Radar-based severe storm climatology for Austrian complex orography related to vertical wind shear and atmospheric instability.

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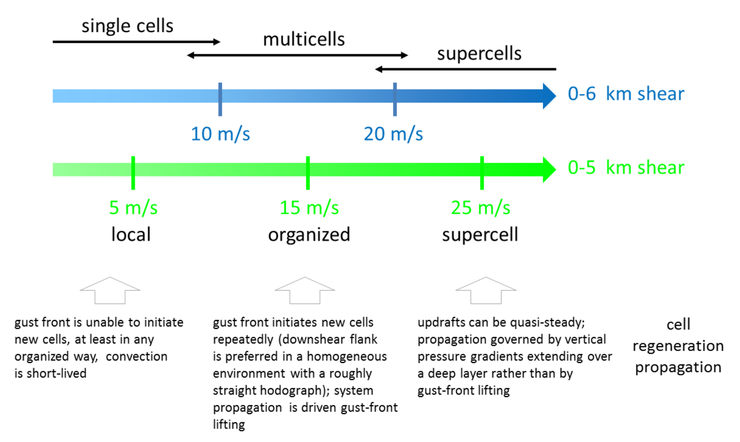
Abstract

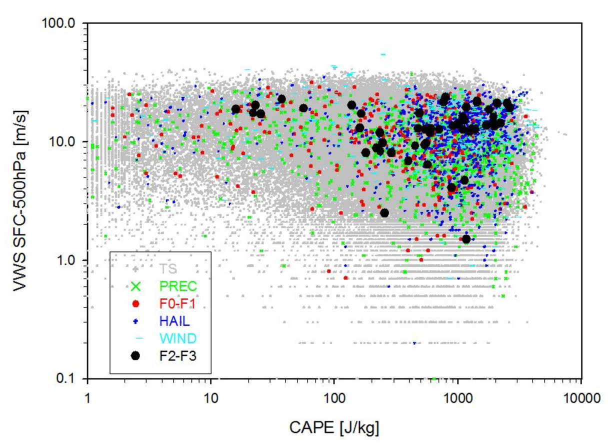
Thunderstorm development in Austria is highly influenced by orographical forcing especially in summer. The further development toward local severe storm formation depends on the strength of instability and vertical wind shear which interact with mesoscale influences. For closer insight, the temporal and spatial distribution of severe thunderstorms as a function of CAPE and deep vertical wind shear are examined. A five year period of C band weather radar data is exploited over the complex orography of Austria and linked to ECMWF ERA-Interim data for classification of synoptic flow, vertical wind shear and instability.
A minimum of severe storms over the Alpine crest in high altitudes of the Southwest region is observed which corresponds to lightning data. Westerly and southerly flow classes are associated with more widespread intense thunderstorm development. One of the key results is that the strong deep-layer shear environment leads to organized, line oriented patterns over wide areas of Austria. These preferred areas for severe storm occurrence can be well used for nowcasting. Especially during low CAPE conditions the magnitude of deep-layer shear is very important for the spatial arrangement, maximum size of the convective system, and time of occurrence. For the eastern part of Austria and the Alps, high deep-layer shear tends to produce larger cell cores in terms of high radar reflectivity. For the Alps during low CAPE conditions and for the eastern part of Austria for all CAPE classifications, the strong deep-layer shear increases the frequency of severe storms and shifts the peak of occurrence from afternoon toward the evening.

