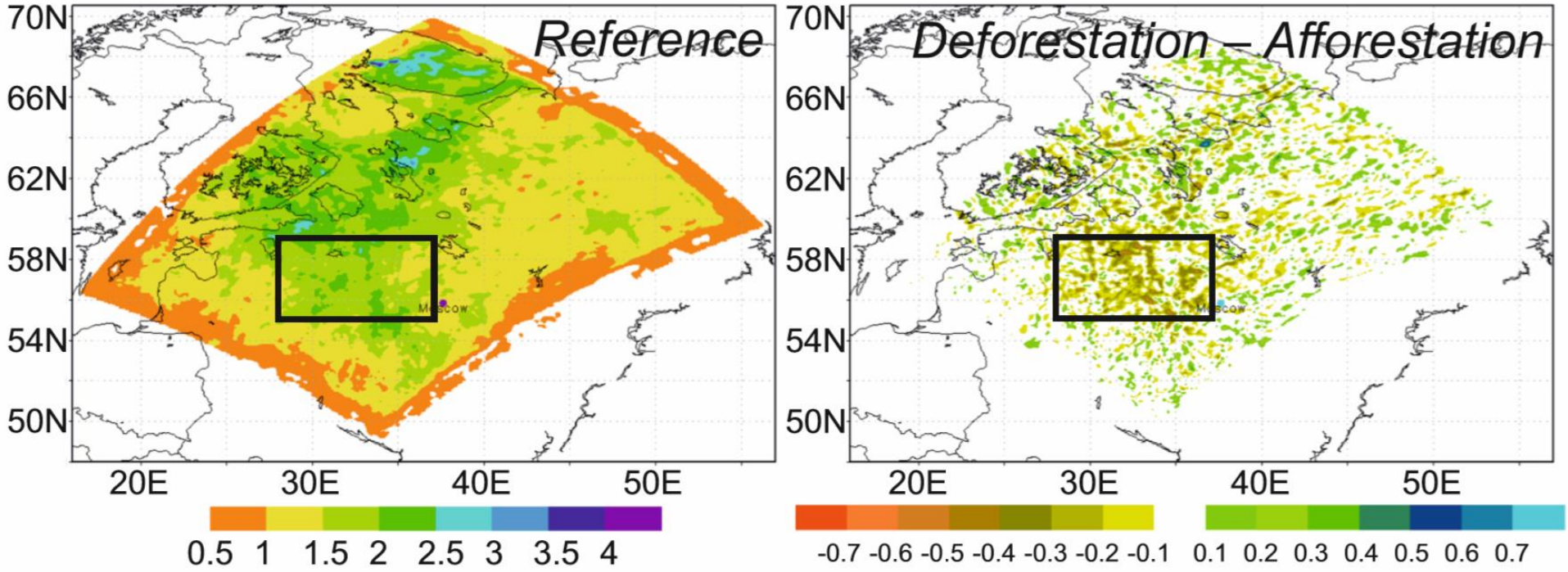

*The spatial patterns of the air temperature difference (at 2 m) between experiments: Deforestation – Reference*

