A new meteorological diagnostic: CURV (Curvature Using Radial Variation)

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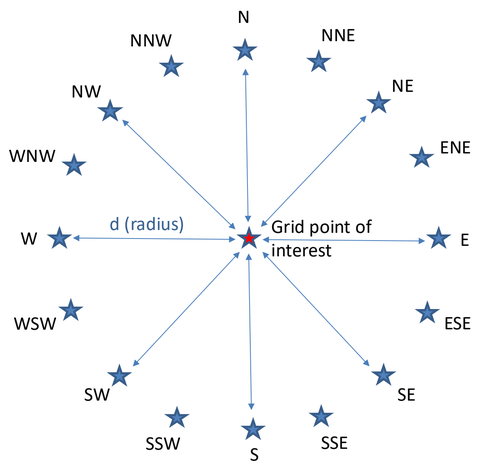
1. What is CURV?

CURV is a simple method that uses radial variation around each point in a gridded field to identify troughs, ridges, hollows and peaks at a scale of interest. It quantifies the amount of curvature of the contours of the field. When applied to Mean Sea Level Pressure (MSLP), it can be used to detect cyclones and anticyclones and cyclonic and anticyclonic curvature, which is closely related to large-scale vertical motion and surface weather. Here's how it is calculated.

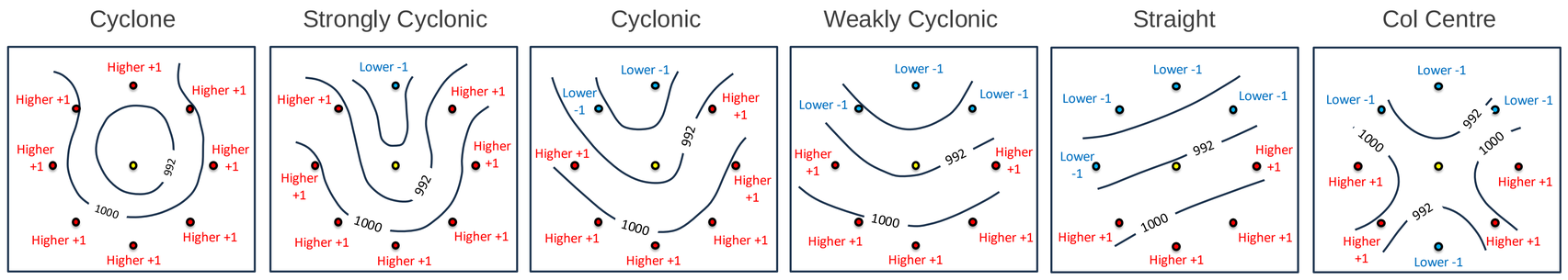
1. For each grid-point find either 8 (or 16) surrounding locations at equal angles apart at a distance d (radius) away.

2. Assign each surrounding point a value of +1 if it has a higher value (e.g. of MSLP) than the central point or -1 if lower.

3. Add up all the +1 and -1 values to obtain the value of CURV, which ranges from -8 (-16) for a hollow to +8 (+16) for a peak.



If applied to MSLP, CURV ranges from -8 (-16) for an anticyclone to +8 (+16) for a cyclone. Schematics show how CURV values relates to curvature.



