

# An extended perspective for DMC - Initiation in the Alpine Region?

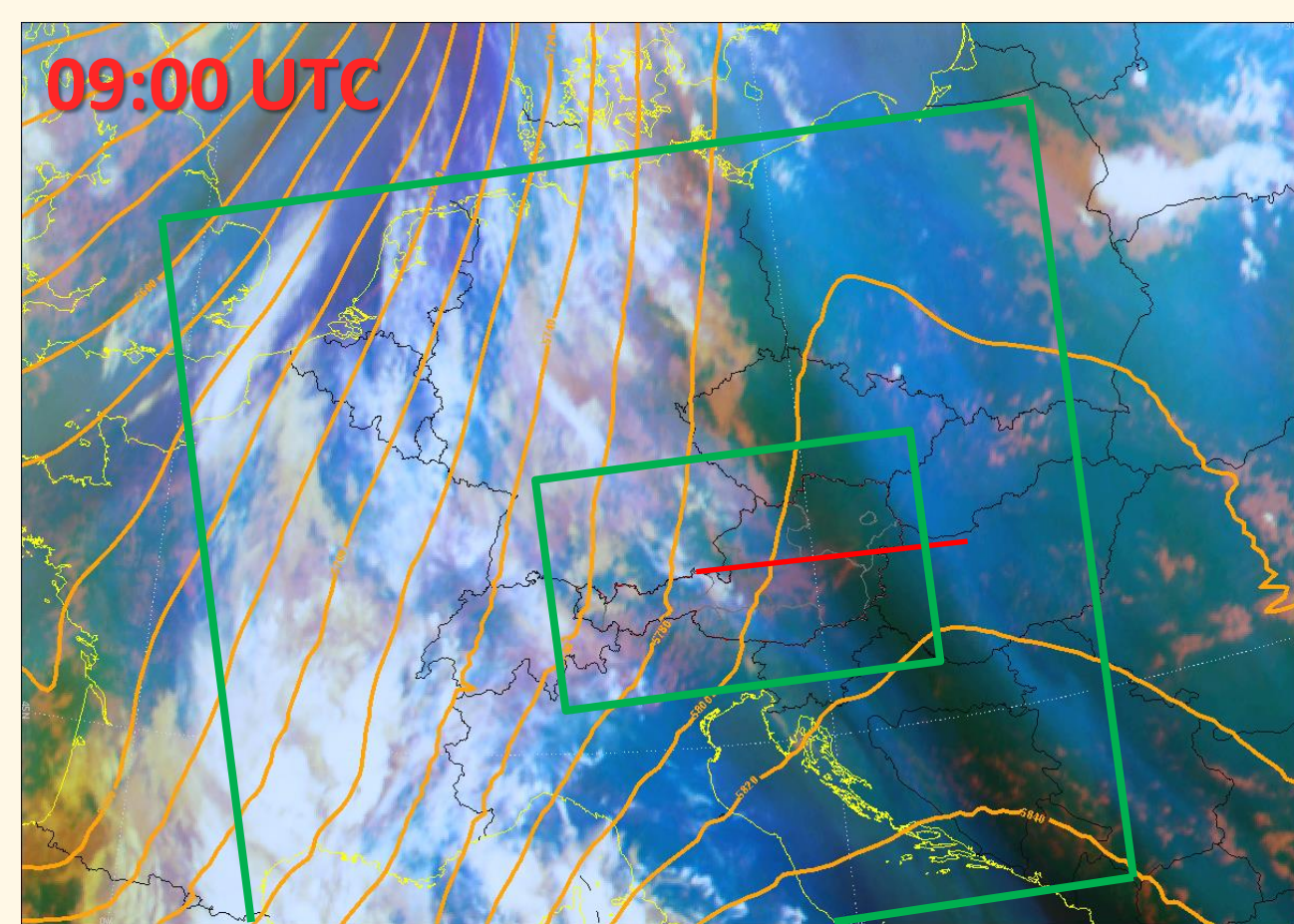
Thomas Krennert<sup>1</sup>, Astrid Kainz<sup>1,2</sup>, Stefano Serafin<sup>2</sup>

(1) ZAMG, Central Institute of Meteorology and Geodynamics, Hohe Warte 39, A – 1190 Vienna, [t.krennert@zamg.ac.at](mailto:t.krennert@zamg.ac.at)

