Appendix S1

Verification of ERA-Interim pseudo-soundings at Irene

Upper air soundings are performed regularly at five stations in South Africa (see Figure 1 in main manuscript for locations) and only two of the places are over the interior (Bloemfontein and Irene). Soundings are also released intermittently at Upington and Springbok (Northern Cape Province). Research has shown that the Gauteng Province receives a relatively high frequency of hail days (Carte and Held, 1978, Le Roux and Olivier, 1996) and the Irene sounding was chosen to verify the ERA-Interim pseudo sounding. The Irene weather station is located over central Gauteng province and these soundings may be considered proximity soundings for the province (Dyson et al., 2015). Data from the Irene sounding was compared to the ERA-Interim pseudo-sounding at the closest grid point to the Irene weather station (ERA Irene).

The temperature, dew point temperature and wind strength at 850, 800, 700, 600, 500, 400, 300, and 200 hPa from the 1200 UT Irene sounding in the warm season (October to March), were compared to the 1200 UT ERA Irene data for the period 1979 to 2017. The calculated error measures are the linear determination coefficient (R^2), the relative absolute error (RAE), and the mean Bias (the mean of the Irene sounding and ERA Irene differences) (Ohtani and Naito, 2000). R^2 values higher than 0.5 is considered to represent a good fit while RAE values close to zero are ideal (Manzato, 2008).

The long term mean temperatures of the Irene sounding and ERA Irene compare very well (solid lines in Figure S1). The 850 and 800 hPa ERA Irene temperatures are about 1° C higher than the Irene sounding but with temperature biases between the two data sets less than 0.5° C for all other pressure levels (Figure S2 top). The R^2 values for temperatures at all pressure levels are above 0.5 (Figure S2 middle) and the RAE less than 0.1 except for 600 hPa where the RAE value is 0.4 (Figure S2 bottom).

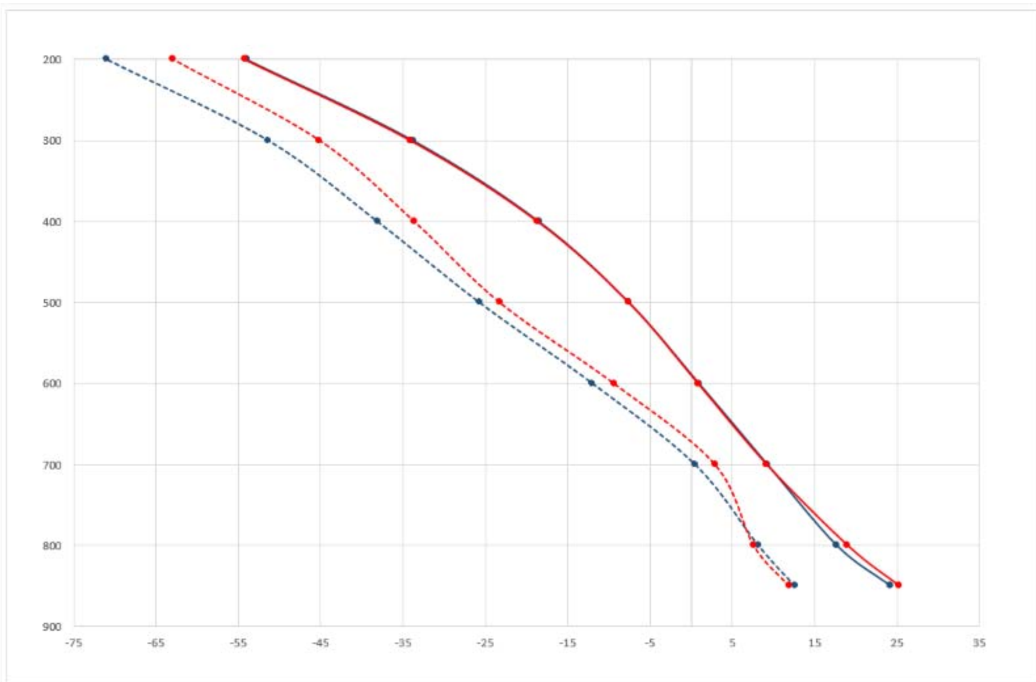

Figure S1: Vertical profiles of temperature (solid lines) and dew point temperature (dashed lines) at Irene weather office (blue) and the ERA-Interim pseudo-sounding at the closest grid point to Irene (ERA Irene) (red).

The 850 and 800 hPa dew point temperatures in the two data sets are very close (dashed lines in Figure S1). At lower pressure levels the biases become more negative and at 300 hPa the Era Irene dew point is more than 8 degrees higher than the Irene sounding (Figure S2 top). The RAE values for the different pressure levels are between 0.2 and 0.3, except for 700 and 600 hPa where the values are above 0.5 (Figure S2 bottom). The poor performance of dew point temperature in the mid-troposphere is also reflected in the R^2 values where at 700 hPa the value is only slightly higher than 0.4 (Figure S2 middle).). As a parcel of air is lifted from its lifting condensation level and rises vertically in an unstable atmosphere, dry mid-tropospheric air will be responsible for entrainment and weaker updrafts (Brimelow et al., 2002). However, the dry air evaporated into the cloud at mid-levels will result in cooling and a lowering of the height of the melting level and thereby reducing the melting of the hailstone during its descent. Rasmussen and Heymsfield (1987) argued that high relative humidity values

(> 50%) will prevent descending ice particles from melting until the air temperature reaches 4° C. The lower 700 hPa moisture in the Irene sounding (relative humidity 40%) will result in the descending hail stone melting faster than in ERA Irene where mid-level relative humidity is 50%. The higher mid-level moisture in the mid-troposphere on ERA Irene will therefore most likely result in larger hailstones.

