Supporting Information

Figure S1. Set-up used for current-voltage measurements of perovskite solar cells under mimic HAPS environment.

Figure S2. Solar cells temperature throughout the day in stratosphere calculated at summer solstice, -15° latitude in southern hemisphere. Values of -86°C (cold), -56°C (nominal) and -37°C (hot) were taken as assumptions for the outside air temperature at night. The cold and hot temperatures represent the extreme cases found in stratosphere.
Figure S3. PV parameters (fill factor, $V_{oc}$, $J_{sc}$ and PCE) of perovskite solar cells measured between -70°C and +20°C under constant AM1.5G illumination and vacuum (10 mbar).
Figure S4. Statistical result of the device parameters under AM1.5G.

Figure S5. Series resistance ($R_S$) and shunt resistance ($R_{sh}$) at different temperatures extracted from the inverses of the slopes at $V_{oc}$ and $J_{sc}$, respectively.
Figure S6. Variations in PV parameters of encapsulated and non-encapsulated devices measured at 10 mbar and 25°C under AM1.5G illumination.