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Bioclimatic indexes in the Arctic: summary for November 2021 – April 2022 and weather Comfort Outlook for summer 2022

Anastasiia Revina

Arctic and Antarctic Research Institute (AARI)

Svetlana Emelina, Maria Tarasevich, Vasilisa Vorobyeva

Hydrometeocentre of Russia

ACF
Arctic Climate Forum

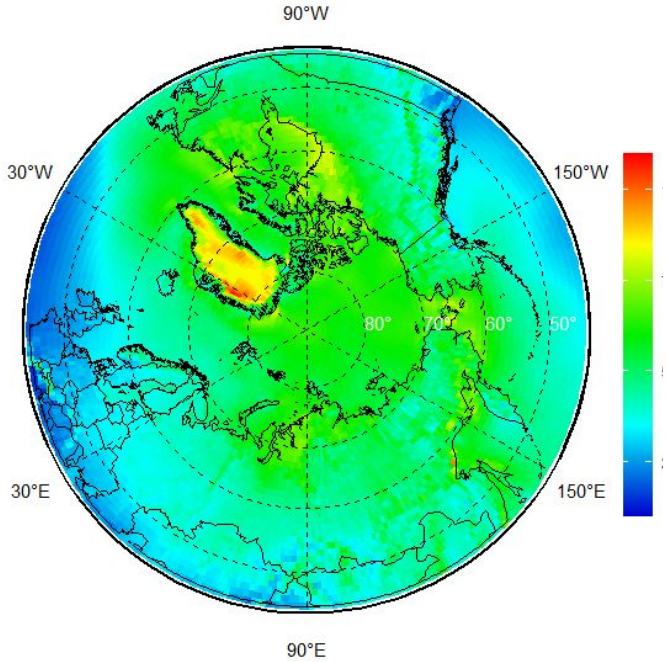
Summary
for November 2021 – April 2022

Anastasiia Revina (AARI)
nfennni@gmail.com
Svetlana Emelina (Hydrometcenter Russia)

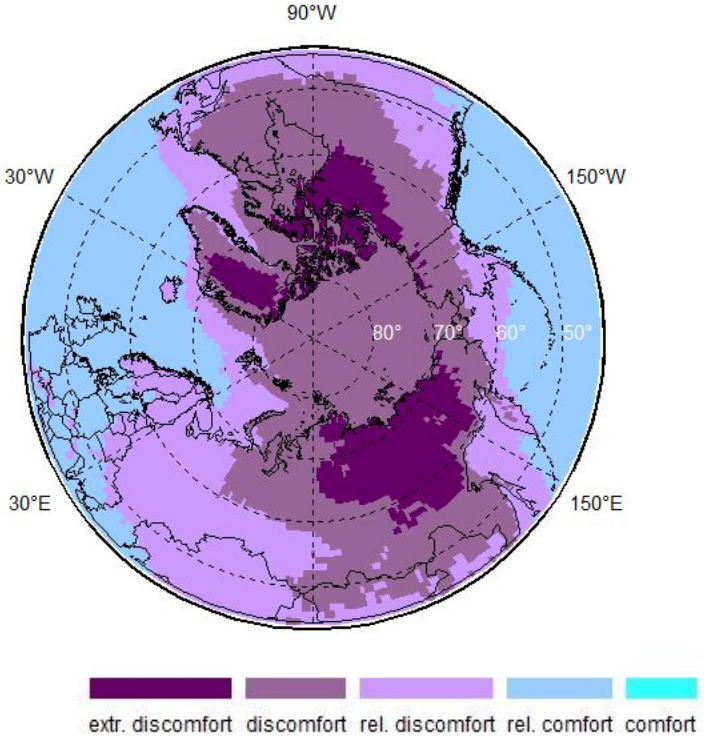
Bioclimatic indexes and formulas

Some bioclimatic indexes are based on surface air temperature (SAT) extremes, and some indexes combine SAT, relative humidity and wind speed

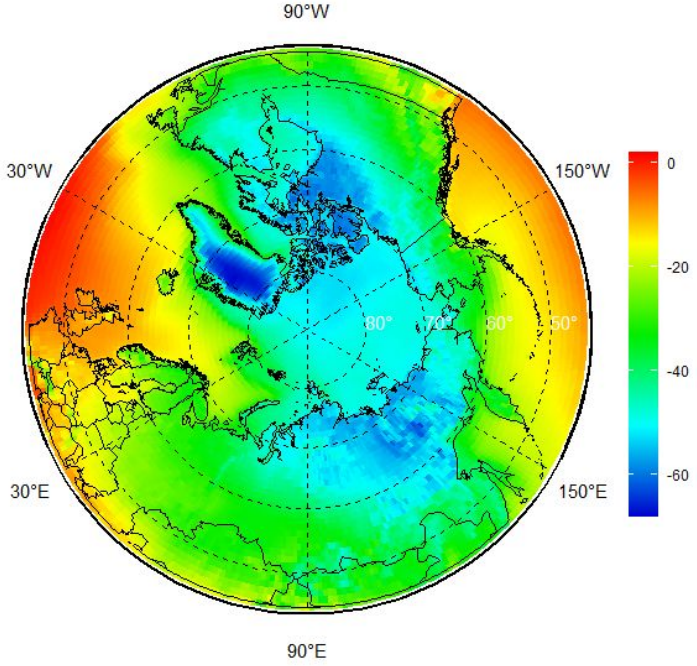
Bodman's weather severity index (S)	$S = (1 - 0.04\ T)\ (1 + 0.272\ v)$
Effective temperature by Missenard (ET)	$ET_M = t - 0{,}4\,(t - 10)(1 - f/100),$
Net Effective Temperature by Hentschel (NET)	$\mathrm{NET} = 37 - \dfrac{37 - t}{0.68 - 0.0014f + 1/(1.76 + 1.4v^{0.75})} - 0.29t(1 - 0.01f),$
Wind-Chill Temperature Index (WCT)	$\mathrm{WCI} = 13.12 + 0.6215T_a - 11.37v^{+0.16} + 0.3965T_a v^{+0.16}$



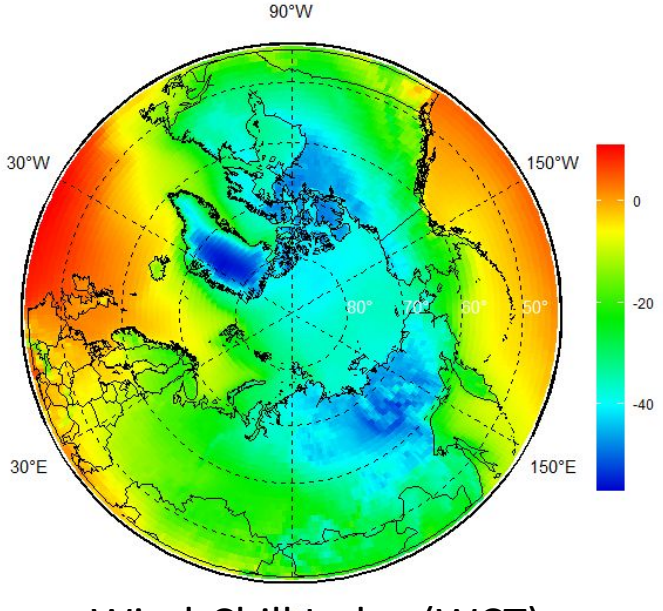
Bodman's weather severity index



Effective temperature (ET)



