# Surface Atmospheric Temperature as Indicator of Climate Change in the Arctic

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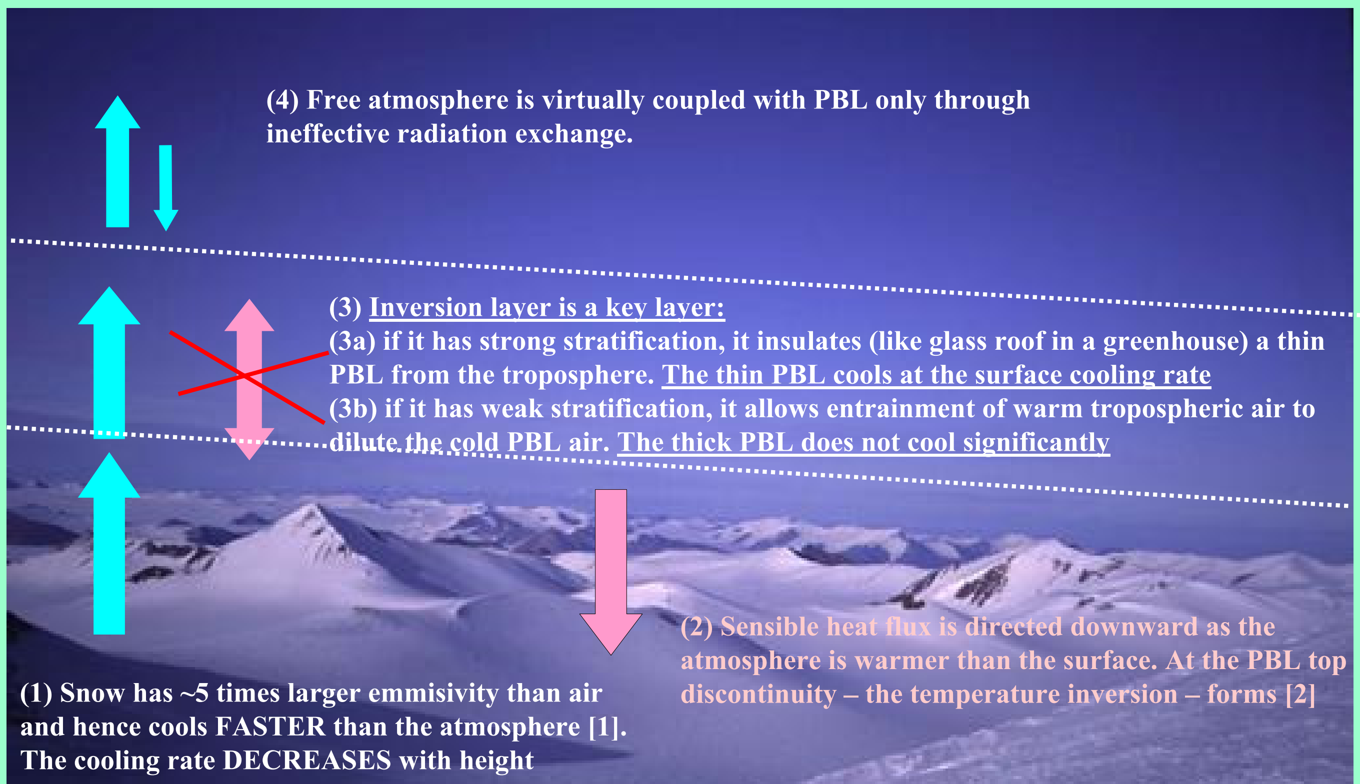
**Abstract.** Surface atmospheric temperature (SAT) is one of the most reliable atmospheric characteristics used to quantify climate change. Contrary to what has been always implicitly assumed, changes in the SAT have loose relations with changes in trends in the tropospheric and its heat content (Scheme 1, [1]). Physical reasoning suggests that the thin Arctic planetary boundary layer (PBL) would quickly equilibrate its temperature with the surface (usually low) temperature. A thicker, storm-mixed PBL conveys the turbulent mixing deeper into the inversely stratified troposphere and hence maintains warmer SAT (Fig. 1). Observations revealed that these two mixing regimes produce a bi-modal distribution in the SAT (Fig. 2) corresponding to "coreless winters" [2]. The bi-modality may have profound impact on the perception of the Arctic climate given that the SAT is warmer and less variable in deep PBLs (Fig. 3). The trends should be a combination of trends (Fig. 4) due to changes in the heat content and due to changes in the occurrence of the deep mixing. The latter reflects rather changes in storm activity (wind speed trend, Fig. 5) than changes in a local heat budget. The warming tropospheric trends expected from the radiation greenhouse and polar amplification [3] should result in thinning not thickening of the PBL (Fig. 1), thus, leading to a weaker warming or even cooling traced in the heat content or even SAT (Fig. 4).