Motivation

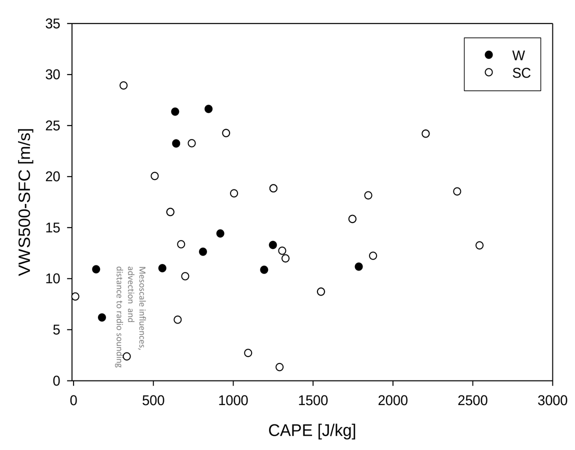


Discrimination of thunderstorm types based on vertical wind shear adopted from Markovski and Richardson (2010) and Bluestein (1993) where deep layer shear determines the convective mode.

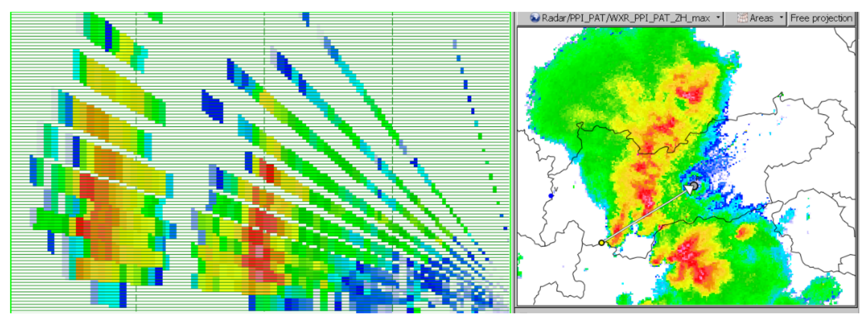
Is there interaction with topographic effects ?



Scatter plot with respect to vertical wind shear between lowest model level and 500 hPa and surface-parcel based CAPE for different European severe and ordinary thunderstorm categories (Kaltenboeck et al., 2009)

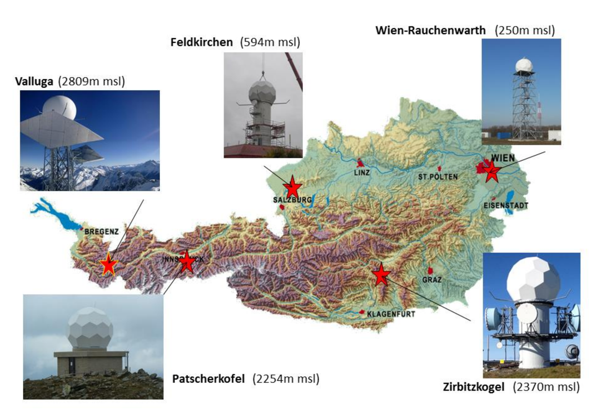


51 Austrian severe local storms in relation to deep-layer shear and CAPE (derived from radio soundings between 1997-2003). Mesocyclones are labeled as white dots (SC, supercell) which include 30 tornado and 3 funnel cloud reports. Black dots (label W) indicate severe wind reports.

