Updating the Use of HAILCAST in NSHARP

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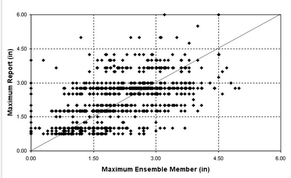
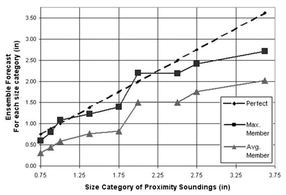
Original HAILCAST ("JB09", Jewell and Brimelow 2009)

- 1-D coupled cloud/hail growth model used in National Centers Sounding and Hodograph Analysis and Research Program (NSHARP)
- environment defined by single sounding, profiles of vertical velocity and water content from parcel
- hail model inserts liquid hail "embryo" at cloud base and tracks evolution; updraft duration W_{dur} from Energy-Shear Index (ESI)
- parcel initial temperature and dewpoint perturbed, producing ensemble of 25 members
- two versions: embryo size, cloud entrainment, and base updraft speed calibrated from MU mixing ratio (**v1**) or set to "best" calibrated values from JB09 (**v2**)



Forecasted vs. reported hail size for JB09 v2 HAILCAST.



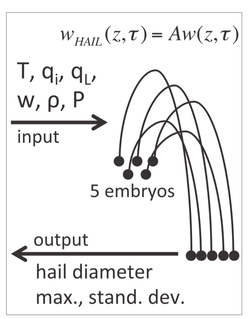
Observed size category vs. mean of binned JB09 v2 forecasts.

Updated HAILCAST ("AER", Adams-Selin and Ziegler 2016)

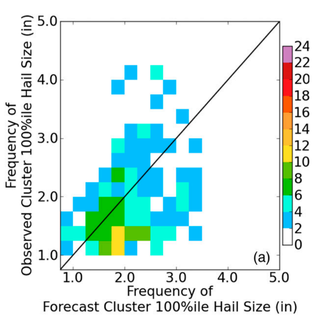
- 5 frozen embryos of different sizes inserted aloft (-8 or -13 C level)
- hailstone motion across updraft parameterized:

$$W_{\mathrm{hail}}(z,\tau) = \begin{cases} \left[0.6\sin\left(\frac{\pi\tau}{W_{\mathrm{dur}}}\right) + 0.6\right] W(z) & \text{if } \tau \le W_{\mathrm{dur}} \\ 0 & \text{if } \tau > W_{\mathrm{dur}} \end{cases}$$

- refinements to hail growth model (density, collection efficiency, melting/shedding)
- updraft duration, cloud-base updraft speed, and entrainment specified as in JB09 (**v1** and **v2**)
- T/Td perturbations => 125-member ensemble; take max size (**MAX**) or max of embryo means (**MME**)



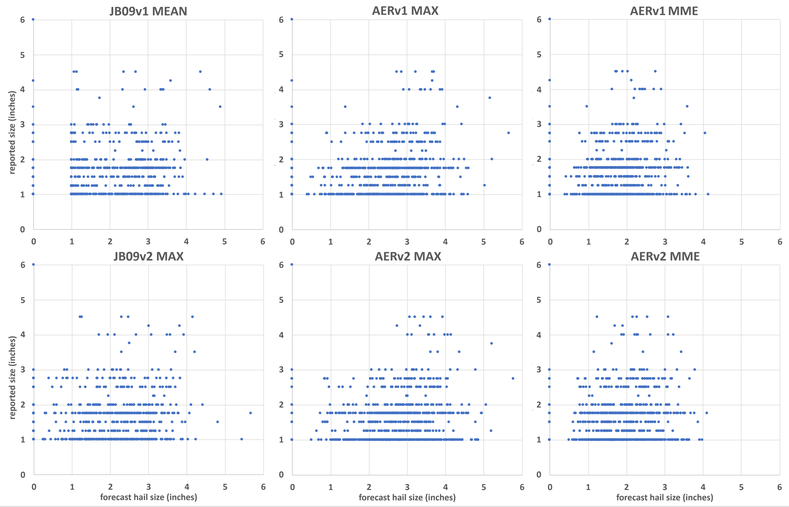
Operating schematic for AER version of HAILCAST

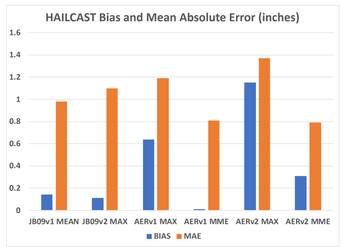


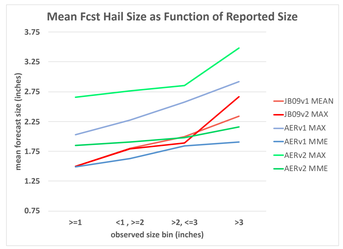
Maximum observed vs. WRF-HAILCAST hail size, May 2014 and 2015

Verification vs. Hail Reports (1" or greater)