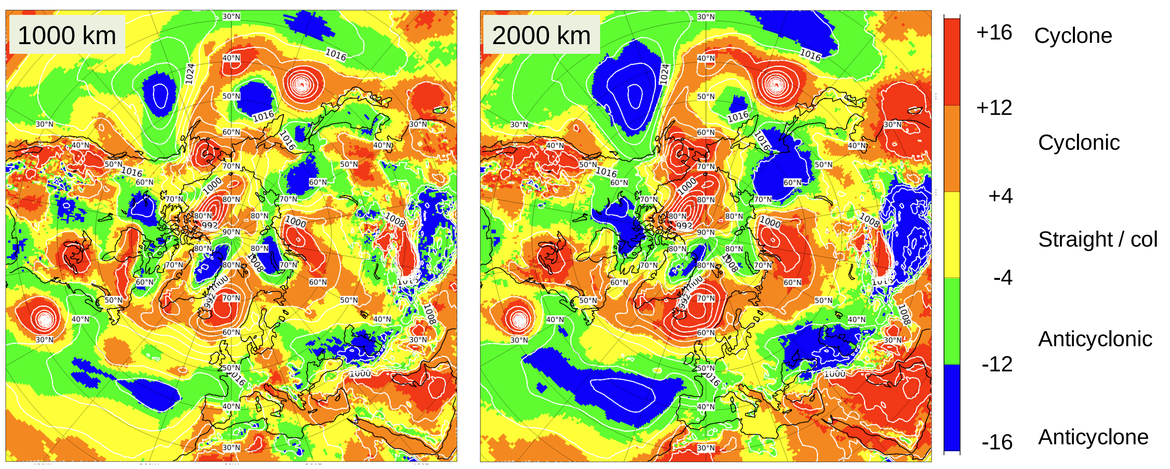
2. Potential uses of CURV

- To identify cyclonic and anticyclonic regions in operational forecasts
- To provide a dynamical context (or surrogate) for surface weather
- To enable verification and routine monitoring of synoptic patterns
- To examine weather pattern predictability at different scales
- To compare or blend forecasts or ensembles with different resolutions
- To apply regime-based verification, post processing or Machine Learning
- To detect upscaling from smaller-scale ensemble differences to larger scales
- To identify dynamical structures (e.g. baroclinic lows, downstream development or blocking patterns)
- To use in climatological studies of synoptic weather patterns

This list is not exhaustive. Some examples relating to the use of CURV with ensembles are shown in this poster.

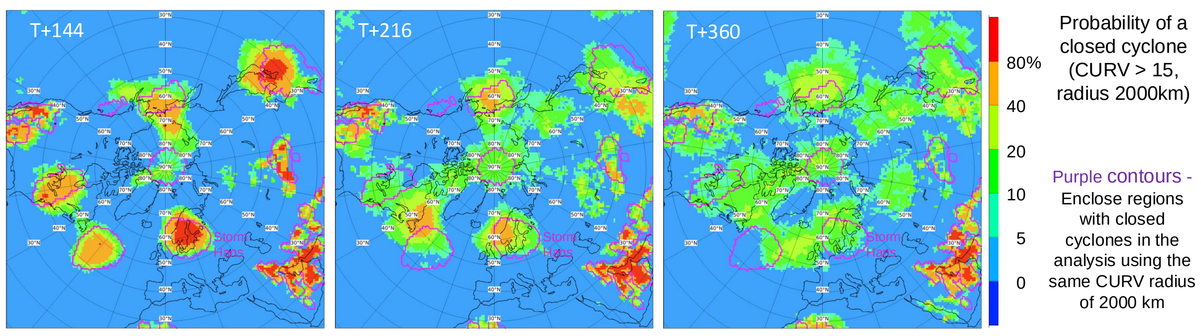
3. What does CURV look like?

Examples of CURV computed for MSLP on a 0.5° grid using 16 points with radii of 1000 and 2000 km, valid at 00 UTC 18 Aug 2024 T+120. White contours show MSLP.



