Diagnoses of severe convection during the cold season in France

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Introduction and objectives

USA is well-known for its high frequency of tornadoes. Nevertheless, formation of tornadoes are also quite common over western Europe (including France). Such severe convection events occur typically during the warm season, but a non negligeable amount also occurs during the cold season (oct/nov => march) in an environment called « HSLC » High Shear Low CAPE (DLS > 18 m/s and MUCAPE << 1000 J/kg). During this season, classical severe convection parameters, such as SCP (Supercell Composite Parameter) and STP (Significant Tornado Parameter) are not able to detect severe convection events such as tornadoes or severe convective gusts as they are high CAPE-dependent.

Over the past 5 years, studies have been performed over southestern USA to determine the favourable ingredients for the severe convection development in a HSLC environment. For instance, Sherburn and Parker (2014) Sherburn & al. (2016), Parker (2017) proposed new severe convection parameters : SHERBS3, SHERBE, MOSH, MOSHE

➡ **The goal of this study is to compute and validate those parameters through 12 HSLC situations occuring in France.**

Data and diagnoses

Situations

9 cases between 2016 and 2019 were severe convective winds and tornadoes occured in HSLC conditions + 3 cases without severe events and reports

Gusts > 50 Kt (blue) and tornadoes (red) observed during the 9 days studies

NWP models

Both operational NWP models in use at Météo-France:

- **ARPEGE**: global, resolution of 7.5 km around France
- **AROME**: local, NH, resolution of 1.3 km

Sherburn and Parker (2014), Sherburn & al. (2016) diagnoses

$$\text{SHERBS3} = \frac{\text{S3MG}}{26} \times \frac{\text{LLLR}}{5.2} \times \frac{\text{LR75}}{5.6}$$

$$\text{SHERBE} = \frac{\text{ESHR}}{27} \times \frac{\text{LLLR}}{5.2} \times \frac{\text{LR75}}{5.6}$$

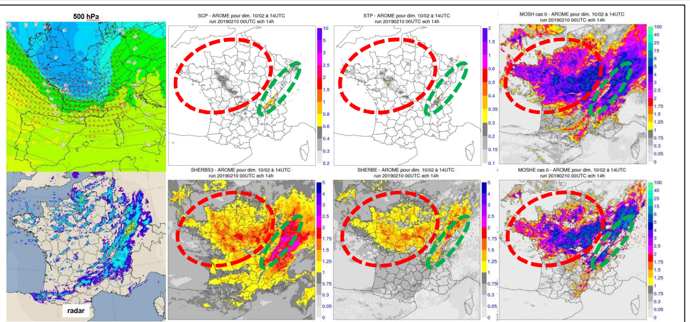
$$\text{MOSH} = \left(\frac{(\text{LLLR}-4)^2}{4}\right) \times \left(\frac{\text{S15MG}-8}{10}\right) \times \left(\frac{\text{MAXTEVV}+10}{9}\right)$$

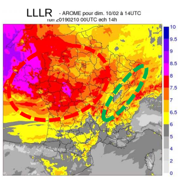
$$\text{MOSHE} = \left(\frac{(\text{LLLR}-4)^2}{4}\right) \times \left(\frac{\text{S15MG}-8}{10}\right) \times \left(\frac{\text{MAXTEVV}+10}{9}\right) \times \left(\frac{\text{ESHR}-8}{10}\right)$$

Where:
LLLR: 0-3 km lapse rate
LR75 : 700-500 hPa lapse rate
S3MG: 0-3 km bulk shear vector magnitude
S15MG: 0-1.5 km bulk shear vector magnitude
ESHR: effective shear magnitude
MAXTEVV: potential instability

MAXTEVV is a term that approximate the release of potential instability by a synoptical forcing (i.e. product of ω and $d\theta_e/dz$). It is computed every 0.5 km from 0-2 to 0-6 km and only the maximum value is kept. Note: even if AROME is a NH model, it is possible to compute VV with the hydrostatic assumption.

First results and limits





Case study 1: On 10th of Feb 2019, a cold front evolved in a squall line over eastern France with gusts between 50 and 65 KT. Behind this front, most of France is hit with showers and gusts < 50 KT.

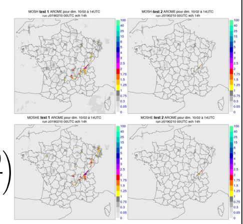
Results: The 4 Sherburn and Parker diagnoses show high values over whole France. **The problem is due to the LLLR term: over western Europe, unstable weather is associated with maritime air mass and so high instability in the low levels during cold season.** We also tried another colorscale for SCP and STP adapted to cold season with still false alarm over NW France. However, we must keep in mind that the SCP/STP parameters are more suited for supercell (including tornadic) environment.