# Results: influence of forest cover change on the air temperature and precipitation




Differences in precipitation between experiments:
Deforestation – Reference

# Results: influence of forest cover change on the air temperature and precipitation

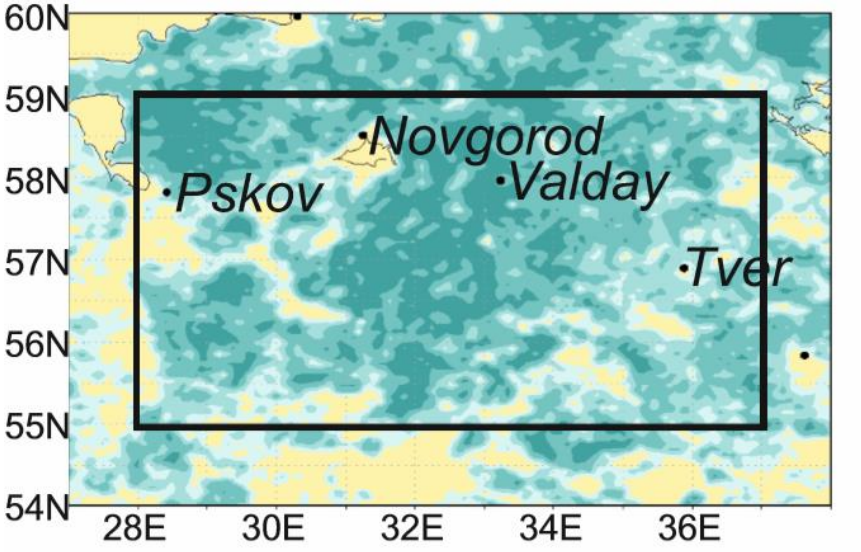



*The spatial pattern of Selyaninov hydro-thermal coefficient, HTC (Selyaninov, 1928) for year 2016*

Selyaninov hydro-thermal coefficient (*SHTC*): $K = 10 \times P / \sum t$,

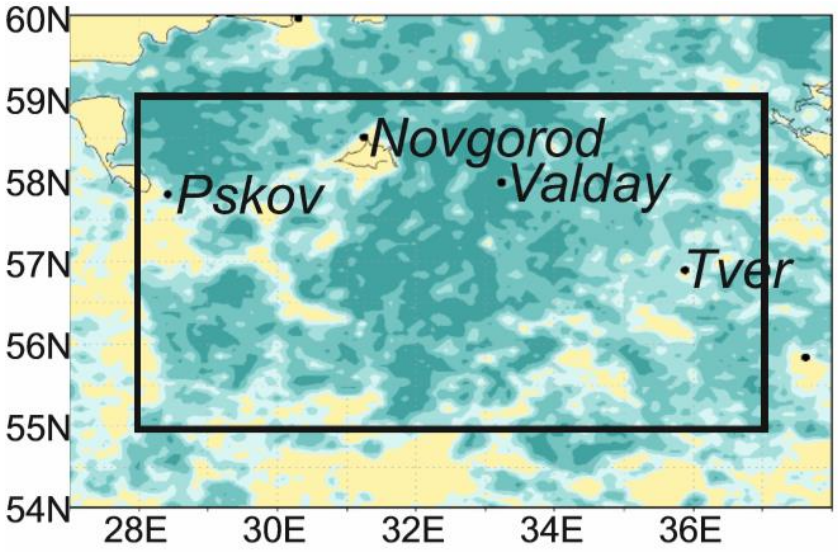
*where* $\sum t$ *— the sum of mean daily temperatures during the period it exceeds +10 °C,*
*P — total precipitation amount in mm for the same period.*

# Results: influence of forest cover change on wind speed and fog frequency




| *Number of days with wind speed > 8 m/s* | | | |
|---|---|---|---|
| Station | Reference | Deforestation | Afforestation |
| Valdai | 1 | 35 (+34) | 1 (0) |
| Novgorod | 9 | 29 (+20) | 1 (–8) |
| Pskov | 5 | 25 (+20) | 3 (–2) |
| Tver | 5 | 16 (+11) | 0 (–5) |

# Results: influence of forest cover change on wind speed and fog frequency




**Fog detection based on COSMO meteograms:**
The fog parameter given in meteograms indicates the presence of condensed water in the lowest 100-meter atmosphere level and is quantified in octs. Thus, we consider all values lower than 8 octs correspond to weather conditions that are favorable for the formation of fog, 8 octs is assumed as the prediction of fog.

| Station | *Number of favorable situations for fog formation* | | | *Number of fogs (8 octs)* | | |
|---|---|---|---|---|---|---|
| | Reference | Deforestation | Afforestation | Reference | Deforestation | Afforestation |
| Valdai | 73 | 69 (–4) | 91 (+18) | 21 | 16 (–5) | 20 (–1) |
| Novgorod | 58 | 41 (–17) | 72 (+14) | 9 | 7 (–2) | 10 (+1) |
| Pskov | 32 | 25 (–7) | 50 (+18) | 7 | 5 (–2) | 15 (+8) |
| Tver | 34 | 30 (–4) | 51 (+17) | 7 | 5 (–2) | 8 (+1) |

# Conclusion

Deforestation results in decrease of the air temperature in cold half of the year and in increase – in summer time. The afforestation results in opposite effects.