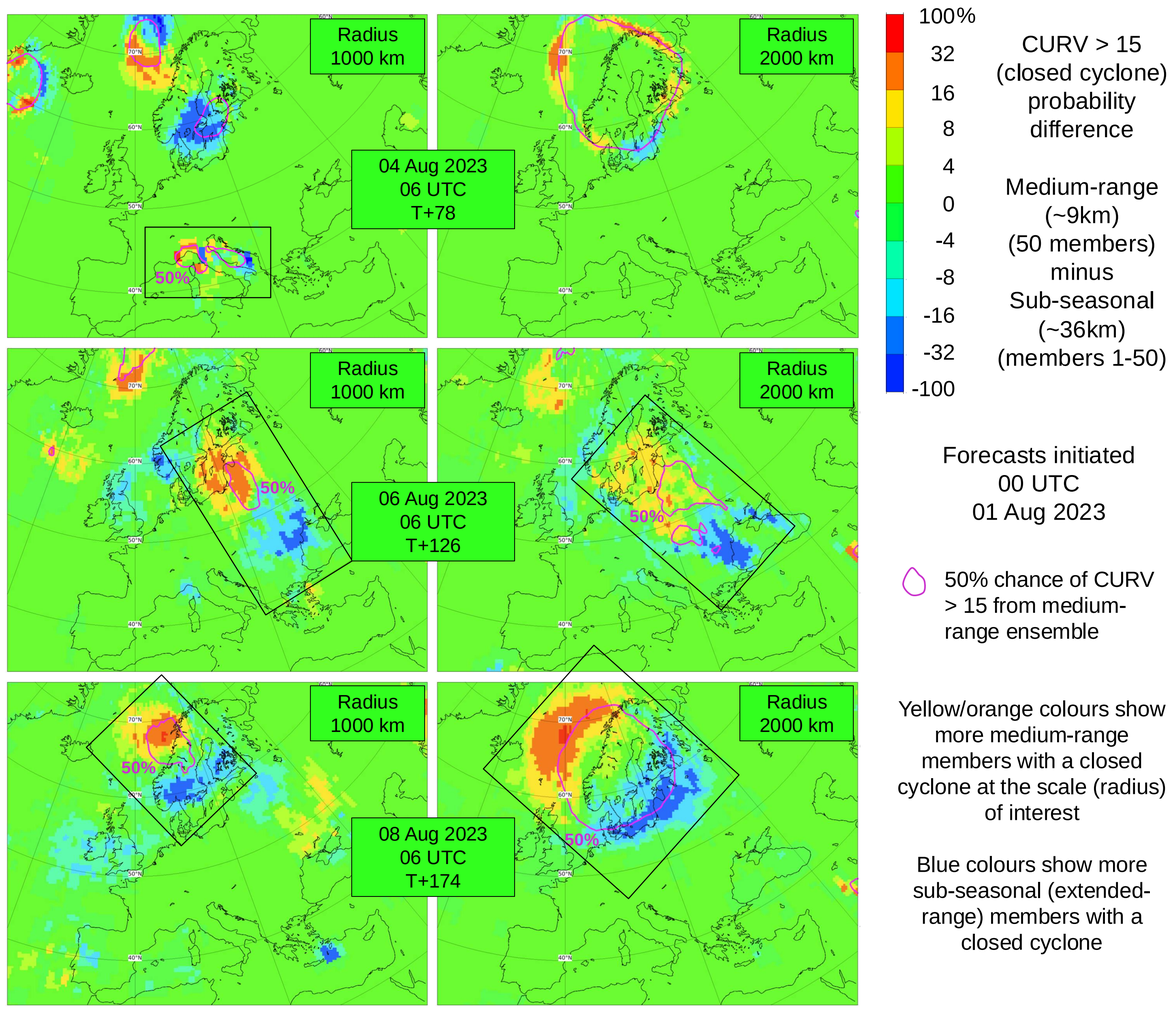
4. Ensemble probabilities using CURV

IFS medium-range ensemble probabilities of closed cyclones (CURV>15) valid at 00 UTC 08 Aug 2023. Storm Hans caused flooding in Sweden 07-10 Aug 2023.



5. Ensemble differences and upscaling

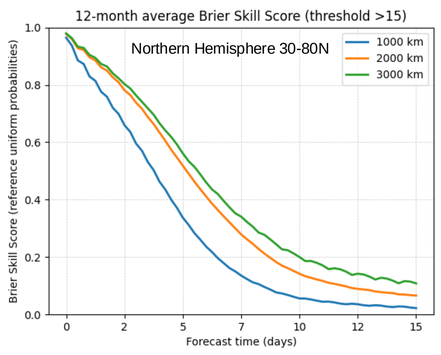
Differences between equivalent IFS medium-range and sub-seasonal (extended-range) probability forecasts of a closed cyclone using two radii. Differences emerge over northern Italy (radius 1000 km) in association with convection (top left). The differences propagate northeast and upscale, resulting in a systematic difference in the positioning of Storm Hans seen most prominently at radius 2000 km (bottom right).



6. Ensemble verification and predictability

Brier Skill Scores for IFS medium-range ensemble forecasts from May 2023 to April 2024, for CURV probabilities of an enclosed cyclone verified against identically computed CURV analysed outcomes, using radii of 1000, 2000 and 3000 km.

Skill drops more quickly and saturates earlier at smaller scales. Verification of CURV can be used to determine the predictability of MSLP (or geopotential height) curvature at different scales.



BSS reference: uniform probability of occurrence from frequency in operational analyses