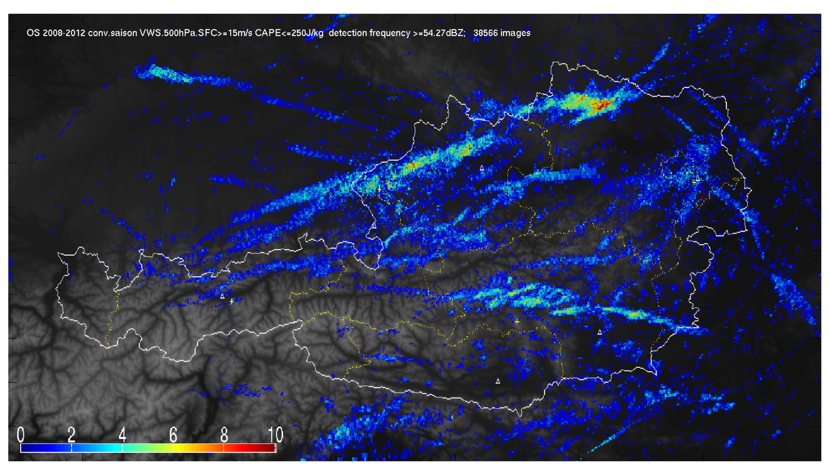


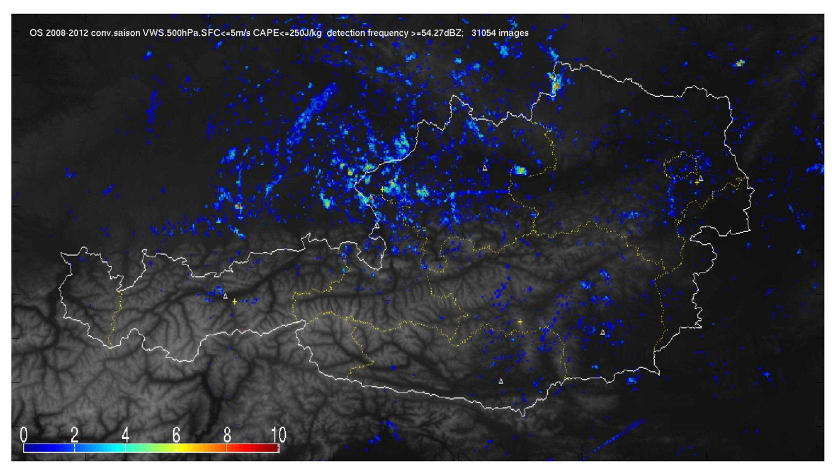
Downburst damage at Innsbruck airport in 2007 and example of cross section through downburst producing thunderstorms on 7th July 2015 in Innsbruck.

Conditional Climatology of Austrian Weather Radar Data: Shear/CAPE influence on spatial distribution, diurnal cycle and size of MCS:

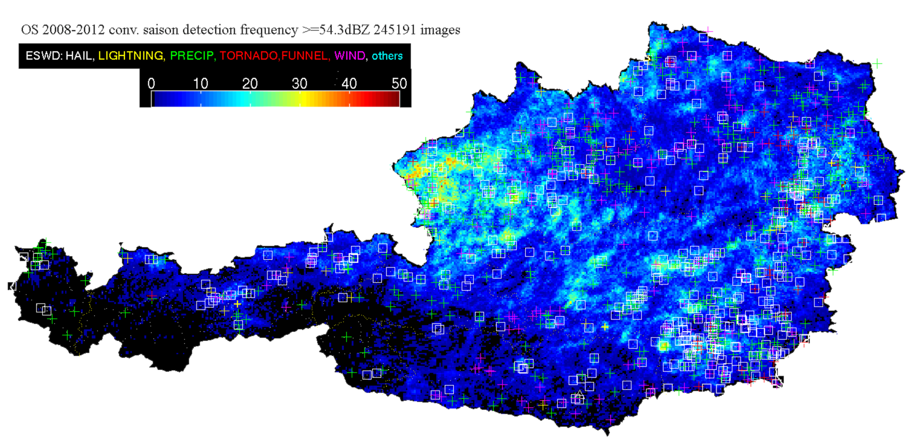


present Austrian C-band weather radar network.