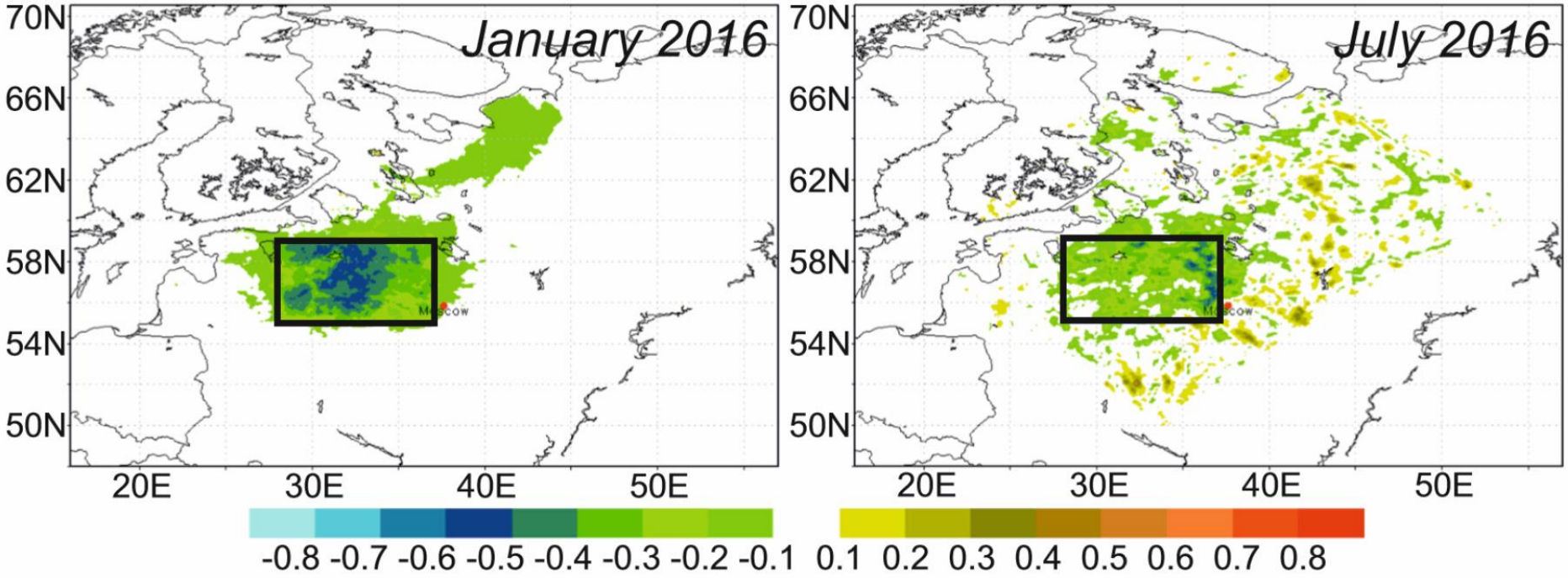
An increase of annual temperature range in the case of deforestation is about 0.6°C and it can lead to small increase of climate continentality, whereas the decrease of annual temperature ranges by 0.3°C in the case of afforestation and promotes the milder climate conditions.

Deforestation leads to small decrease of the annual precipitation amount by 35 mm (about 4%) , whereas afforestation leads to increase of precipitation amount by 15 mm (less 2%).

The precipitation changes are concentrated in the experimental area for winter months and are disseminated for modeling domain for summer conditions.

Deforestation processes lead to higher frequency of the days with strong wind speed and lower frequency of fog events. In case of afforestation, the number of days with high wind speed changes insignificantly, whereas the fog frequency is significantly grown.

# Results: influence of forest cover change on wind speed and fog frequency




*Difference of monthly mean dew points: Deforestation – Reference*