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Self-organizing map classification of the boundary layer profile – a refinement of Eastern Mediterranean winter synoptic regimes

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The boundary layer (BL) profile over the coastal plain of Israel, Eastern Mediterranean (EM), varies considerably during winter. Although, in the context of air pollution, the characteristics of the BL height (BLH) was intensively investigated, a quantitative classification of the BL profile regimes has not been performed. Here, we seek to reveal the dominant, recurring regimes of the BL profiles, their quantitative characteristics and links to regional synoptic-scale patterns.
An objective unsupervised classification of winter BL radiosonde profiles is performed for the first time by multi-parameter self-organizing map (SOM) analysis. The analysis uses high-resolution, 12-UTC data of wind, temperature, humidity and pressure measurements during Dec-Feb 2007-2018, and yields 30 distinct profile regimes.
Composite analysis using ERA5 reanalysis suggests strong association between the profile regimes and synoptic weather systems and highlights four groups: 1. Deep winter cyclones with strong westerly wind and precipitation; 2. Strong surface anticyclones and Red Sea troughs (RST) with a mid-tropospheric ridge, moderate dry easterly wind and extreme temperatures. 3. Moderate pressure gradients under shallow cyclones, anticyclone to the west and RST to the east of Israel. 4. Active RSTs, accompanied by upper-tropospheric trough/cutoff low and heavy precipitation. For the first time, general objective classification observes the active RST without requiring specific criteria.
Consistent with previous knowledge, the new classification exhibits distinct categories of thermal stability, BLH and turbulence. Importantly, we show that the automatic objective classification of profile data from a single station can be a sensitive discriminator of winter synoptic regimes in the EM, and therefore explains the variability of the BL profile. It facilitates the study of the interaction between the BL and the free troposphere and may improve the prediction of air pollution or future BL profile regimes based on long time series from historical data or climate models.