Operational Usability of Symmetric Instabilities during Convective Initiation

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Introduction: During the warm season at least about 40% of all convective events in the greater Alpine region can be related to air mass convection (pulse convection). A forecaster would find widespread distinct gravitational instability (500 < CAPE < 2500 J/kg) and conditional instability, respectively; also sufficient moisture for initial shallow convection over mountainous regions is existent. Due to entrainment, capping inversions (CIN) and lack of sufficient lift, further deep convective development would often be disabled. For the case study of the 28 July 2005 parameters like negative Equivalent Potential Vorticity EPV and Symmetric Convective Available Potential Energy SCAPE indicate the existence of symmetric instabilities in the area prone to deep moist convection. Also, upper level moisture gradients mark zones with increasing vertical shear and deformation. In order to identify those areas where saturated parcels could experience an additional lift to reach their Level of Free Convection LFC, forecasters may assess information about symmetric instabilities, additionally.

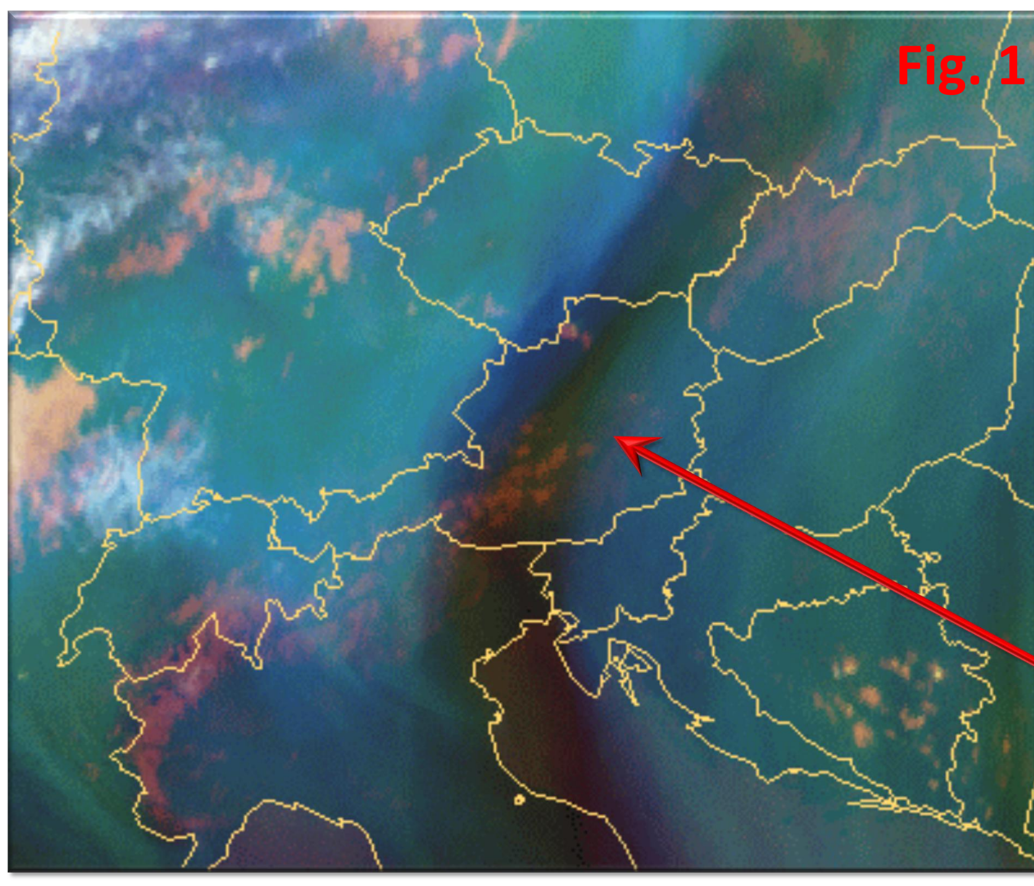

Fig.1: 28 July 2005, 1100 UTC, MSG RGB Image composite:
IR 8.7µ (red)/ WV 7.3µ(green) / WV 6.2µ(blue)

Low clouds, shallow convection (red), mid level clouds and water vapour (green), water vapour at upper levels (blue), high clouds and deep convection (white).
Shallow convection can be seen as red and orange coloured features, mid- and upper level moisture gradients mark narrow zones of increased wind speed, in this regard unidirectional wind shear and further a gradient of equivalent potential temperature (Santureette, Georgiev, 2005).

