Summer noontime \( h_mF_2 \) long-term trends inferred from \( f_oF_1 \) and \( f_oF_2 \) ionosonde observations in Europe

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Long-term \( h_mF_2 \) trends may serve as an indicator of the thermosphere cooling due to the CO\(_2\) concentration increase in the Earth’s atmosphere. Unfortunately required long-term reliable \( h_mF_2 \) observations are absent. A new method has been proposed to solve this problem using available monthly median \( f_oF_1 \) and \( f_oF_2 \) ground-based ionosonde observations. Such manually scaled observations are available on European stations for a period of 5 solar cycles. Summer (June) daytime \( f_oF_1 \) observations are used to retrieve: exospheric temperature \( T_{ex} \), neutral composition ([O], [O\(_2\)], [N\(_2\)]) and the total solar EUV flux with \( \lambda < 1050\text{Å} \). Fitting with vertical plasma drift \( W \) (the only unknown parameter) calculated \( f_oF_2 \) to the observed one the height of F2-layer maximum, \( h_mF_2 \) may be found. Such calculations have been done using Sodankylä and Juliusruh \( f_oF_1 \) and \( f_oF_2 \) observations for the (1958-2017) period. Two methods were used to remove solar and geomagnetic activity effects from the retrieved \( h_mF_2 \) long-term variations: i) by a normalization with the Shubin \( h_mF_2 \) monthly median model and b) using a regression with an index \( = F_{10.7}^\alpha + Ap^\beta \), where \( \alpha \) and \( \beta \) are fitted parameters. Both methods give negative statistically significant (at 99% confidence level) trends \( h_mF_2 \) but with different magnitudes: \( \sim 0.7\% \) per decade at Juliusruh and \( \sim 2\% \) per decade at Sodankylä. Over four decades (the period of cooling due to the CO\(_2\) concentration increase) this gives a decrease in \( h_mF_2 \) of \( \sim 8 \) km at Juliusruh and \( \sim 25 \) km at Sodankylä. Both estimates are larger than expected under a 20\% increase in the CO\(_2\) abundance. Possible mechanisms are discussed.