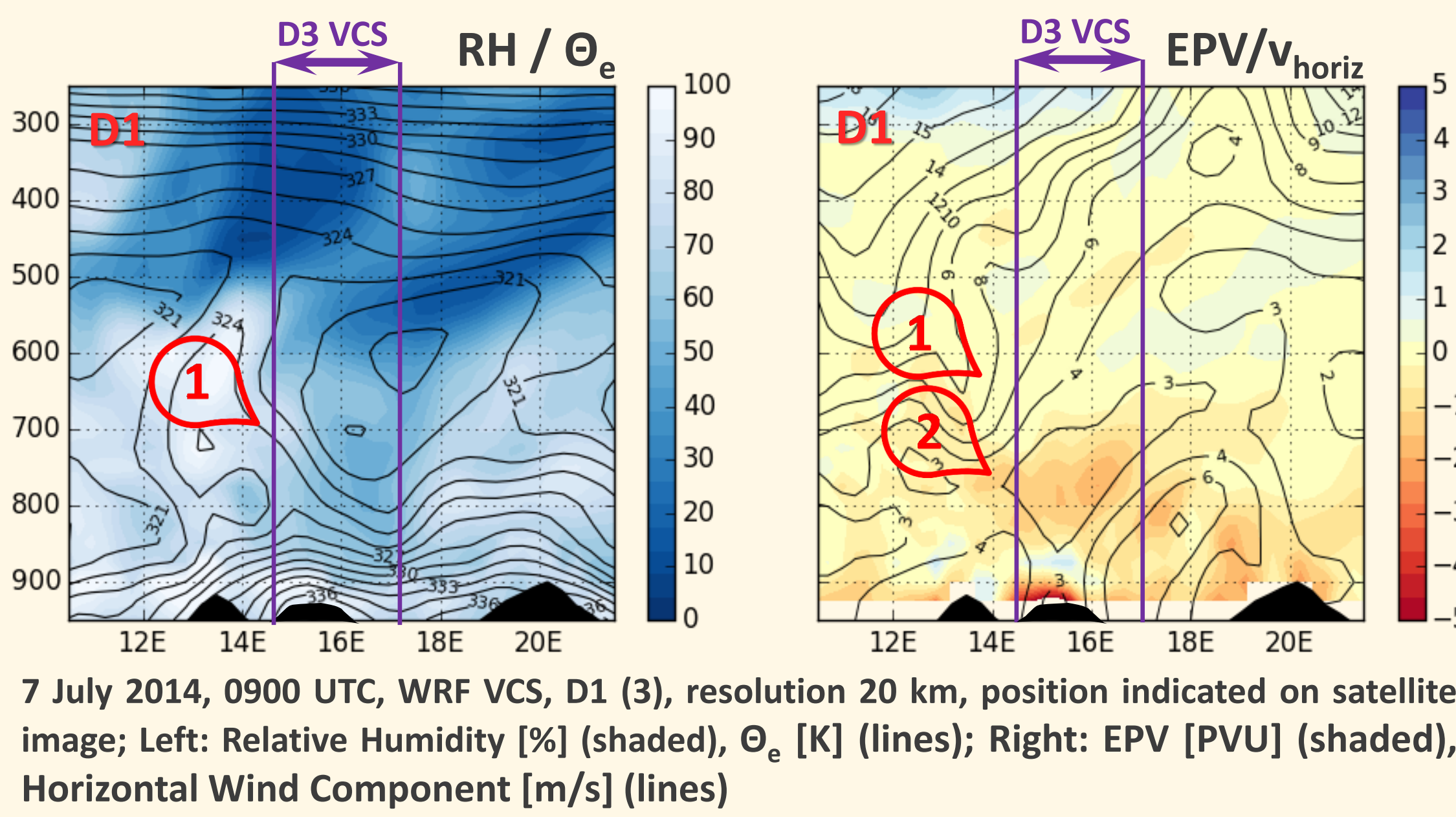
(2) Department of Meteorology and Geophysics, University of Vienna, Althanstraße 14, A – 1090 Vienna, Austria, [stefano.serafin@univie.ac.at](mailto:stefano.serafin@univie.ac.at); [astrid.kainz@gmail.com](mailto:astrid.kainz@gmail.com)

