Assessment of snow water supplies for Istra station territory using Sentinel-2 imagery data

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1 Introduction

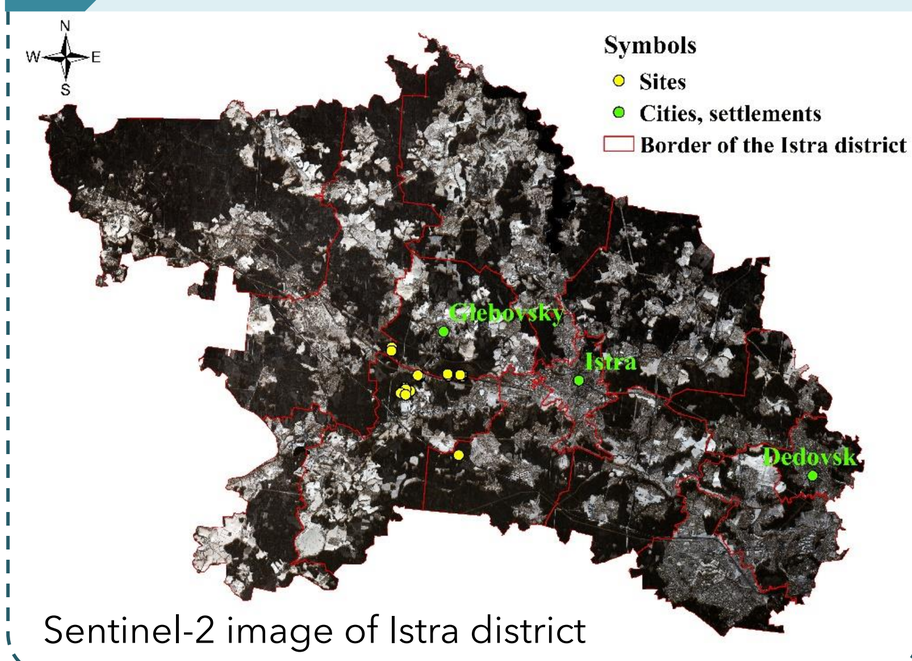
The **water content of the snow cover** is a crucial factor forming the surface and subsoil runoff and river regimes. The soil snow accumulation impacts the landscape elements significantly and determines forest ecosystems' resistance to early spring droughts, which adversely affect dark coniferous forests.

Nowadays, there are some difficulties in assessing the snow accumulation in various forest ecosystems caused, among other reasons, by the disproportion of snow cover distribution within landscape and vegetation elements.

This research aims to design methodological bases for snow water content determination using data of field studies of the snow supply and density and Sentinel-2 imagery data analysis.

Satellite imagery decoding allows obtaining data on the snow and its water content for large areas while conducting small-scale fieldwork based on the relationships of snow cover features with forest density, species composition, and forest age.

2 Study area



Sentinel-2 image of Istra district

3 Materials and Methods

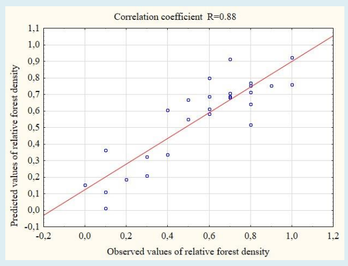
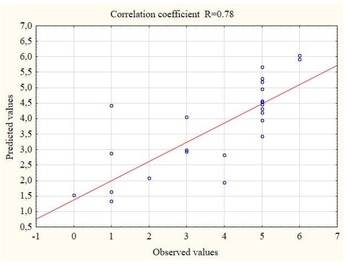
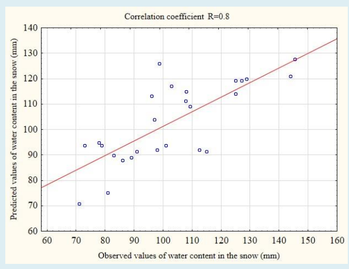
The primary study goal was to develop a method for determining water content in the snow using Sentinel-2 imagery data. For achieving the goal, the **following steps** were executed:

1. In February-March of 2021, **snow samples** were taken in various forest types and open areas;
2. Forest inventory attributes were measured;
3. The relationship between forest attributes and their forest spectral-reflective characteristics obtained from the Sentinel-2 imagery was revealed;
4. The dependencies between snow water content, forest attributes, and spectral-reflective characteristics were identified;
5. The study area was zoned according to water supplies in snow cover, based on forest inventory interpretation data.

The fieldwork was carried out on the **Istra research station** of the FBU VNIILM (Moscow region, Istra district, Zhilkino). The **samples of snow** were taken on routes in **forest stands** of various species composition, age, and density and in open areas along meadows, clearings, burnt areas, and agricultural lands without forest vegetation.

Forest attributes were determined according to the **relascopic circular plot method** [9]. Satellite images atmospheric correction using the **Dark Object Subtraction (DOS) method** [1, 2] was implemented before data processing. **Statistica 13.0** software was applied for data analysis. **Envi 5.0** were used to calculate water supplies from Sentinel-2 imagery, and **ArcGis** – for classifying the images, scaling, and turning them into maps.