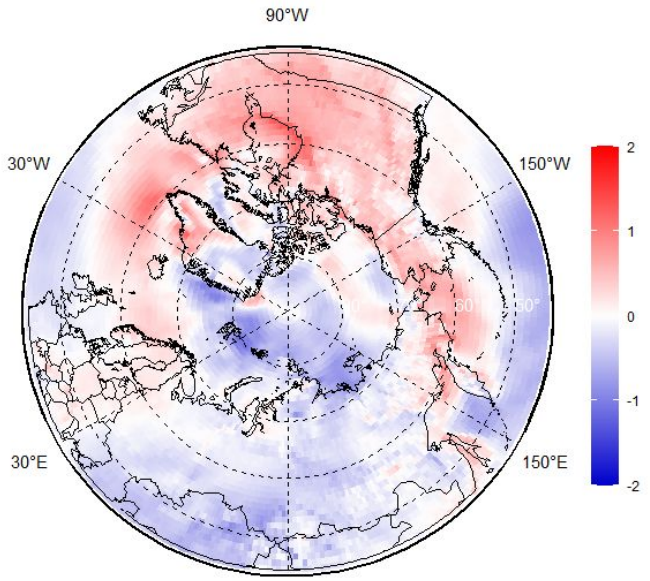
Net Effective Temperature (NET)



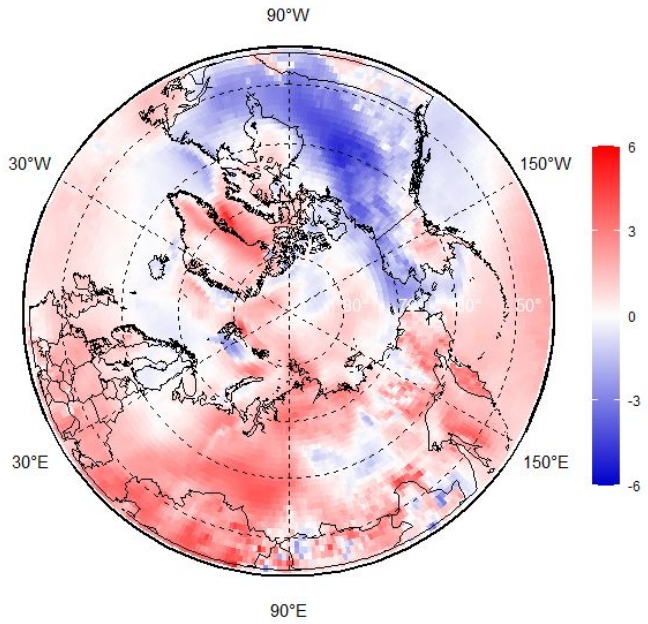
Wind-Chill Index (WCT)

Bioclimatic indexes in DJF (Dec, Jan, Feb) 2021/2022

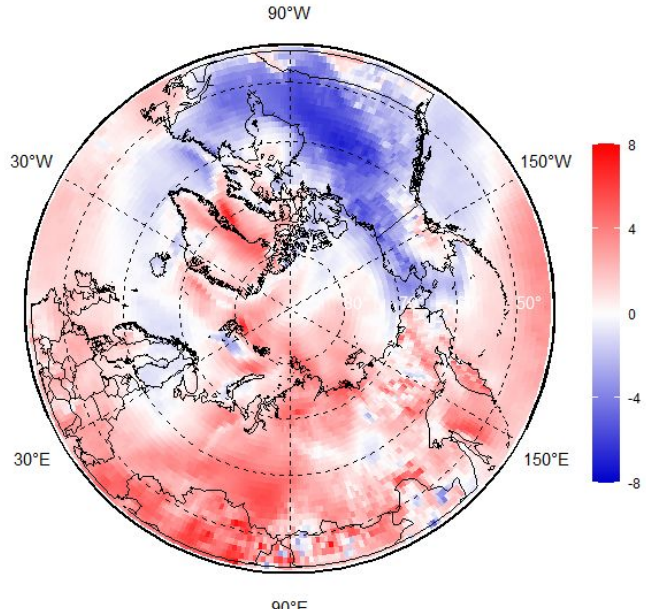
Arctic is in the very severe and extremly severe zone according to Bodman's index. ET shows the discomfort zones, with a stronger difference between extreme discomfort and discomfort zones in Western Sibirea. NET and wind chill indexes show more dedicated conditions in Yakutia region and in Canada in comparison with Bodman index.



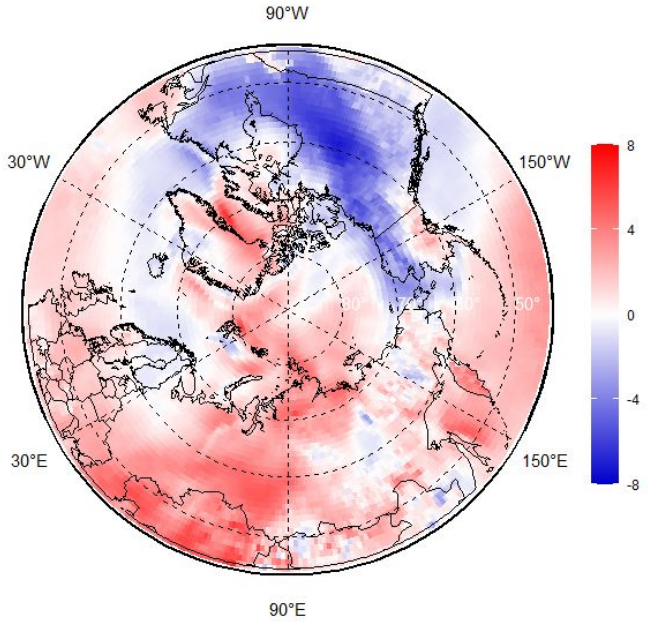
Bodman's weather severity index



Effective temperature (ET)



Net Effective Temperature (NET)

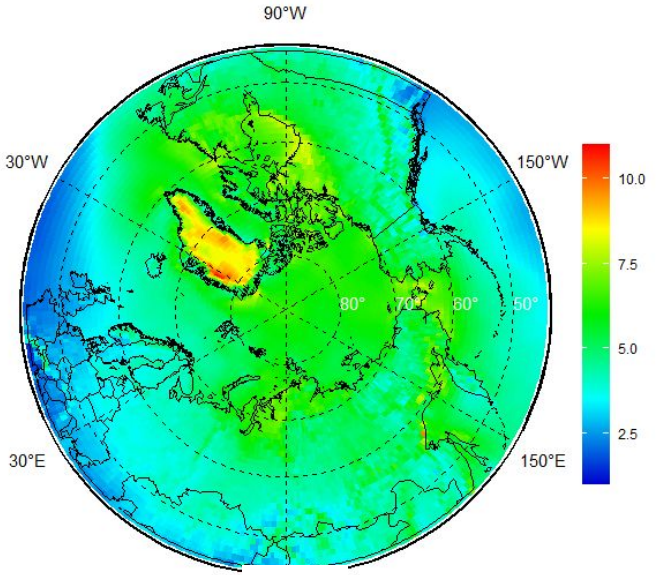


Wind-Chill Index (WCT)