Predicting the exact location, intensity and propagation of thunderstorms and convective complexes remains a challenge to operational forecasters, in particular in the presence of orography, in the absence of fronts and when a forecast lead time of more than three hours is desired. Single-cell or pulse convection, developing without fronts, represents about 30% of the summertime convection in the Eastern Alpine region, Krennert et al. (2003). Studies of satellite imagery in similar cases showed, that upper tropospheric moisture gradients (UTMG) are often favourable locations for the initial evolution from shallow to deep moist convection (DMC). In a simulation with the WRF model for the case of 7 July 2014, the evolution of DMC occurs in conjunction with a significant increase in vertical wind shear, horizontal and vertical gradients of Equivalent Potential Temperature  $\Theta_e$  and inertial instability in the vicinity of a UTMG. Hence, the coexistence of moist gravitational and moist symmetric instabilities along the UTMG seems plausible.

## Synoptic boundary conditions & predictors of symmetric, conditional and inertial instabilities



7 July 2014, 0900 UTC, MSG RGB image: IR 8.7 $\mu$ m (red) / WV 7.3 $\mu$ m (green) / WV 6.2 $\mu$ m (blue); orange lines: 500 hPa Geopotential; red line: VCS D1; green squares: D2 and D3, D1 bigger than image plane

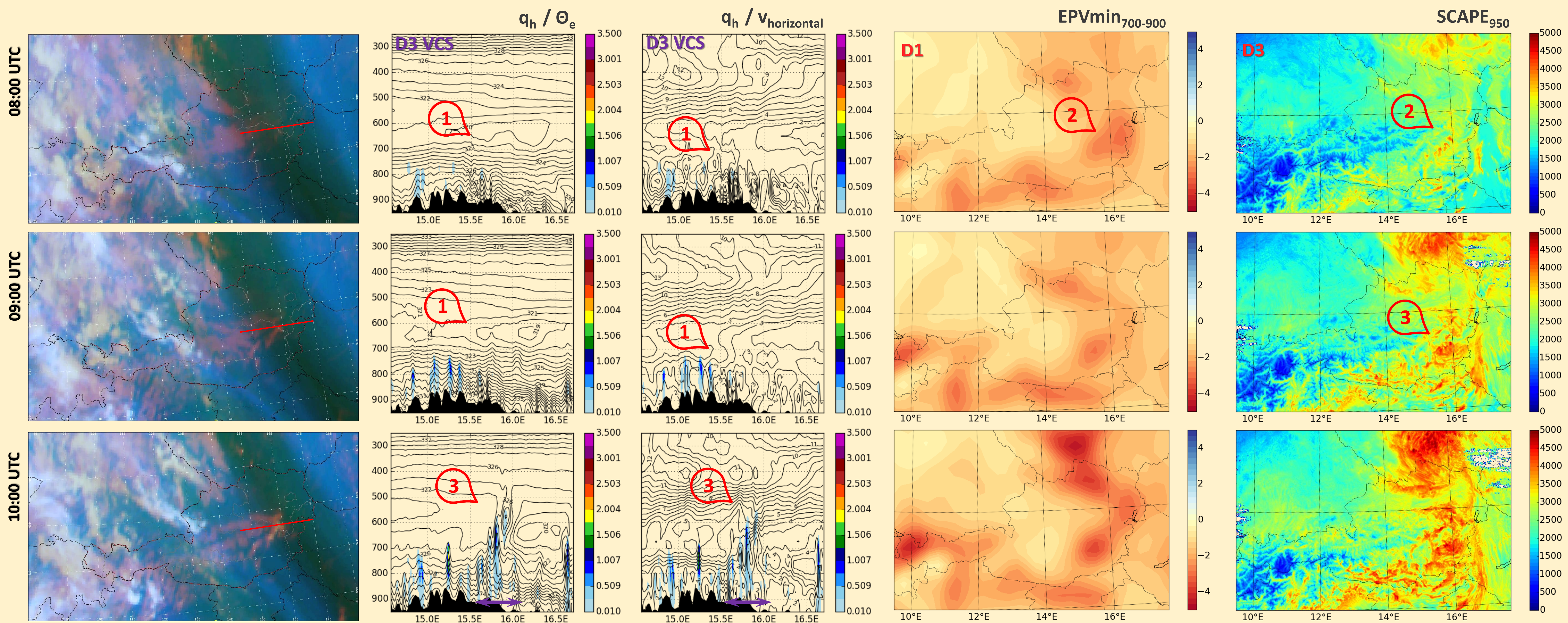


7 July 2014, 0900 UTC, WRF VCS, D1 (3), resolution 20 km, position indicated on satellite image; Left: Relative Humidity [%] (shaded),  $\Theta_e$  [K] (lines); Right: EPV [PVU] (shaded), Horizontal Wind Component [m/s] (lines)