"Upscale development" (Xu, 1986a):
- Initial development of small-scale moist gravitational convection,
- release of symmetric instability -> mesoscale (banded) convective clouds,
- most likely occurrence : outside of frontal regions, absence of synoptic-scale air mass boundaries

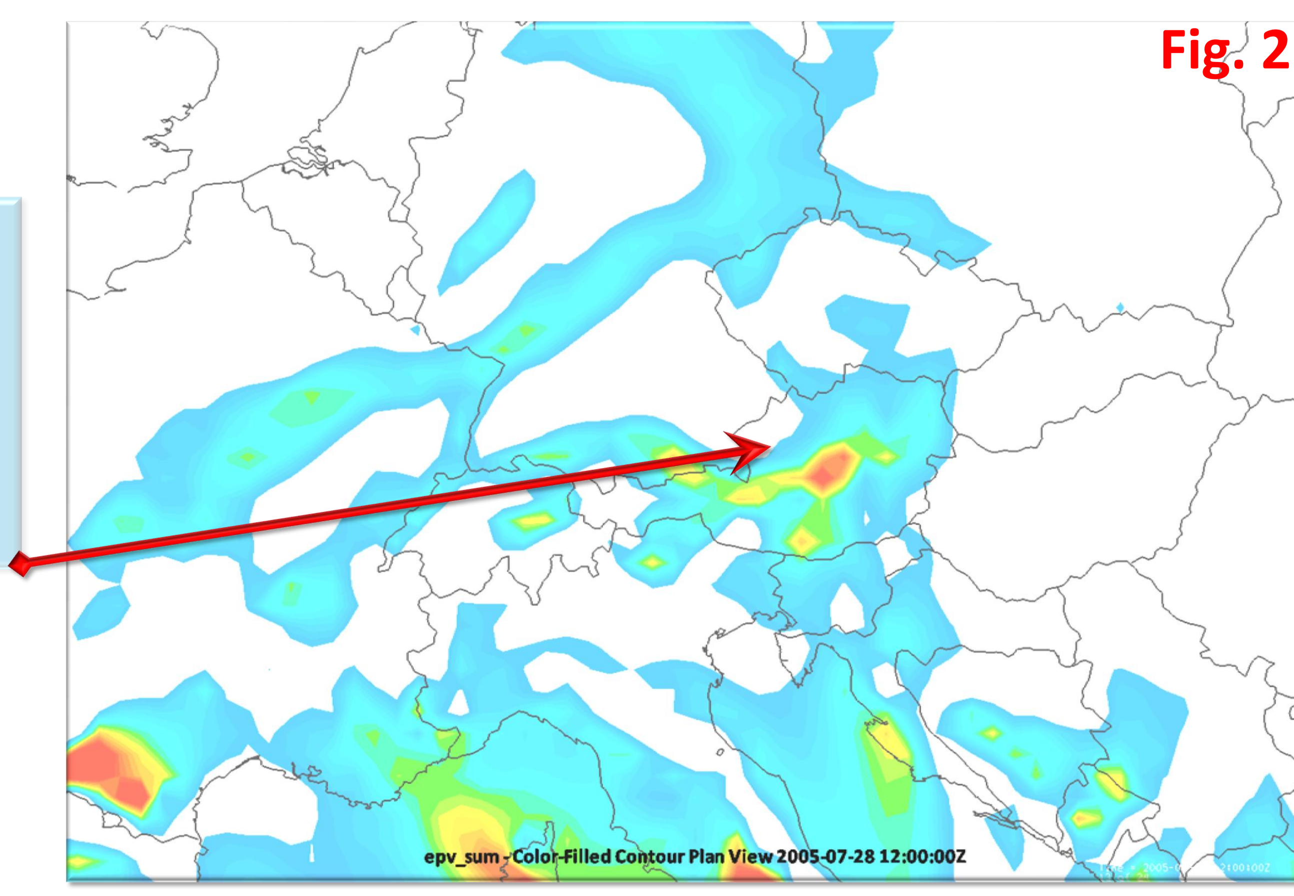

Fig.2: 28 July 2005, 1200 UTC, Eqivalent (Moist) Potential Vorticity,
EPV [|-5| (blue) – |-30| (red) 10^{-6} K*m²/kg*sec, increment 0,3] , 850 – 500 hPa, WRF-model

- Negative EPV indicates areas of symmetric instability SI (Schultz, Knox, 2007)
- Saturated buoyant air parcel reaches a zone of distinct negative MPVg
- Through a possible release of SI slantwise convection might follow (cms^{-1})
- Provides sufficient lift for the air parcel to reach LFC?

