Storm Attribute Diagnostics in Operational Convective Forecasting at the Bureau

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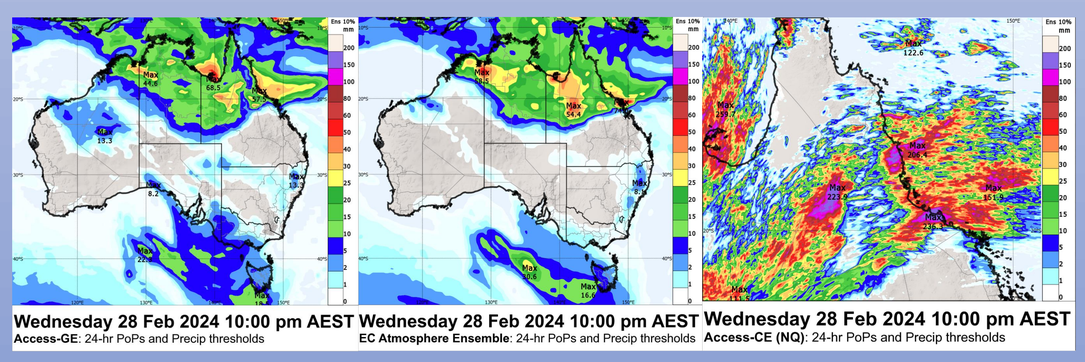
Harald Richter and the Thunderstorm and Heavy Rainfall team

The Bureau delivers most of its convection-related services through the Thunderstorm and Heavy Rainfall (TSHR) team which, in effect, represents the organisational view on non-severe and severe convective storms from minutes out to almost a week. For the shorter forecast time range, out to about 1.5 days ahead, the Bureau's ACCESS-City models are very influential regarding the Thunderstorm and Severe Weather Outlook, a forecast that graphically summarises the expected distribution of convective storms and their associated hazards (large hail, damaging wind gusts, and heavy rainfall) in probabilistic form. Experience within TSHR over the past two warm seasons in particular has built up an appreciation of strengths and weaknesses of the ACCESS-City models for the prediction of severe convection and heavy rainfall. In this presentation we will share some of these impressions in their service context, and from it indicate the most desirable directions for model development from an operational benefit point of view.

Currently Available Storm Attributes at the Bureau

- Producing five types of storm attributes:
  - 2-5 km updraft helicity (UH) for left-moving and right-moving supercells, and maximum UH of both
  - Updraft speed (as a column maximum between 1000-100 hPa)
  - 10-m wind gusts
  - Total lightning based on the McCaul scheme
  - Column-maximum hail diameter based on the Thompson scheme as implemented in the UM
- Apart from a few instantaneous fields, produce maximum fields over time periods of 1-hr, 3-hr, 15-hr ("rest of today" concept for a 00-15 UTC validity time) and 24-hr
- Produced on seven separate domains across Australia where 12-member 2.2 km ensembles are run 4x/day
- ACCESS-A/AE: Plan to introduce a single national 1.5 km CAM and national 2.2 km CAM ensemble domain by 2026.

Rainfall predictions from CAMs



24-hr precipitation accumulations (90th percentile cut through the ensemble output) for the period ending 12 UTC on 28 Feb 2024. From left to right the panels show output from the ACCESS-GE ensemble (APS3), the EC ensemble and the ACCESS-City Ensemble (North Queensland domain). As is a typical occurrence, the global model accumulations along the northern Queensland coastal regions are several times less than the City Ensemble accumulations.

