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Forest response to heat waves at the dry timberline

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Predictions of climate change consistently indicate continuous warming and drying for the entire Mediterranean basin and other regions during the next century. Investigating forest functioning at the current dry and hot "timberline" has therefore implications for predicting future forest distribution. In such investigations we should consider the forest adjustments to extreme conditions both at the long-term average climate basis, as at the time-scale of episodic extreme events, such as heat waves and droughts. Investigating both aspects in a 45-yr old semi-arid pine forest at the dry timberline (<300 mm annual rainfall) we observe adjustments that improve carbon-, nitrogen- and water- use efficiencies. An important aspect in the ecosystem sustainability is its ability to rapidly recover from extreme conditions, both at the short-term and the seasonal scale. A remarkable example is provided by the episodes (usually 2-4 days) of Easterly dry and hot air that are common in spring (so-called "Hamsin" events). During these events air temperature increases and relative humidity decreases within hours by 10˚C and 40%, respectively. Net ecosystem CO_2 exchange (NEE) and photosynthesis (GPP) sharply decline, predominantly in response to the drastic increase in vapor pressure deficit (up to 6kPa), but then show full recovery to the pre-stress values within 24 h past the event. Similarly, following 5-6 months of seasonal drought, the forest resumes high photosynthetic activity within $\sim$5 days following the first rain episode of about 10 mm in the fall. We show that these transient responses are useful in partitioning between the ecosystem responses to short-term atmosphere-driven stress and longer-term soil moisture stress. An ecosystem model (MuSICA) was used to test our understandings of underlying processes, and our ability to account for such differential responses.