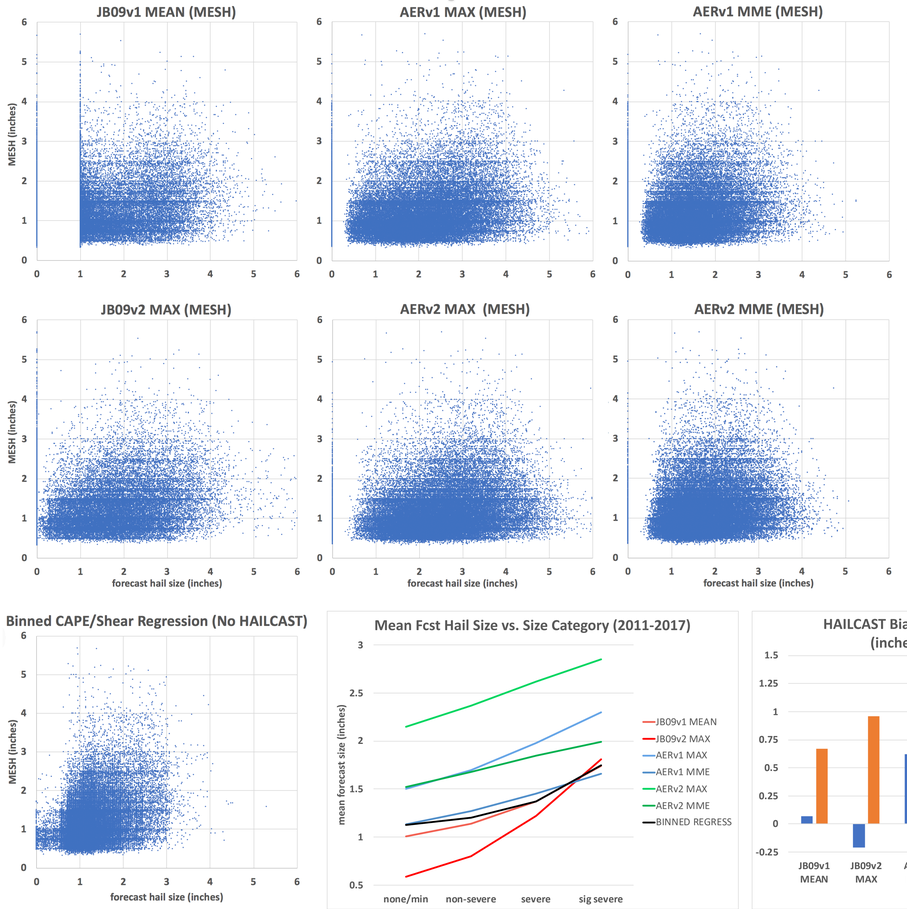
- CONUS hail reports from 2015 filtered by max size within 100 km radius and +/- 2 hr window (N=829)
- soundings from SPC mesoanalysis; max CAPE from 9 nearest grid points (40 km spacing) over previous 2 hr



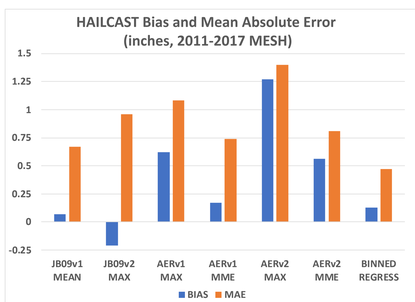




Verification vs. Maximum Estimated Size of Hail (MESH)

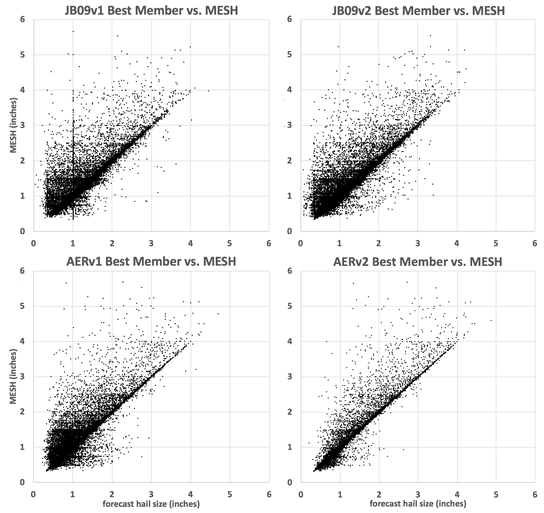


- archived MESH (2011-2017) filtered by max value (track area >5 km^2) within 100 km, +/- 2 hr (N=55019)
- same procedure for soundings as used for verification vs. reports
- large bias and RMSE when using ensemble max; less when using MME in AER versions
- relatively small changes in forecast mean size as MESH category increases
- similar results from regression of historical data (no HAILCAST)



Conclusions and Continuing Work

- Updated HAILCAST produces only small improvement in NSHARP in its current form.
- Updraft duration W_{dur} is a primary source of error in hail size forecasts. Relying only on environmental CAPE and shear (i.e. using ESI) to estimate W_{dur} is not sufficiently accurate, particularly for large sizes.
- An "ensemble of ensembles" was obtained for each HAILCAST version by running each case for a range of specified W_{dur} from 10 min to 1 hr. The best member forecast from each version was stored.
- The results indicate that each version of HAILCAST (AERv2 in particular) will generally be capable of producing accurate hail size forecasts if a better method of estimating W_{dur} can be found.



Acknowledgements

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