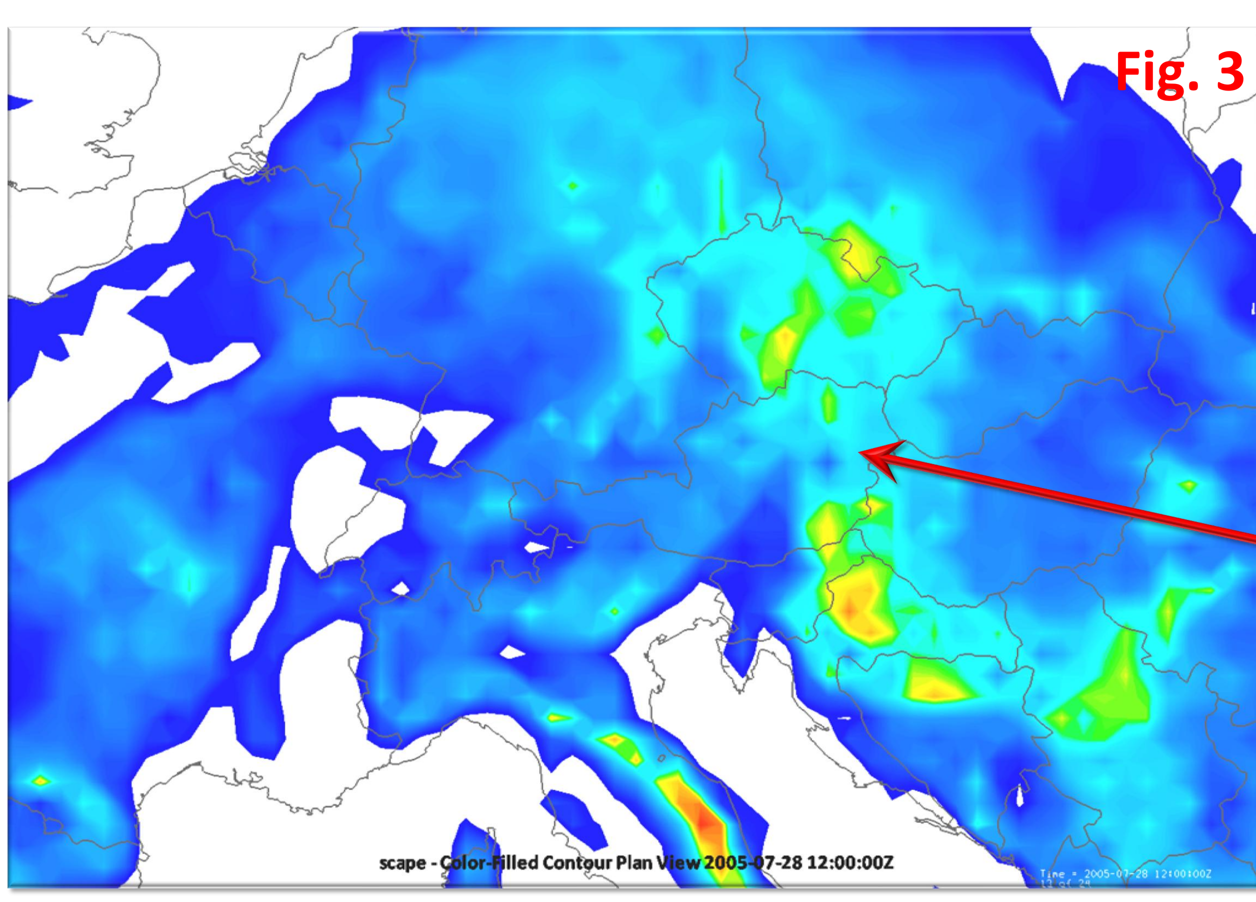

Fig.2: 28 July 2005, 1200 UTC, Symmetric Available Potential Energy,
SCAPE [500 (blue) – 3000 (red) J/kg, increment 30] , above 950 hPa, WRF-model

- SCAPE indicates the potential for symmetric instability (calculated after Dixon, 2000)