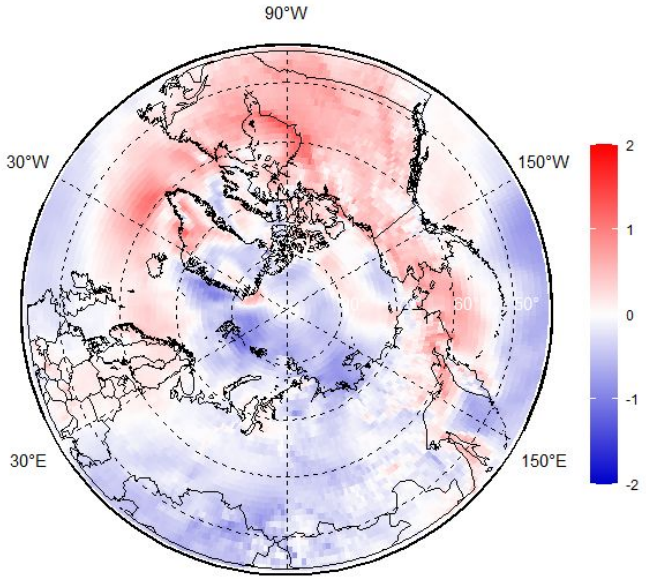
Bioclimatic indexes in DJF (Dec, Jan, Feb) 2021/2022 Anomalies from 1991-2020

Bodman's index shows more mild conditions in Eurasian part (negative anomalies from 1991-2020) and more severe conditions in Canadian-American part (positive anomalies). It is in agreement with ET an NET positive anomalies in Eurasian part excluding certain areas of Yakutia and negative anomalies in the Northern America. Southern Greenland and Bering Sea and Kamchatka areas have positive anomalies for all indexes.

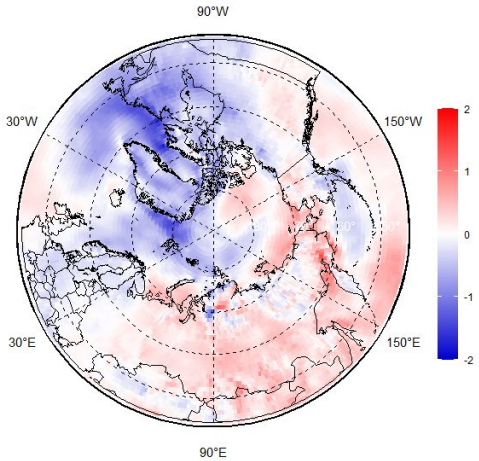
Bodman's index of weather severity DFJ 2021/2022



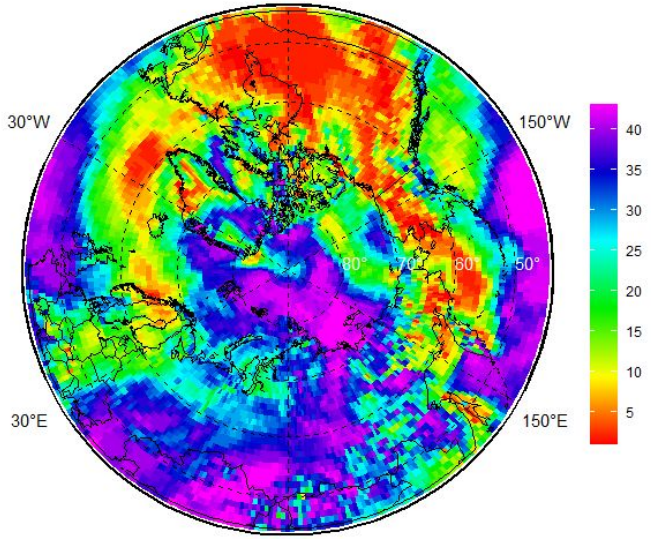
DJF



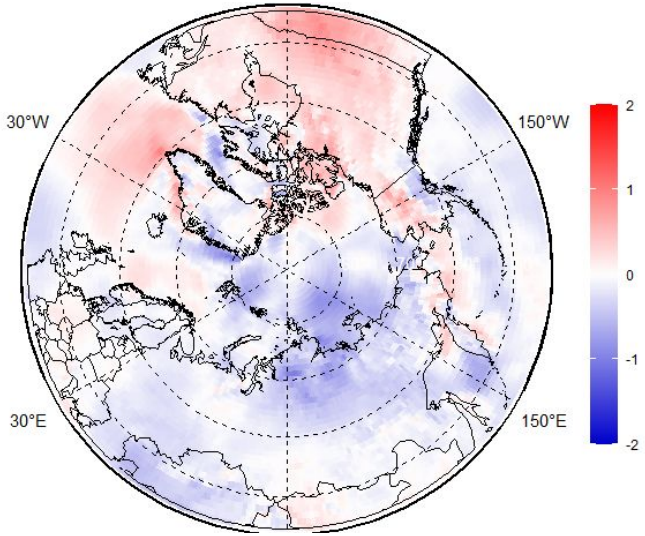
DJF anomaly (1991-2020)



DJF 2020/2021 anomaly (1991-2020)



DJF ranks (1959 – 2021)

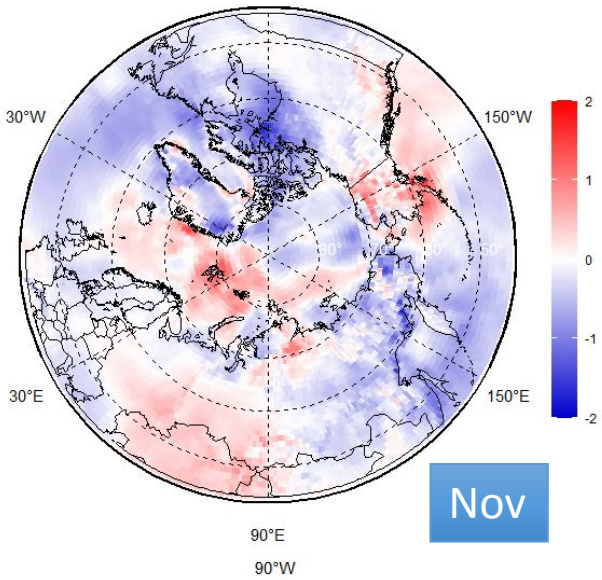


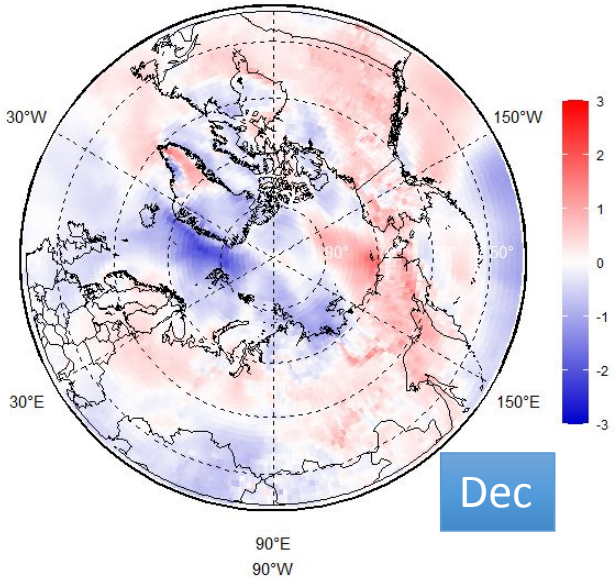
FMA anomaly (1991-2020)