New formulations

In order to cope with the issue related to the LLLR term, a new formulation of MOSH/MOSHE is necessary :
- test 1: formulation without the LLLR term
- test 2: LLLR is replaced by (CAPE/300)

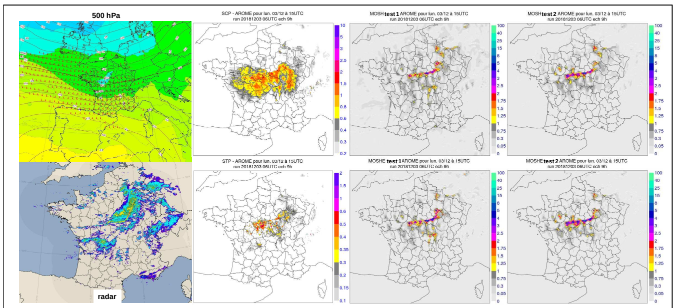
$$\text{test1: MOSH} = \left(\frac{\text{S15MG}-8}{10}\right) \times \left(\frac{\text{MAXTEVV}+10}{9}\right)$$

$$\text{test2: MOSH} = \left(\frac{\text{CAPE}}{300}\right) \times \left(\frac{\text{S15MG}-8}{10}\right) \times \left(\frac{\text{MAXTEVV}+10}{9}\right)$$

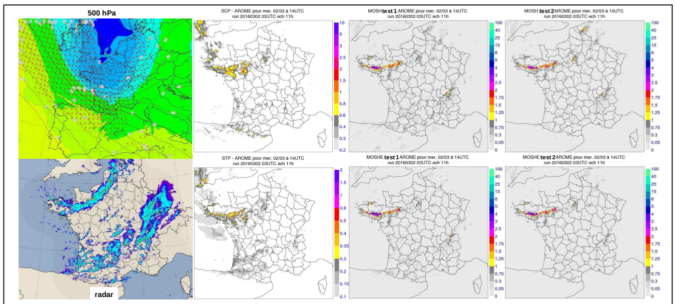


➡ Results are very encouraging

Results



Case study 2: On 3rd of Dec 2018, a LEWP swept across northern half of France with gusts between 50 and 60 KT. Although AROME provides a good forecast, it is noteful that the MOSH and MOSHES modified give a much more precise signal than SCP and STP (with a cold season colorscale).

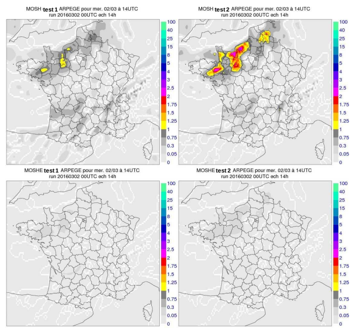


Case study 3: On 2nd of March 2016, a derecho hits all Northern France associated with gusts between 50 and 75 KT + one tornado report along its track.

Results: AROME captures the western flank of the squall line. Results of both MOSH/MOSHE modified are encouraging, although for the eastern flank the values are too low.

SCP/STP (cold season colorscale) are comparable but propose false alarm over SW France.

For this situation, the gobal model ARPEGE is very interesting to use in addition with AROME. Indeed, both MOSH modified suggest the entirety of the squall line.



Conclusion

This study consists in evaluating the Sherburn and Parker (2014), Sherburn & al. (2016) parameters over France. However, over western Europe, the airmass associated with HSLC conditions is different than in the USA. Because of its maritime origin, it has been found that the use of the LLLR term is not relevant for the detection of severe convection over France.

The following step of this study has been to adapt those parameters to european cases. New formulations are suggested and the results are very encouraging when a QLCS occurs for both NWP model ARPEGE (global) and AROME (regional).

Outlook

To confirm those preliminary results, more case study need to be investigated. A statistical approach will confirm the best formulation of MOSH/MOSHE and the values to normalize the different terms. Also, the comparison between MOSH/MOSHE and SCP/STP has to be continued, even if they are suited for supercells environments.

Moreover, the relevance of MOSH/MOSHE generally depends on the term MAXTEVV. If the models are totally wrong, it might lead to errors. To avoid that, it will probably be necessary to try to reduce the weight of this term.

REFERENCES
King J.R., Parker M.D., Sherburn K.D., Lackmann G.M., 2017. *Rapid evolution of cool season, low-CAPE severe thunderstorm environments.* Weather and Forecasting, 32, 763-779.
Parker M.D., 2017. *What have we learned about High-Shear Low-CAPE severe weather? A review. ESSL Testbed.*
Seity Y., Brousseau P., Malardel S., Hello G., Bénard P., Bouttier F., Lac C., Masson V., 2011. *The AROME-France convective-scale operational model.* Monthly Weather Review, 139, 976-991.
Sherburn K.D., Parker M.D., 2014. *Climatology and ingredients of significant severe convection in High-Shear Low-CAPE environments.* Weather and Forecasting, 29, 854-877.
Sherburn K.D., Parker M.D., King J.R., Lackmann G.M., 2016. *Composite environments of severe and nonsevere High-Shear Low-CAPE events.* Weather and Forecasting, 31, 1899-1927.