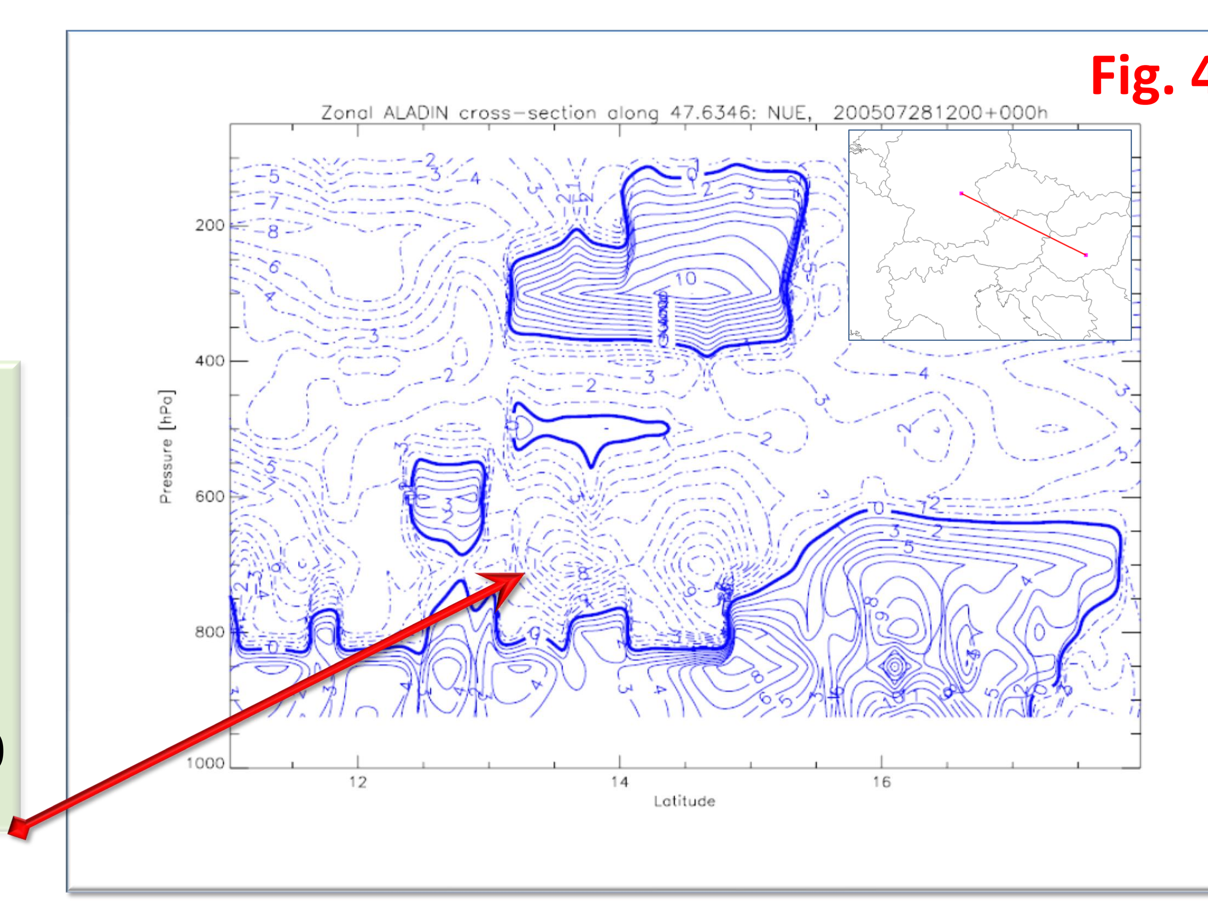

Fig.4: 28 July 2005, 1200 UTC, Geostrophic Wind-Vector-Gradient Matrix ("NUE"), ALADIN-model
zonal vertical cross section, negative values represent the increase of the gradient of EPV in case of ξ < 0

- "Horizontal gradients of conservative field quantities (such as: EPV, Θe) are strengthened by the geostrophic wind field when deformation terms are dominant" (Emanuel 1994)
- -> Derivation of a geostrophic wind-vector-gradient matrix ("NUE")

Equation 1: Divergence (D), Stretching Deformation (E), Shearing Deformation (F) and Relative Vorticity (ξ)

$$\mathbf{v} = sign(\xi)\cdot\left(\frac{D}{2} + \left|\left[\frac{(E^2+F^2-\xi^2)}{4}\right]\right|^{\frac{1}{2}}\right)$$