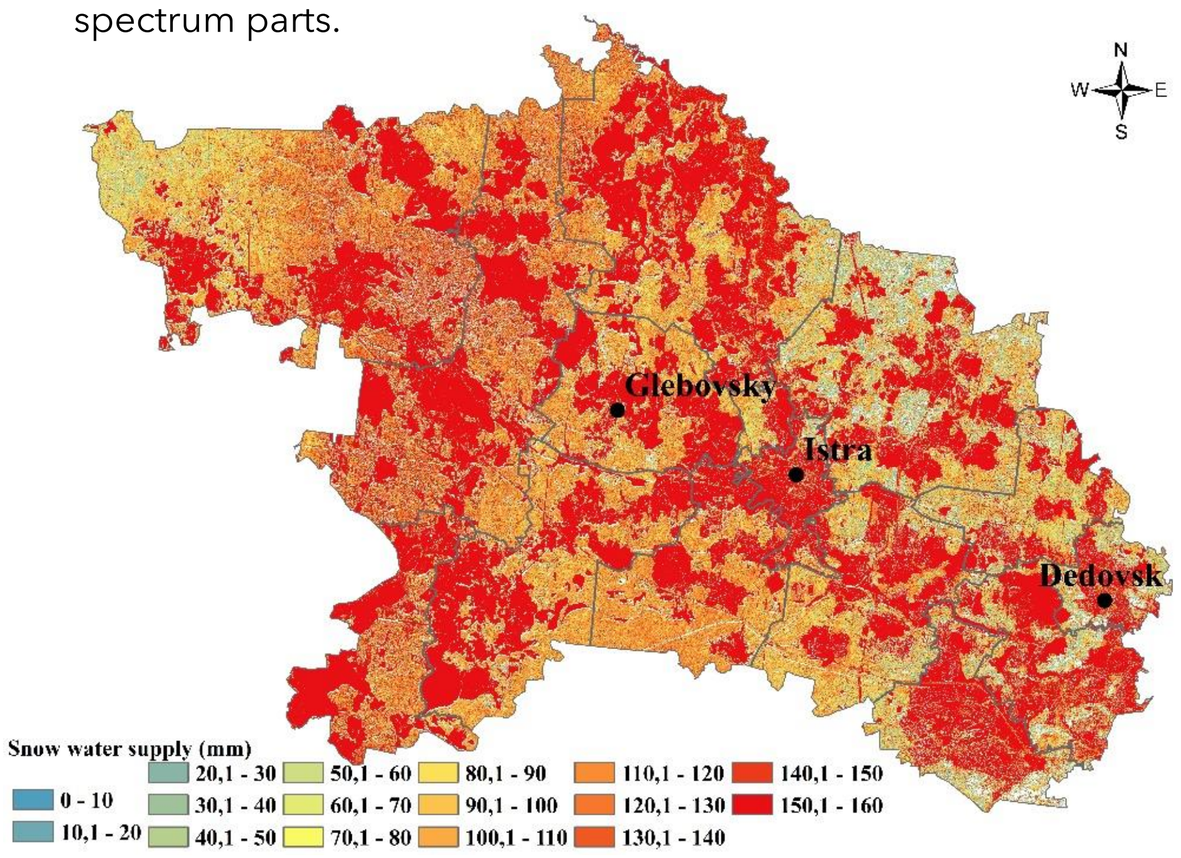
4 Results

Models	Effectiveness
P = 1,10178394103-68,9935033788*B3 + 46,9040325114*B4 – 0,693105780645*B8 + 202,268997873*B3*B4 + 173,950144302*B3*B8 – 114,473772545*B4*B8 – 859,053473418*B3*B4*B8,	 R=0,88
Species = 9,48450289629 + 56,6218072055*B2 – 52041,9531774*B2^2 – 1638,53036755*B3 – 142411,452288*B3^2 + 1936,31705738*B4 + 48220,7018009*B4^2 – 319,338592108*B8 + 1873,24396842*B8^2 + 201889,031966*B2*B3 – 64329,8799461*B2*B4 + 3018,55471848*B3*B4 – 8713,67034042*B2*B8 + 38980,1434607*B3*B8 – 30235,2661327*B4*B8	 R=0,78
M = 120,976494221 – 0,800670424181*Species + 20,0932196275*P – 0,674941243587*H – 0,356011851306*A	 R=0,80

M – water content in snow cover, mm,
P – forest density,
H – forest height,
A – forest age

B2 – blue spectral channel,
B3 – green spectral channel,
B4 – red spectral channel,
B8 – near-infrared spectral channel

Statistical data analysis revealed a **relationship between forest density, age, and species composition** and the **forest spectral-reflective characteristics** in visible and infrared spectrum parts.



Istra district **zoning according to the snow water supplies** based on the Sentinel-2 imagery data processing

Large volumes of snow are concentrated in open territories such as fields, burnt areas, clearings, and non-closed forest plantations.

5 Conclusion

- **Snow accumulation and distribution depend on forest density, age, and species composition**. It is possible to **predict** snow water supplies volume in vast areas based on its relationship with the forest inventory attributes.
- **Water supplies forecast** can be made using satellite imagery.
- It is possible to **design snow water supplies maps for large areas** based on satellite imagery data processing.
- The research results confirm the data on a remarkable snow accumulation in open spaces and forest plantations.