**Scheme 1.** Planetary boundary layer effect on formation of the Arctic surface temperature. Photo: View from Barbeau Peak (Ellesmere Island) by Eric Phillips (icetrek.com)

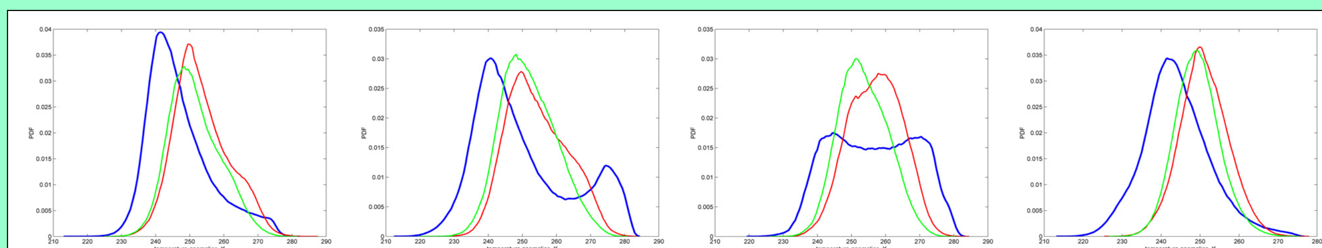


**Figure 2.** Probability density function for the SAT (blue) and temperatures at 850 mb (red) and 700 mb (green) corrected by the mean gradient (8 K/km). From left to right: Pacific, Canadian, Atlantic and Siberian Sectors.