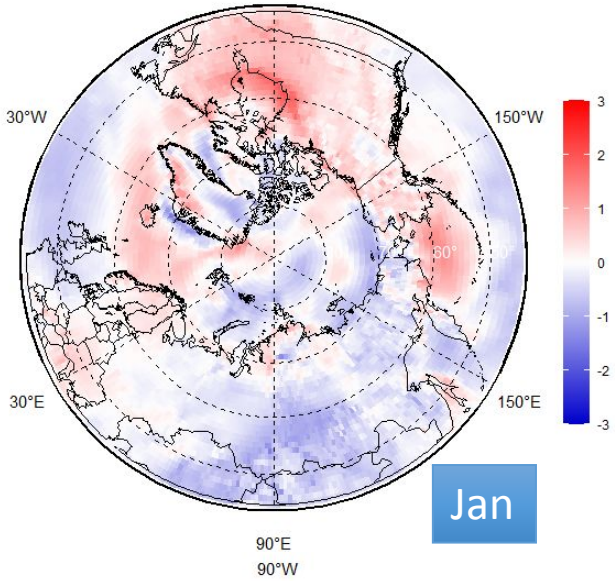
Bodman's anomalies from 1991-2020 for winter (DJF) and spring (FMA) periods are mostly the same. In comparison with last year, when it was reversed: more mild conditions in Greenland-American sector and more severe conditions in Eurasian part.

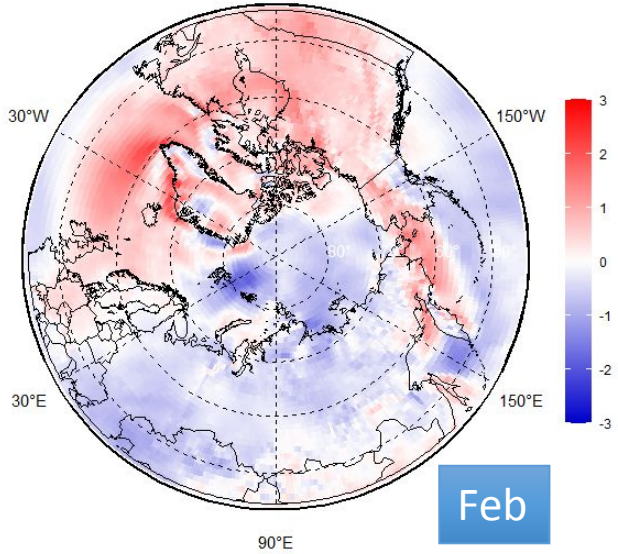
Bodman's index of weather severity

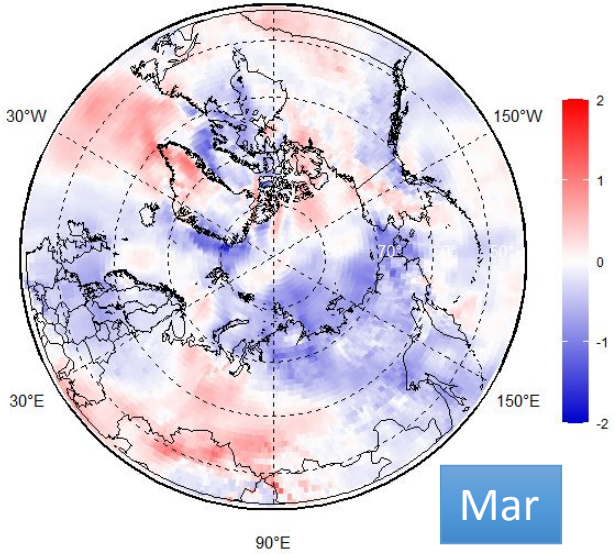
The variability of Bodman's index between months is seen: unlike mean DJF and FMA, there were positive anomalies in Eurasian part (in November and March in the Western Siberia and in December in the whole Arctic part of Russia and in the Chukchi Sea) and negative anomalies in November in North American part of the Nothern Hemisphere.