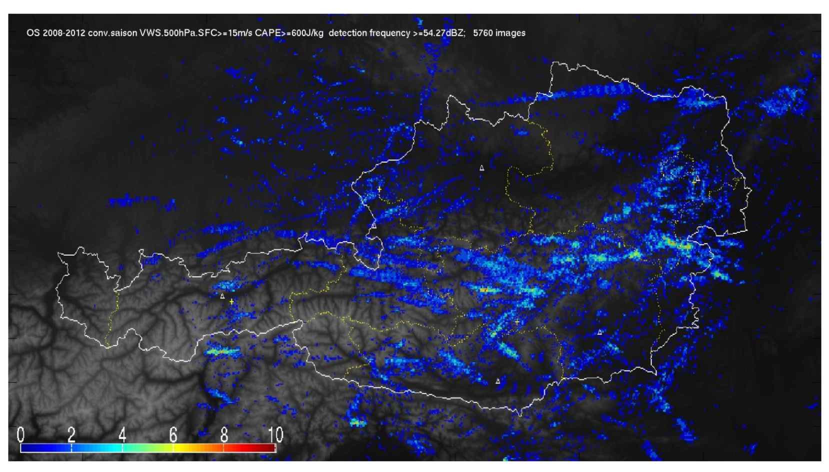


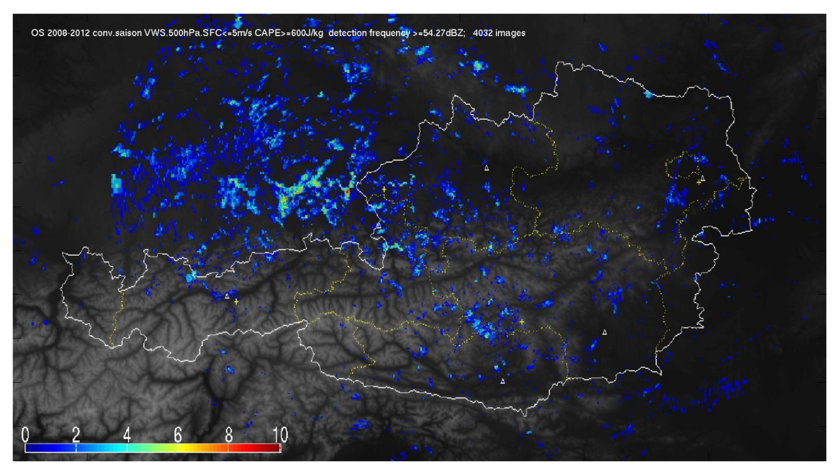


Spatial frequency distribution of Z ≥ 54 dBZ for cases accompanied by low CAPE (≤ 250 J/kg) and comparison between strong deep-layer shear (VWS500) ≥ 15 m/s (LCHS, left) and very weak VWS500 ≤ 5 m/s (LCLS, right) conditions, respectively.

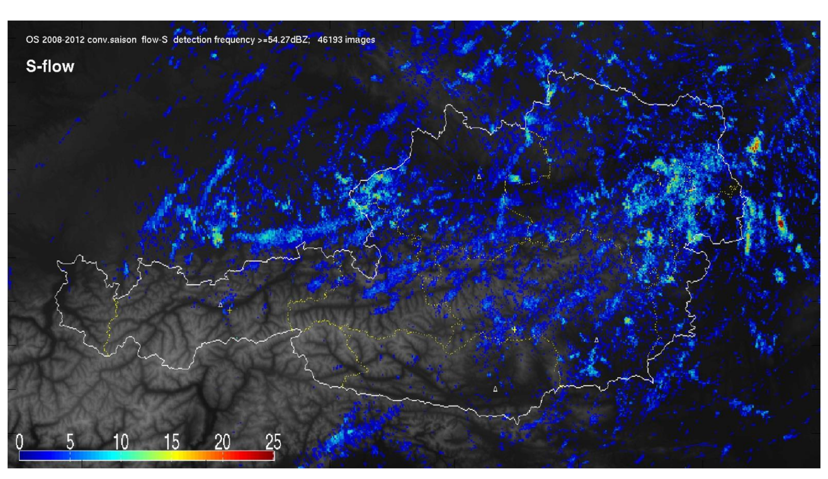


Frequency distributions of Z ≥ 54 dBZ (absolute numbers) overlaid by ESWD severe storm reports for the convective season 2008-2012. White rectangles indicate large hail, yellow/green/red/magenta crosses depict damaging lightning/heavy precipitation/tornados/damaging wind reports, respectively.