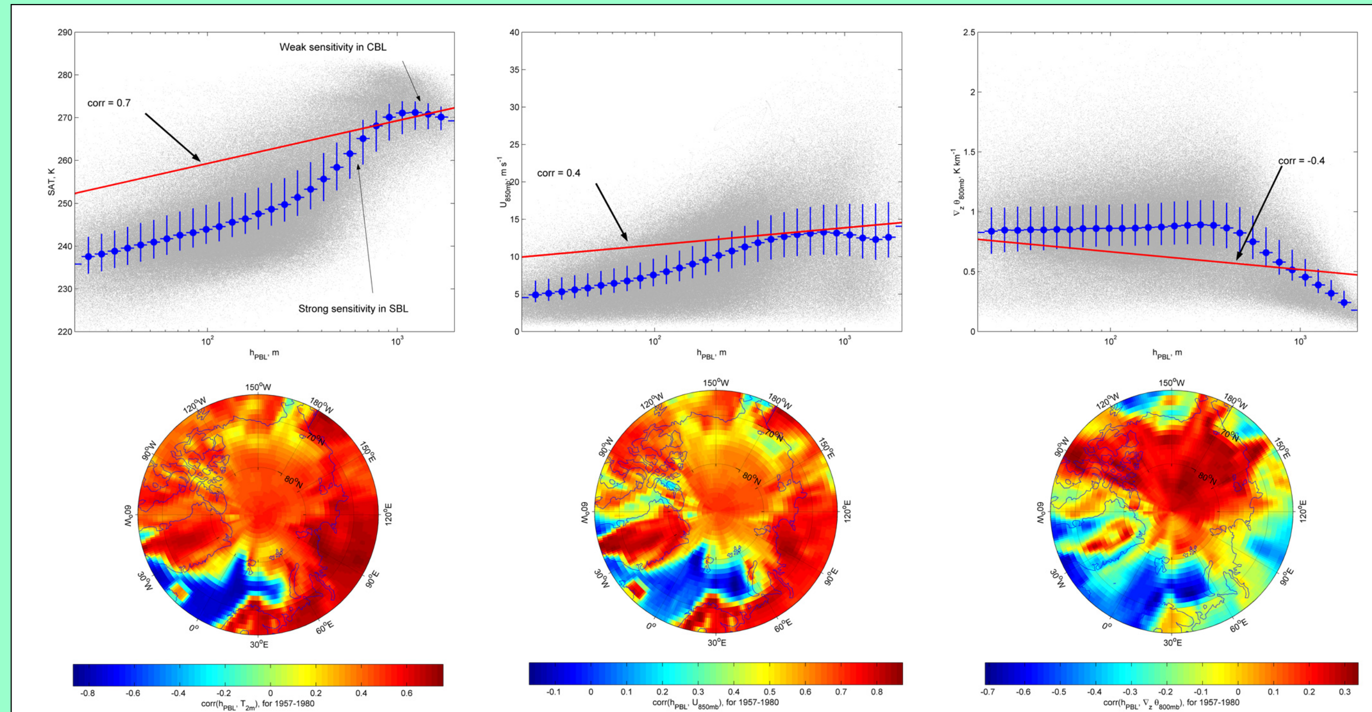



**Figure 1.** Dependence between the depth of the PBL and the SAT (left), wind at 850 mb (centre) and temperature gradient in the inversion (right): dots – original ERA-40 data; bars – data averaged in $h_{PBL}$ bins and their standard deviations; line – mean correlation. Corresponding map plots show geographical distribution of correlations. The SAT in shallow, mostly stably stratified PBLs has strong sensitivity (0.05 K/m) and correlation (>0.6) with $h_{PBL}$. *To change the SAT in deeper PBL stronger heating/cooling must be applied.* The SAT correlates with wind speed and anti-correlates with stability [4],[5]. Thus, under stronger wind (Fig. 3 and 5), the SAT should increase even under unchanged radiation balance. Global warming increases the tropospheric temperature [6], increasing stability and counteracting the surface warming.

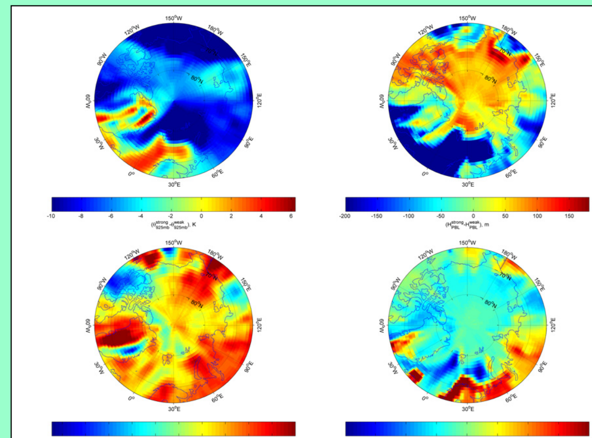


**Figure 3.** Mean (over 1980-2001) difference of the PBL conditions during strongly and weakly stratified days (upper panels) and windy and calm days (lower panels) and the wind trend in ERA-40.

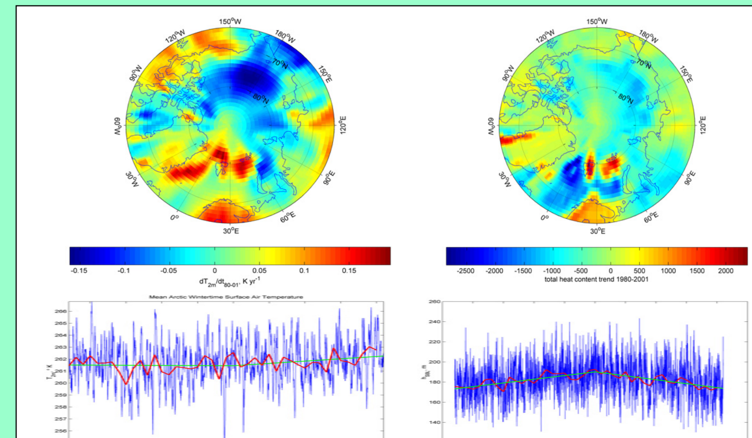


**Figure 4.** Distribution of the SAT (upper left) and the PBL heat content per (in K $m^{-1}$ $yr^{-1}$, upper right) trends in ERA-40 data and the mean Arctic (60N-90N) trends in the SAT and $h_{PBL}$: blue – daily; read – yearly; green – LSM fit for 1957-80 and 1980-2001.

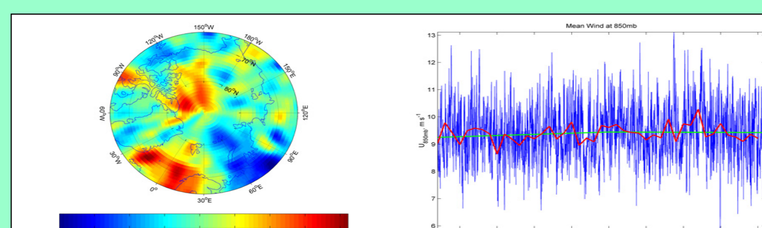


**Figure 5.** Geographical distribution of the wind speed trends and the mean Arctic (60N-90N) trend: blue – daily; read – yearly; green – LSM fit for 1957-80 and 1980-2001. Wind speed is decreasing between 1995-2001 but over the longer period the upward trend dominates.

**References.**

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[4] Zilitinkevich, S., Esau, I., Q.J.R.M.S., 129, 3339-3356, 2003
[5] Zilitinkevich, S., Esau, I., Q.J.R.M.S., 131, 1863-1892, 2005
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