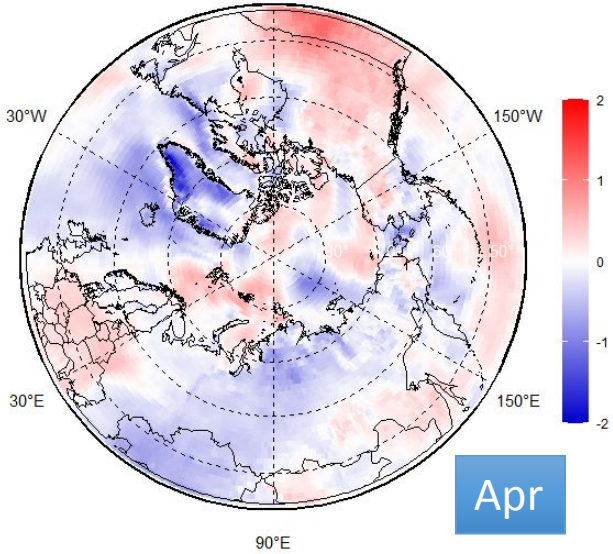




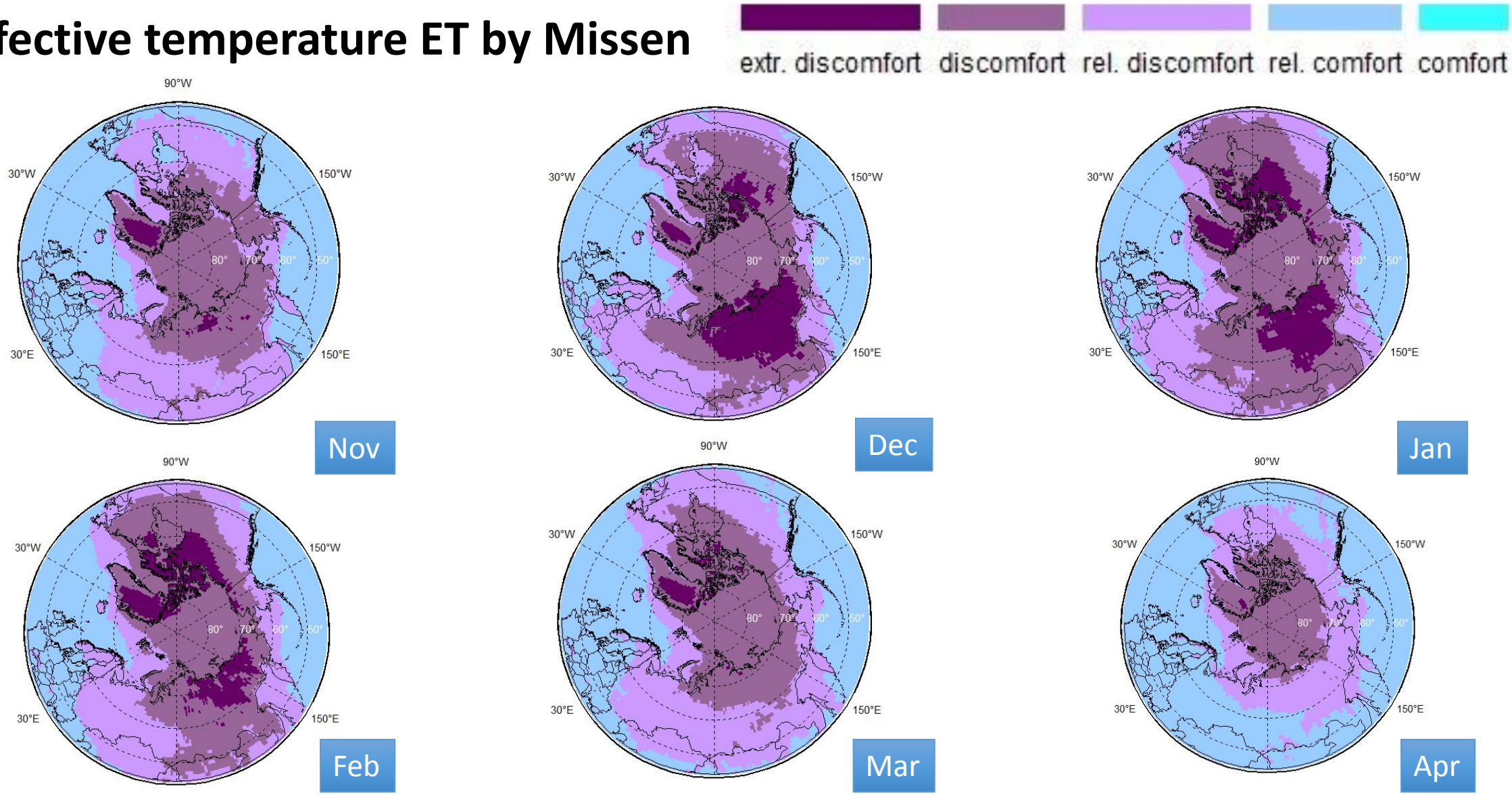








Effective temperature ET by Missen



Monthly ET shows rather severe conditions in the Arctic during all monthes, relative comfort zone coincide with warm ocean in the area of the Greenland and Norwegian Seas and in European part of Northern Hemisphere. Only in April relativly comfort conditions appear in European part of Russia and South and Central Siberia and near 50-60 °N in the North America

Conclusions on current usage of indexes across the world

- Bodman's severity index is used to analyze thermal discomfort in different regions (i.e. in Russia [1], Bulgaria[2])
- ET is used to assess climate comfort (i. e. in Russia [3], Bulgaria[2]), the relationship of ET and cardiopulmonary morbidity and mortality (Taiwan [4])
- NET: relationship of NET with mortality rates (in Hong Kong [5]), NET is used to investigate spatial differences in thermal comfort conditions detecting spatial differences in thermal stress (China [6]), NET provide information of thermal comfort conditions (Romania [7]), to assess the impacts of climate change on the heat stress perception (in East Asia [8]. Average and 95th percentile NET are used.
- WCT is used in meteorological services of many countries (i. e. Canada, USA, Portugal), WCT is used to access the conditions for the health of athletes and tourists interested in winter sports [9], to analyze thermal discomfort in different regions [7]
- Indexes based on daily extremes should provide additional special features

Choice and interpretation of indexes for the domain of our center needs <u>further investigation by the services and end users</u>

Literature for previous slides

1. Kargapolova, Nina A. and Ogorodnikov, Vasily A.. "Numerical stochastic modelling of spatial and spatio-temporal fields of the wind chill index in the South of Western Siberia" *Russian Journal of Numerical Analysis and Mathematical Modelling*, vol. 36, no. 1, 2021, pp. 33-42. https://doi.org/10.1515/rnam-2021-0003
2. Malcheva, Krastina & Gocheva, Anelia. (2014). Thermal comfort indices for the cold half-year in Sofia. Bulgarian Journal of Meteorology and Hydrology. 19. 16-25.
3. Emelina, S. V. Evaluation of the dynamics of comfort of weather and climatic conditions in 1980-2050 on the territory of Russia / S. V. Emelina, A. A. Makosko, A. V. Matesheva // Turbulence, dynamics of the atmosphere and climate: materials of the international conference, Moscow, May 16–18, 2018. - Moscow: Limited Liability Company "Physmatkniga Publishing House", 2018. - P. 222-227. [In Russian]
4. Lin, Yu-Kai et al. “Relationships between cold-temperature indices and all causes and cardiopulmonary morbidity and mortality in a subtropical island.” *The Science of the total environment* vol. 461-462 (2013): 627-35. doi:10.1016/j.scitotenv.2013.05.030
5. Li P.W. and Chan S.T. Application of a Weather Stress Index for Alerting the Public to Stressful Weather in Hong Kong.- J. Meteorological Applications, 2000, vol. 7, pp. 369-375.
6. Zhang, Jie & Wenli, Lai & Zhao, Zhizhong & Wang, Hongrui. (2019). Detecting spatial differences in thermal stress across China. Theoretical and Applied Climatology. 138. 10.1007/s00704-019-02831-x.
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9. Roshan G, Mirkatouli G, Shakoor A, Mohammad-Nejad V. Studying wind chill index as a climatic index effective on the health of athletes and tourists interested in winter sports. Asian J Sports Med. 2010 Jun;1(2):108-16. doi: 10.5812/asjsm.34861. PMID: 22375198; PMCID: PMC3289168.

Weather Comfort Outlook for summer 2022

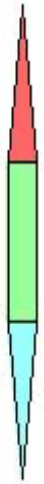
Svetlana Emelina, Maria Tarasevich, Vasilisa Vorobyeva
Hydrometeocentre of Russia
tkachukzn@gmail.com

“Measure” of comfort – effective temperature index

$$ET_m = t - 0{,}4\,(t - 10)\left(1 - \frac{f}{100}\right),$$

where t - air temperature (°C), f - relative humidity (%).

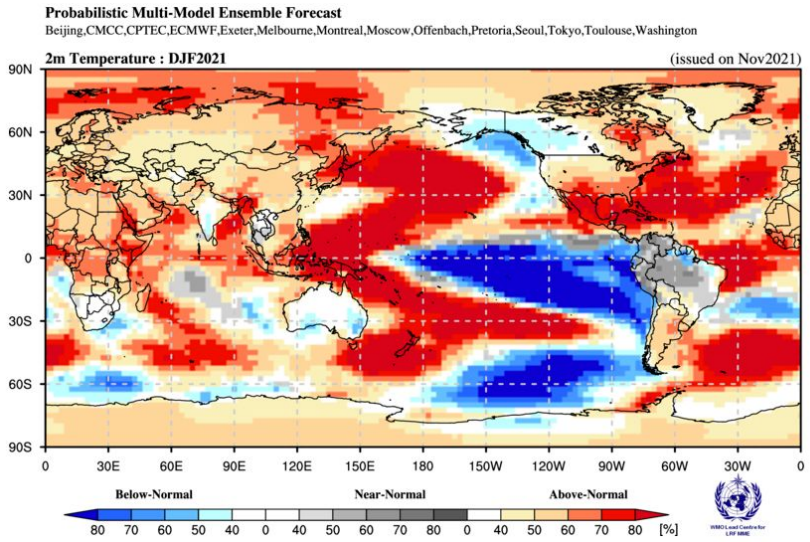
	Thermal sensation	Physiological effect	Comfort sensation
≥+30	Very hot	Incomprensible heat	Discomfort
+24..+30	Hot	Slightly uncomfortable	Partial discomfort
+18..+24	Warm	Comfortable	Comfort
+12..+18	Slightly warm	Neutral	Partial comfort
+6..+12	Slightly cool	Slightly uncomfortable	Partial discomfort
0..+6	Cool	Slightly uncomfortable	Partial discomfort
-12..0	Cold	Uncomfortable	Partial discomfort
-24..-12	Very cold	Uncomfortable	Discomfort
-30..-24	Extremely cold	Incomprensible cold	Extremely discomfort
≥-30	Extremely cold	Incomprensible cold	Extremely discomfort