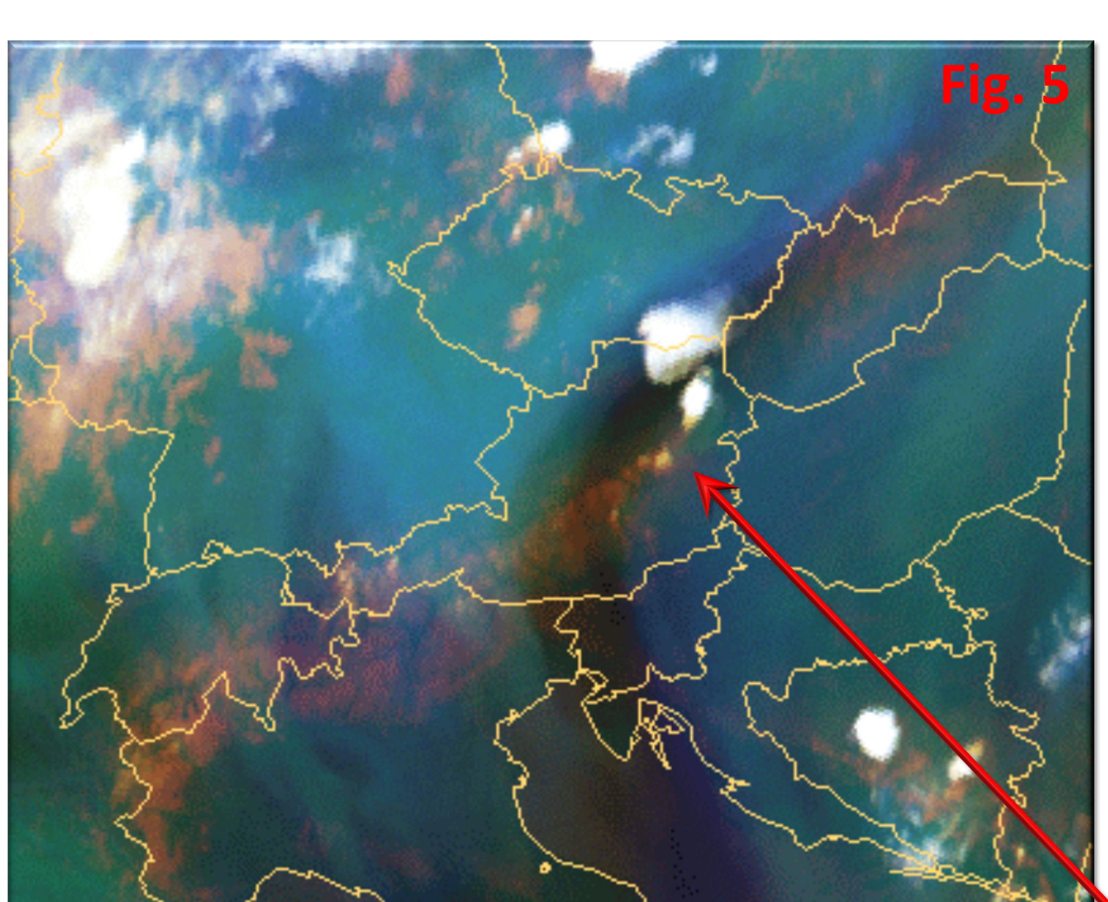

Fig. 5: 28 July 2005, 1500 UTC, MSG RGB as above, fully grown DMC within the area under discussion

The following characteristics can be summarized:
- ✓Distinct vertical shear / little directional shear, Weak gravitational stability
- ✓EPV becoming smaller or negative by deformation at the boundary zone
- ✓Strong thermal gradient induced by the dry and cold intrusion along with the WV dark zone
- ✓Saturated buoyant air parcel reaches a zone of distinct negative EPV, distinct signal from SCAPE
- ✓Release of SI -> slantwise convection might follow (cms^{-1}), sufficient?

Further discussions, limitations (Schultz, Schumacher, 1999):
- Convection can possess characteristics of slantwise convection, gravitational convection, or both
- Coexistence of: Conditional Symmetric Iinstabilities CSI, Conditional Instabilities CI, adequate moisture/lift
- Release of convective-symmetric instability results in a mixture of moist slantwise and moist gravitational – the latter prevails
- CI is a special case of CSI
- Identifying regions with EPV might also indicate CI and gravitational convection

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