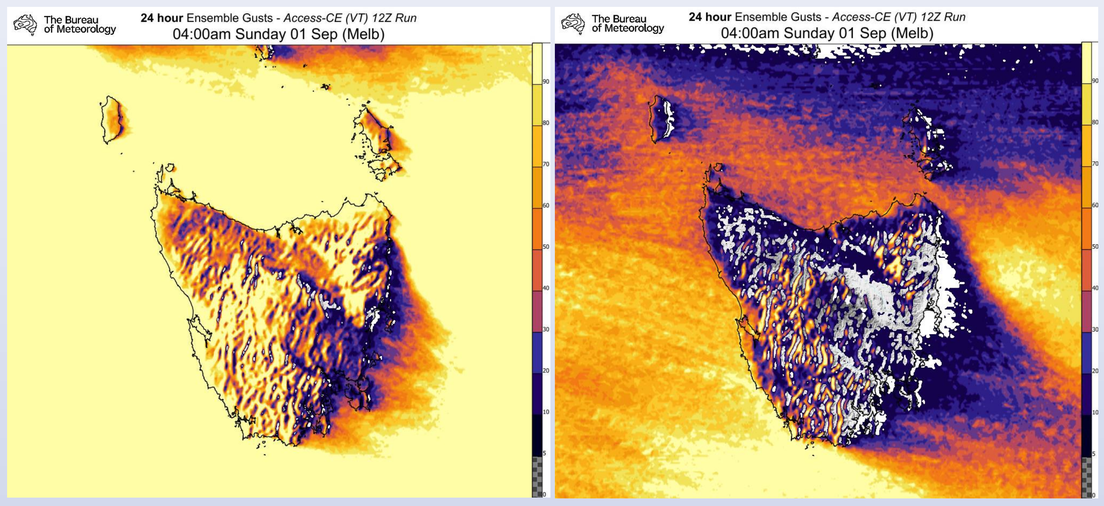
- The TSHR team issues warnings for heavy rainfall that is capable of producing flash flooding. The service treats such heavy rainfall risk separately for severe thunderstorms (a Severe Thunderstorm Warning is used) or larger-scale forcings such as in tropical lows (a Severe Weather Warning is used).
- ACCESS-City generally produces the highest heavy rainfall amounts among all of the operationally available NWP solutions (see 3 panels above).
- ACCESS-City occasionally also produces under-forecasts of heavy rain especially in cases where the model is unable to capture convective initiation events.

Useful New Storm Attributes ("Wishlist")

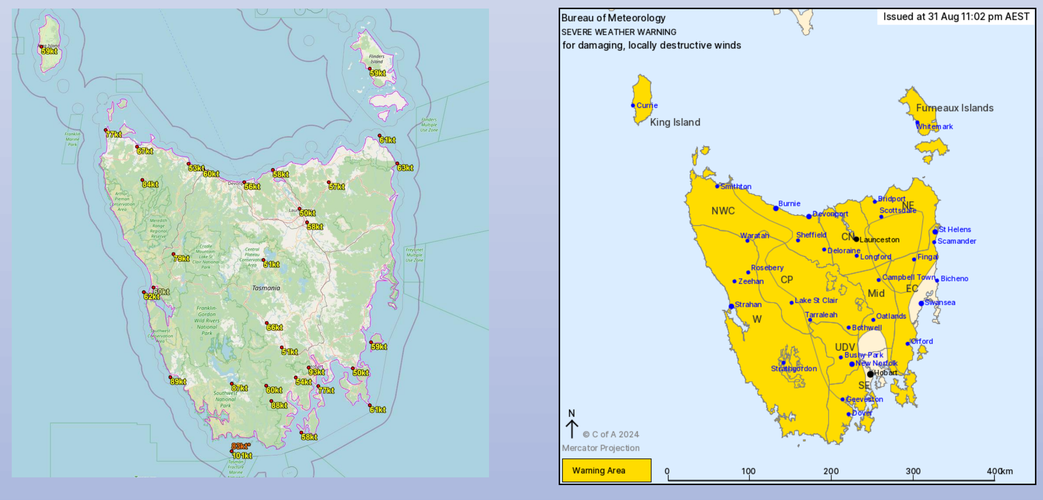
The following list of currently unavailable storm attributes would benefit the TSHR team (and other teams) in the delivery of severe weather and severe thunderstorm services

- Updraft helicity through shallower layers (e.g., 0-1 km and 1-3 km): A good portion of Australia's rotating thunderstorms have rotation in these lower layers, especially in tropical low and cool season environments.
- Thompson (or other) hail size estimate based on NWP once the new microphysics scheme (CASIM) is in place
- Running ACCESS-AE to longer lead times would benefit the Outlooks for Days 2 and maybe Day 3 (in particular, the 12 UTC model run which is the primary input into the National Outlooks). Support for convective forecasting skill beyond +48 hours can be found in the result of NOAA's 2024 Spring forecasting experiment – see https://hwt.nssl.noaa.gov/sfe/2024/docs/SFE2024_tech_memo.pdf