Forecast data

- Test seasonal forecast (JJA 2022) of the model of the Institute of Numerical Mathematics RAS* were used to calculate the effective temperature values for Summer 2022 and hindcasts 1991-2020 for the norms.

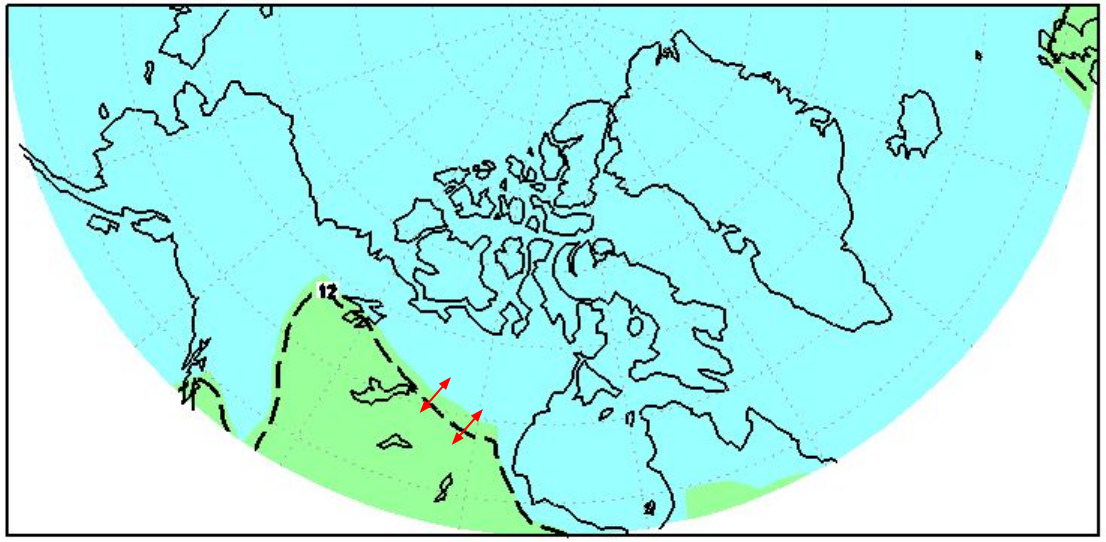
- Resolution 2,5°×2,5°



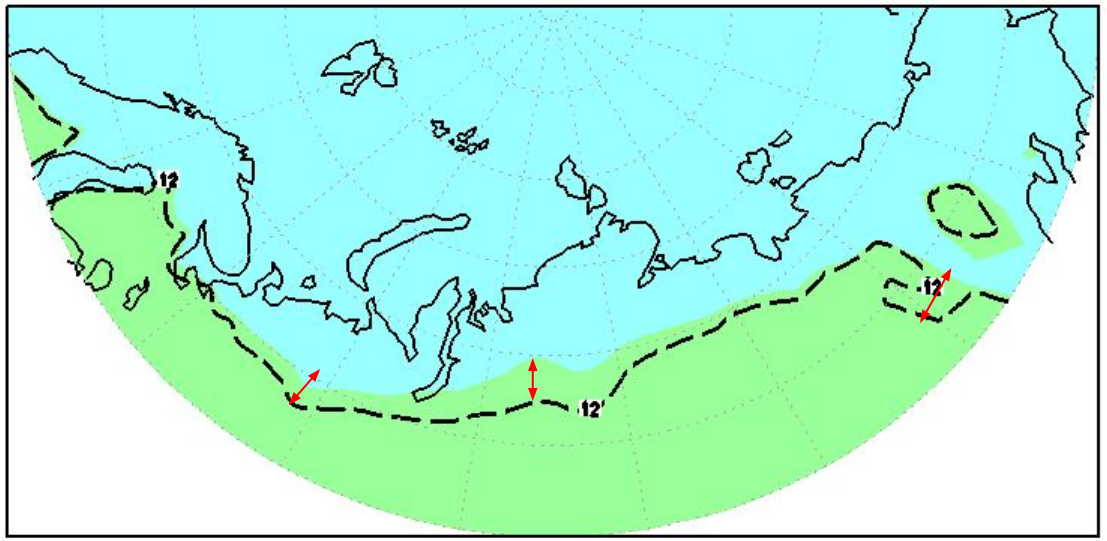
- *Vorobyeva, V., Volodin, E.: Evaluation of the INM RAS climate model skill in climate indicesand stratospheric anomalies on seasonal timescale. Tellus A: Dynamic Meteorology andOceanography 73(1), 1–12(2021).https://doi.org/10.1080/16000870.2021.189243535.
- Vorobyeva, V.V., Volodin, E.M.: Experimental Studies of Seasonal Weather PredictabilityBased on the INM RAS Climate Model. Mathematical Models and Computer Simulations13(4), 571–578 (2021)