The wind strength bias is less than 0.6 at all pressure levels with the wind strength in the Irene sounding in the mid-troposphere being slightly stronger than the ERA Irene wind (Figure S2 top). R^2 and RAE values at the surface for wind speed is not favourable but ERA Irene wind strengths fare quite well at all the other pressure levels (Figure S2 centre and bottom). Wind shear (magnitude of the vector difference in winds at two pressure levels) play a significant role in the development of severe thunderstorms (Doswell III et al., 1996, Brimelow et al., 2002, Brooks et al., 2003). Under strong shear conditions, the updraft is tilted allowing for the updraft and downdraft to be separated and developing hailstones to be advected across the updraft, aiding in hail growth. The R^2 and RAE values show that there is not a good fit of the surface wind strength between the two data sets. This may, in turn, influence the values of wind shear and therefore also the size of the hailstone on the ground.

Even though there appear to be some discrepancies between the observed and modelled sounding at Irene, the following two sections will discuss the performance of the EIH predictions when compared to known severe hail events and observed climatologies in Section 3 of the main manuscript.

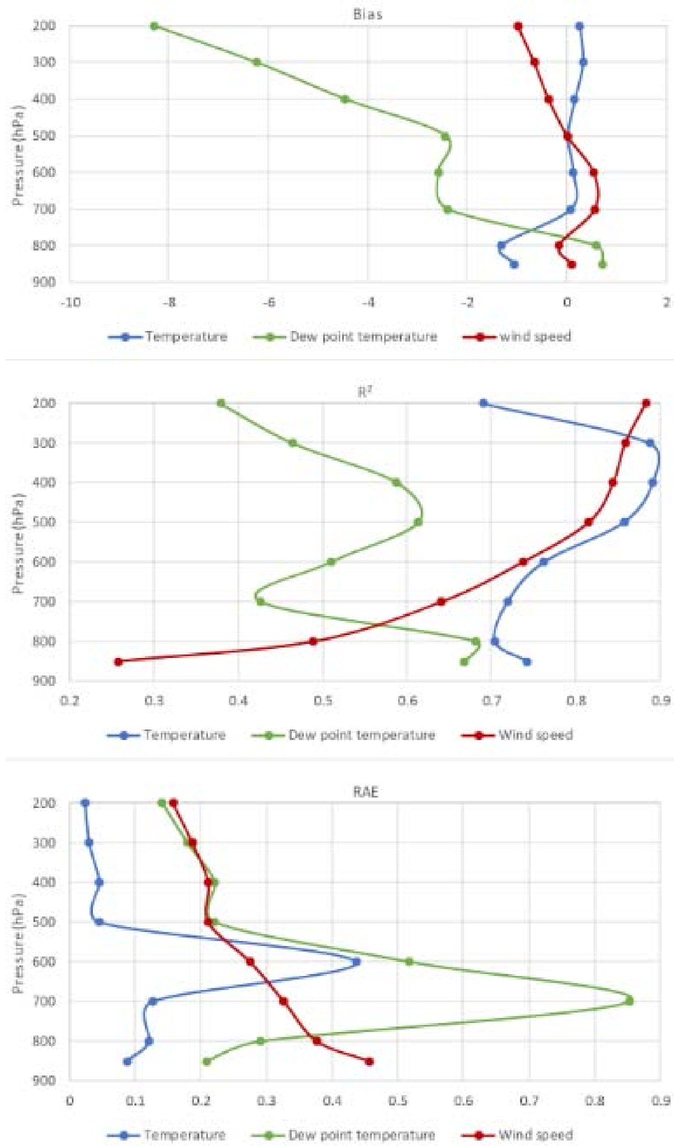

Figure S2: Vertical profiles of mean Bias (top), linear determination coefficient (R2) (centre) and relative absolute error (RAE) (bottom) for temperature (blue), dew point temperature (green) and wind speed (red).

References

BRIMELOW, J. C., REUTER, G. W. & POOLMAN, E. R. 2002. Modeling maximum hail size in Alberta thunderstorms. *Weather and Forecasting,* 17**,** 1048-1062.

BROOKS, H. E., LEE, J. W. & CRAVEN, J. P. 2003. The spatial distribution of severe thunderstorm and tornado environments from global reanalysis data. *Atmospheric Research,* 67**,** 73-94.

CARTE, A. & HELD, G. 1978. Variability of hailstorms on the South African Plateau. *Journal of Applied Meteorology,* 17**,** 365-373.

DOSWELL III, C. A., BROOKS, H. E. & MADDOX, R. A. 1996. Flash flood forecasting: An ingredients-based methodology. *Weather and Forecasting,* 11**,** 560-581.

DYSON, L. L., VAN HEERDEN, J. & SUMNER, P. D. 2015. A baseline climatology of sounding-derived parameters associated with heavy rainfall over Gauteng, South Africa. *International Journal of Climatology,* 35**,** 114-127.

LE ROUX, N. & OLIVIER, J. 1996. Modelling hail frequency using a generalized additive interactive technique. *South African Geographical Journal,* 78**,** 7-12.

MANZATO, A. 2008. A Verification of Numerical Model Forecasts for Sounding-Derived Indices above Udine, Northeast Italy. *Weather and Forecasting,* 23**,** 477-495.

OHTANI, R. & NAITO, I. 2000. Comparisons of GPS-derived precipitable water vapors with radiosonde observations in Japan. *Journal of Geophysical Research: Atmospheres,* 105**,** 26917-26929.

RASMUSSEN, R. M. & HEYMSFIELD, A. J. 1987. Melting and Shedding of Graupel and Hail. Part II: Sensitivity Study. *Journal of the Atmospheric Sciences,* 44**,** 2764-2782.