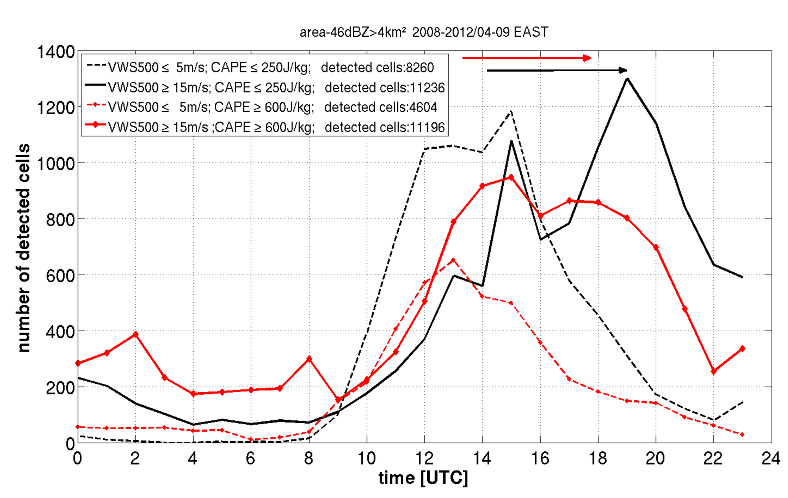




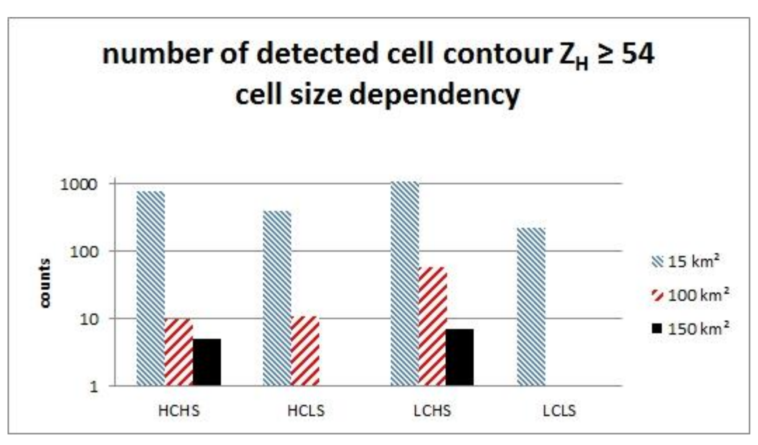
Spatial frequency distribution of Z ≥ 54 dBZ for cases accompanied by high CAPE (≥ 600 J/kg) and comparison between strong deep-layer shear (VWS500) ≥ 15 m/s (HCHS, left) and very weak VWS500 ≤ 5 m/s (HCLS, right) conditions, respectively.



Frequency distributions of Z ≥ 54 dBZ (absolute numbers) for southerly flow configurations (500 hPa) during the convective seasons 2008-2012 derived from Austrian composite (5 min interval) consisting of 4 weather radars.



Diurnal cycle of Z contour exceeding 46 dBZ and an area of 4 km² for the east part of Austria. See legend for different CAPE and VWS500 classifications. Arrows indicate the shift of the maxima to the evening by 2 to 5 hours during strong deep-layer shear conditions.



Number of detected cells for Z contour ≥ 54 dBZ during the convective season 2008-2012 for different cell size areas (> 15, 50, 100 and 150 km²) and different deep-layer shear combinations (HCHS=high CAPE high Shear, HCLS=high CAPE low Shear, LCHS=low CAPE high Shear, LCLS=low CAPE low Shear).

For more details see: Kaltenboeck, R. and Steinheimer, M., 2015: Radar-based severe storm climatology for Austrian complex orography related to vertical wind shear and atmospheric instability. Atmospheric Research, 216-230