Weather comfort level

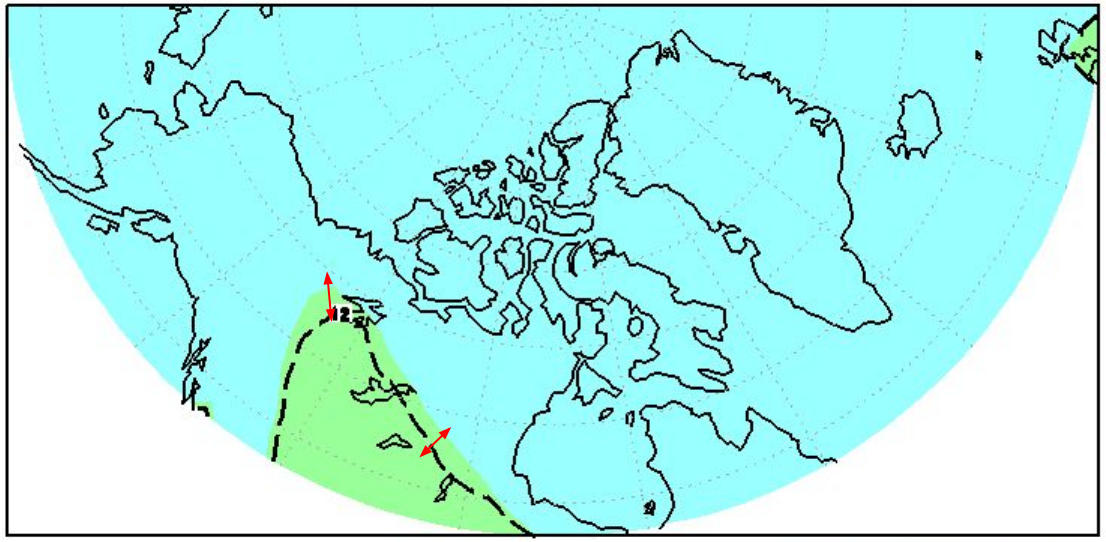
SUMMER 2022



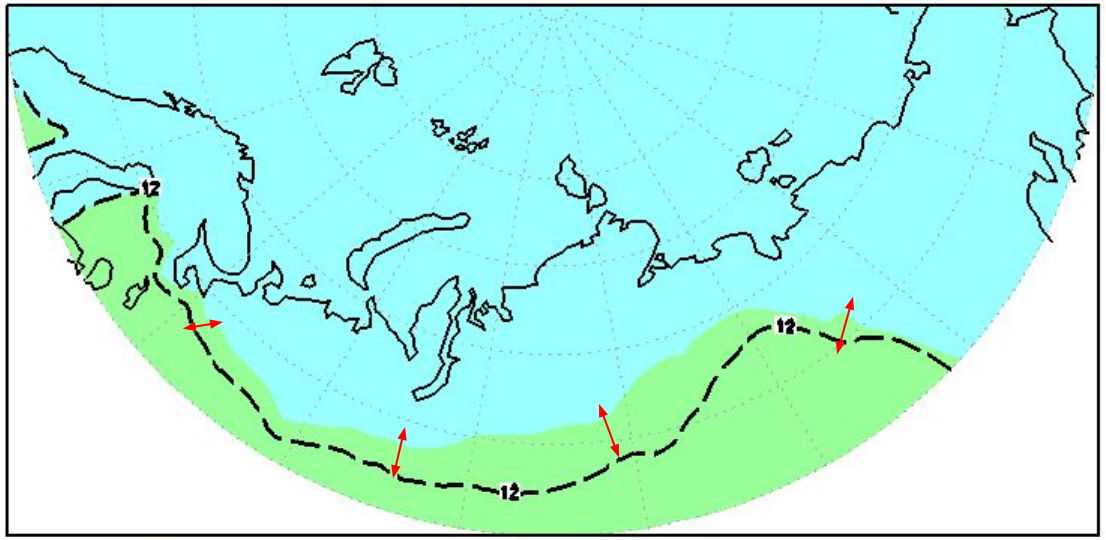
SUMMER 2022



June 2022



June 2022

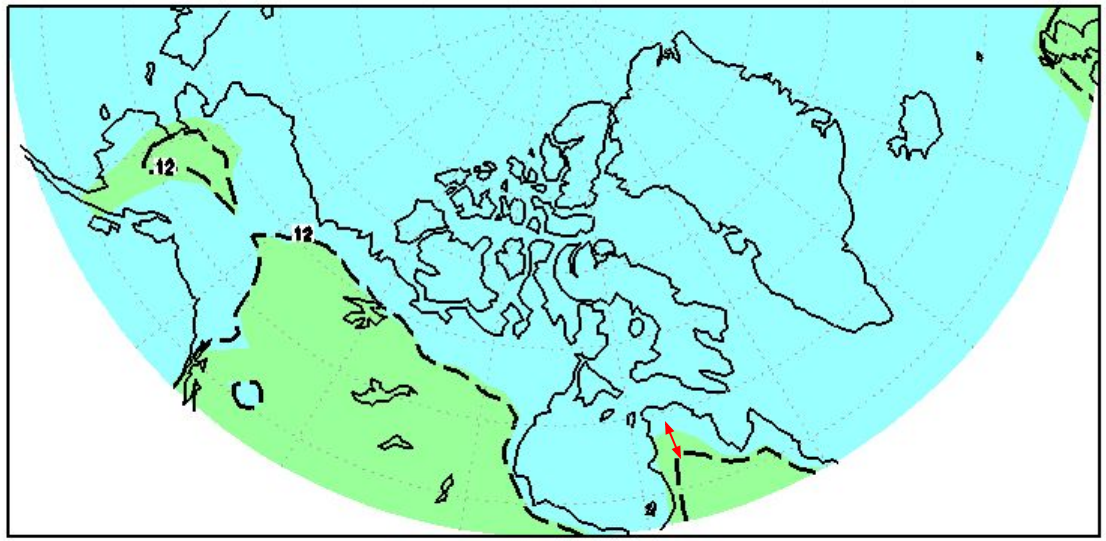


“cold” discomfort comfort “hot” discomfort

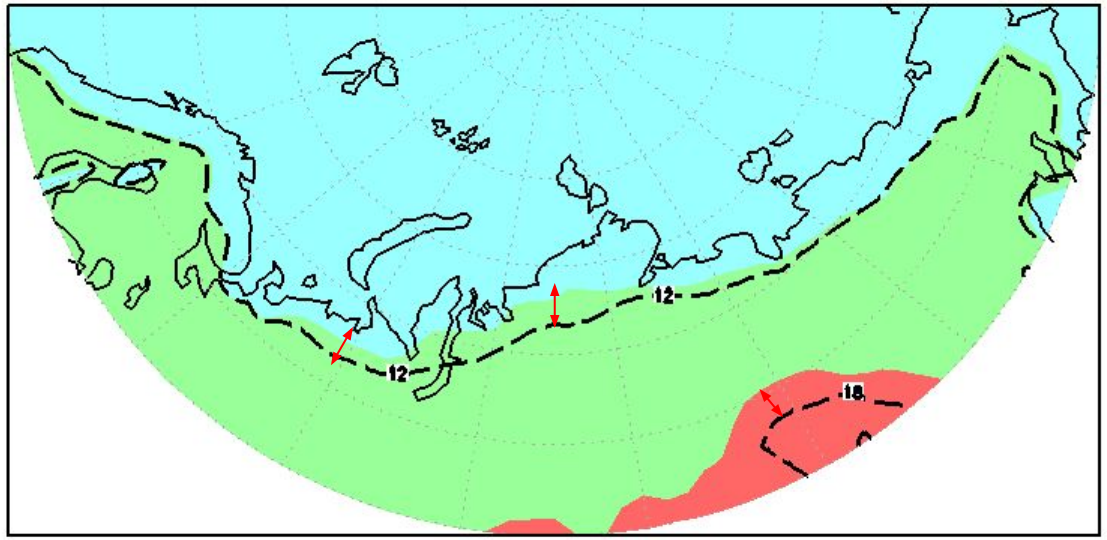
-------- norm (1991-2020)

