Research of surface-based temperature inversions in Nadym (YNAO) according direct measurement and simulation

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Abstract: Temperature inversions are ubiquitous feature of the high-latitude climate and can be dangerous for people's health at formation above urban area. Now, temperature inversions in Arctic cities are studied poorly so Nadym was chosen. For estimation of spatial heterogeneity of this phenomenon gradient complexes with HOBO MX 2303 were installed in urban and rural areas of Nadym. For estimation of model' s quality of simulation of the vertical structure of the atmospheric boundary layer numerical experiment with WRF ARW 4.0 was realized.

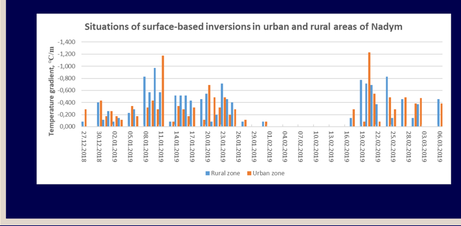
Main issue:

Estimation of surface-based inversions' frequency and spatial distribution in Nadym (Yamalo-Nenetsky Avtonomny Okrug) according direct measurement and simulation

Objectives of the research:

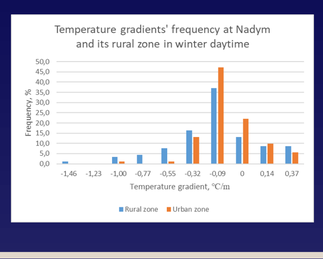
* To install gradient observation complexes with HOBO MX2303 Two External Temperature Sensors Data Logger at urban and rural zones
* To analyze observations' results and to estimate surface-based inversions' frequency and spatial distribution in Nadym
* To realize numerical experiment with WRF ARW 4.0 and to compare results for rural zone with measurements of microwave temperature profiler MTP-5

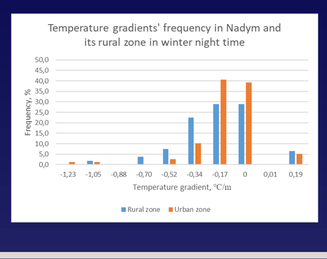
SPATIAL DISTRIBUTION



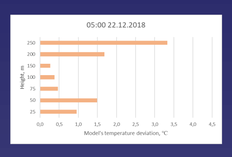
The average temperature gradient of the inversion in the city of Nadym is -0.28 °C/m for the rural area and -0.30°C/m for the urban area.

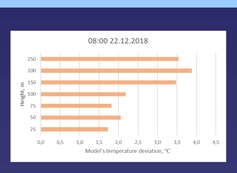
FREQUENCY

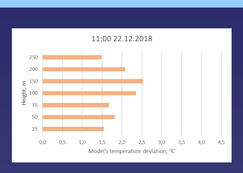


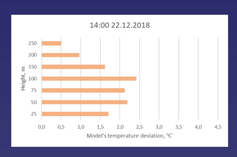


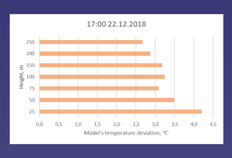
COMPARISON RESULTS OF NUMERICAL EXPERIMENT WITH MTP-5 MEASUREMENTS FOR NADYM'S RURAL AREA

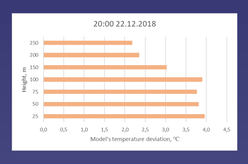


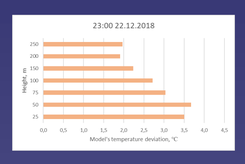












Conclusions

- Frequency of surface-based temperature inversions at the rural and urban areas are almost no different (the difference isn't more than 1-2%).
- Frequency of surface-based temperature inversions at night time is more than 90%, frequency at day time is more than 80%.
- The average temperature gradient of the inversion in the city of Nadym is -0.28°C/m for the rural area and -0.30°C/m for the urban area.
- Maximum deviations of model values is observed in stable stratification cases.

DATA AND METHODS

Why Nadym?

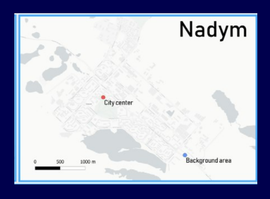
* Population: **44 830**
* Climate: **subarctic continental**
* Relief: **flat**

Gradient measurements

The automatic temperature recorder HOBO MX2303 Two External Temperature Sensors Data Logger

Technical characteristics

* Sensors' altitudes: **1.5 and 3m**
* Time step: **0.5 hour**
* Accuracy (-40°C to 0°C): **0.25°C**
* Measurement range: **-40 to 70°C**
* Measurements' period: **18.12.2018 - 15.10.2019**

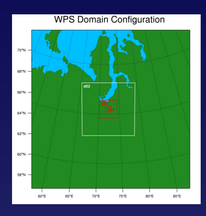


Numerical experiment

The mesoscale nonhydrostatic model WRF ARW, version 4.0

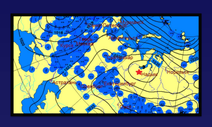
Technical characteristics of numerical experiment

* Period: **22.12.2018 - 23.12.2018**
* **4 nested domains with common center in 65,5°N 72,3° E**
* Initial and boundary conditions: **reanalysis ERA -5 with 0.25°×0.25° resolution**
* Domains horizontal grid increments: **18km, 6km, 2km, 0.5km**
* Number of vertical levels: **37**

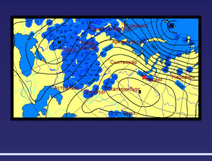


Synoptic situation

22.12.2018 12:00 UTC, Gismeteo data



22.12.2018 12:00 UTC, Gismeteo data



Parameterizations

Microphysics: **WSM 5-class scheme**

Cumulus Parameterization: **Kain-Fritsch scheme**

Planetary Boundary Layer: **Mellor-Yamada-Janjic scheme**

Surface Layer: **Similarity theory (MYJ/Eta)**

Longwave radiation: **RRTMG scheme**

Shortwave radiation: **Goddard short wave**

Land-Surface Model: **Noah-MP Land Surface Model**

Urban Parameterization: **Building Energy Model (BEM)**

Microwave temperature profilemer (MTP-5)

Technical characteristics

* Time step: **5 min**
* Vertical resolution: **25 m (0-100m), 50m (100-1000m)**
* Accuracy: **0.25°C** (0-50m), **0.9°C** (50-600m)

MTP-5 was installed in the airport of Nadym at 2018 by scientists of department of meteorology and climatology MSU, Research Computing Center MSU and A.M.Obukhov Institute of Atmospheric Physics Russian Academy of Sciences