Ensemble–based wind gust guidance



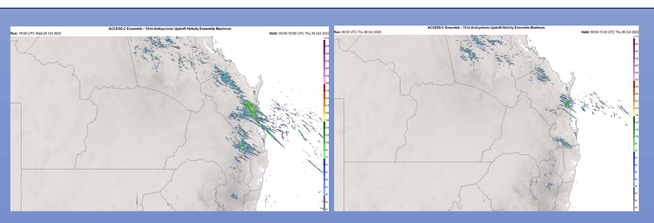
24-hour grid point probability of 10-m wind gusts exceeding 100 km/h (left) and 124 km/h (right) based on the 12 UTC 30 August 2024 ACCESS-CE (VT) ensemble run valid to 18 UTC 31 August 2024. The gust thresholds match the service definitions for damaging winds (100 km/h for westerly flow in Tasmania) and destructive winds (124 km/h) reflected in the Severe Weather Warnings.



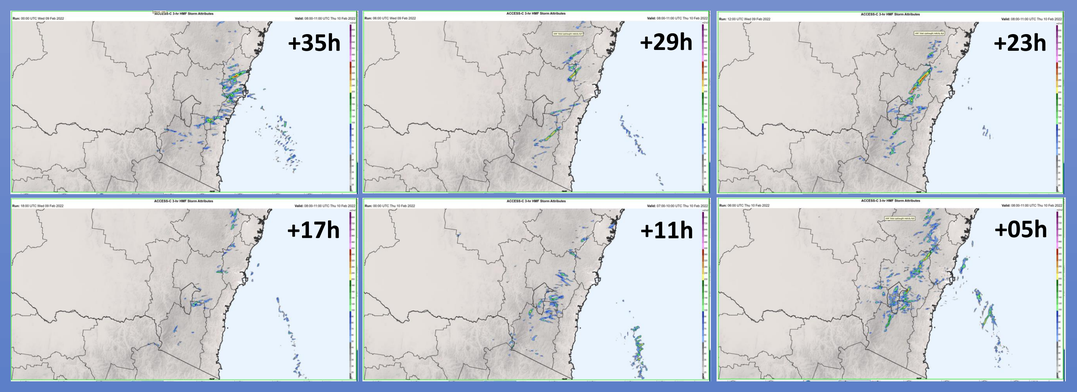
Peak 10-m wind gust observations during the matching 24-hour period ending 18 UTC 31 August 2024 (left) and a Severe Weather Warning active during the later parts of the same 24-hour period (right). Note how the low model gust probabilities along the east coast of Tasmania contributed to the important service decision to exclude a number of major towns from the Severe Weather Warning.

- The temporal and membership wind gust maximum from the convection-allowing ensemble has gained traction in the severe weather warning (larger scale) forecast process.
- CAM guidance is now able to implicitly capture some of the gust generating mechanisms such as downslope windstorms resulting in useful alerting and workload reduction benefits.

Sharp run-to-run changes in updraft helicity tracks



Example 1: 15-hour ensemble maximum 2-5 km updraft helicity valid 00-15 UTC 26 October 2023 based on the 18 UTC 25 Oct cycle (left) and 00 UTC 26 Oct cycle (right).



Example 2: 3-hour maximum 2-5 km updraft helicity valid 08-11 UTC 10 February 2022 generated from six consecutive ACCESS-City (SY) forecast cycles - 00 UTC/9, 06 UTC/9, 12 UTC/9, 18 UTC/9, 00 UTC/10 and 06 UTC/10. In particular, note the sharp drop-off in UH track intensity and number between the 12 UTC/9 (+23h) run and the 18 UTC/9 (+17h) run.

- A common observation in operations is strong run-to-run variations in the UH25 storm tracks, commonly with a reduction in storm numbers and intensity between the 12 UTC and 18 UTC cycles.
- This may indicate a strong sensitivity of UH25 to changes in the data assimilation outputs.
- A consequence of these solution jumps are significant and undesirable jumps in the forecasts and attendant messaging.