Weather comfort level

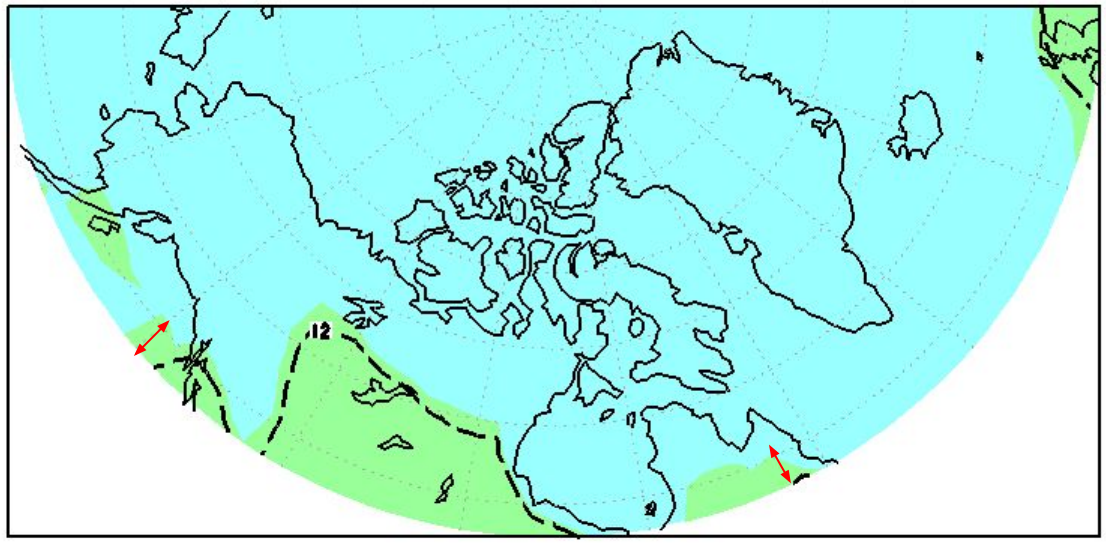
July 2022



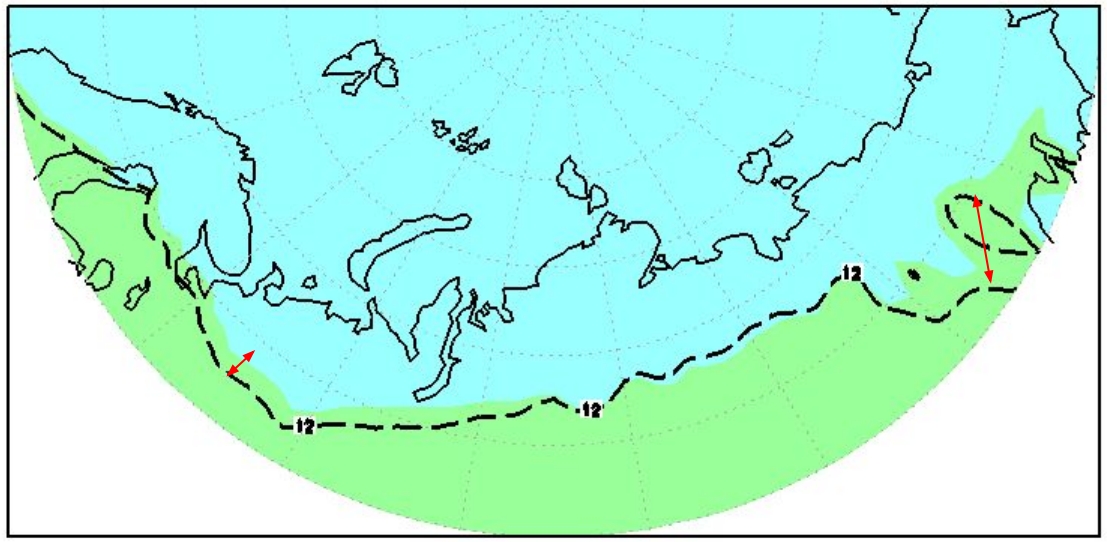
July 2022



August 2022



August 2022

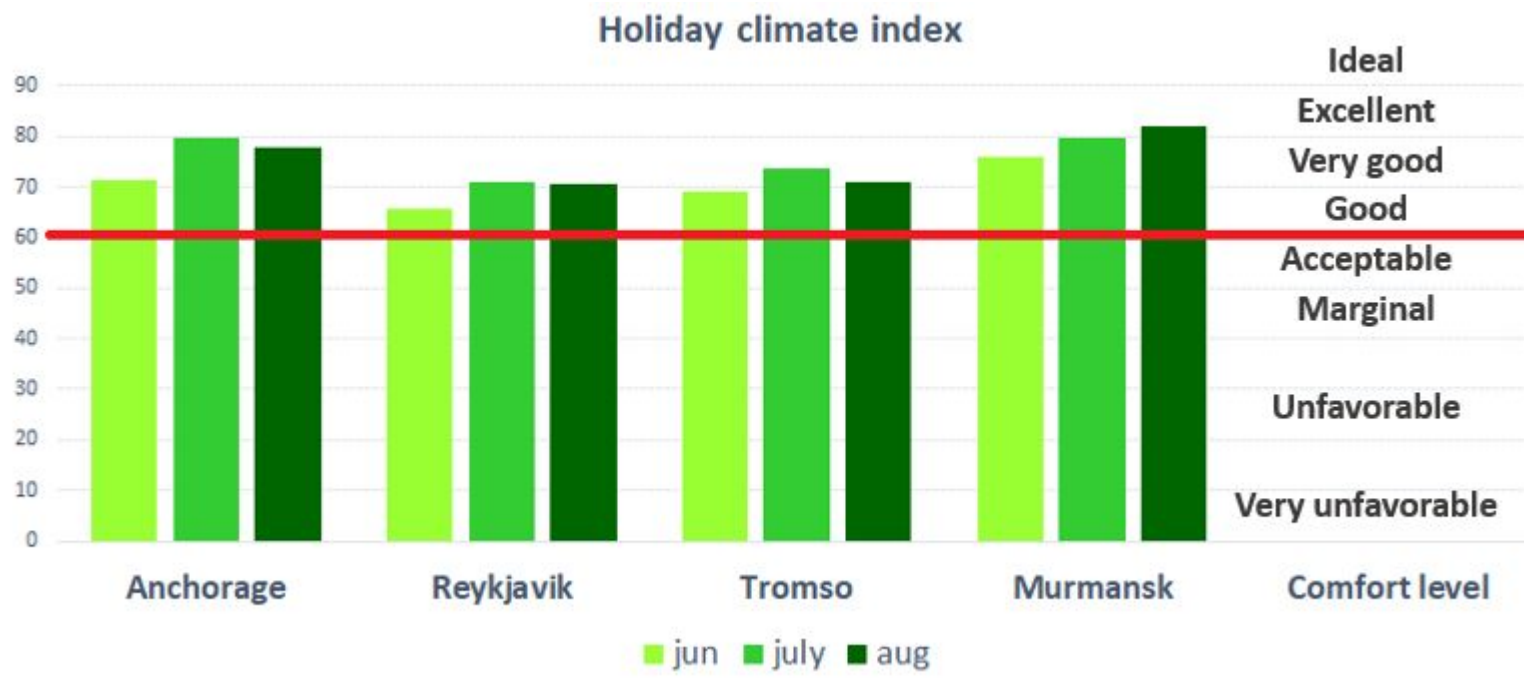


-------- norm (1991-2020)

Comfort for tourism Summer 2022: Holiday Climate Index (HCI)

By United Nations World Tourism Organization (UNWTO)

Air temperature, air humidity, precipitation, cloudiness and wind speed



Thank you!