### Case Study: 7 July 2014, 0900 UTC:

- WRF Simulations:
  - 3 nested (ECMWF) domains, resolution 20 / 4 / 0,8 km (D1 / D2 / D3), only results from D1 and D3 are shown
  - PBL: MYJ; MP: WSM6; LS: RUC-3;  $\omega$ : Grell3D (only in D1)
- Synoptic boundary conditions and vertical cross sections VCS:
  - Indicators for conditional (CI), inertial (II), and conditional symmetric instability (CSI) can be found along the UTMG:
    - Horizontal and vertical gradients of relative humidity RH,
    - Horizontal and vertical gradients of  $\Theta_e$
    - Horizontal and vertical wind shear, gradients of horizontal wind speed
    - negative Equivalent Potential Vorticity EPV (Mc Cann, 1995), between 900 and 700 hPa
  - In the VCS below, the simulation shows the transition from shallow convective towers towards DMC in the vicinity of the UTMG parameters
  - Existence of negative EPV and SCAPE maxima near the first onset of DMC visible in horizontal model fields is also shown

## Satellite imagery, model simulations, their respective time increments and predictor parameters below the UTMG



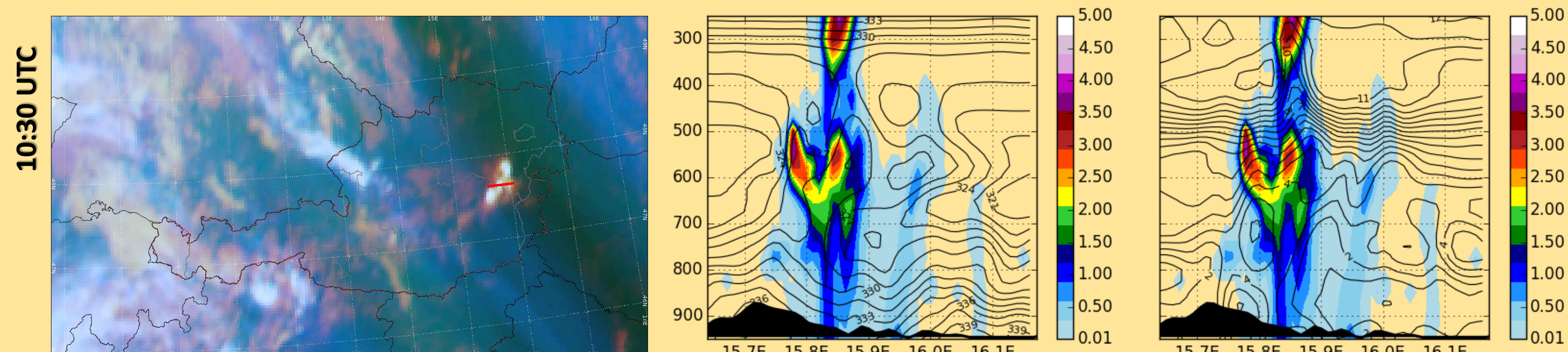
7 July 2014, MSG RGB Image composite: Low Clouds: IR 8.7 $\mu$ m (red); Mid Level Moisture: WV 7.3 $\mu$ m (green); High level Moisture: WV 6.2 $\mu$ m (blue) Red Line: Position of the model simulation VCS, D3

7 July 2014, 08:00 – 10:30 UTC, WRF simulation D3, VCS:
 

- Total hydrometeor mixing ratio [g/kg];  $q_h$ : sum of liquid cloud, rain, ice cloud, snow, and graupel water contents (shadings); Kirshbaum (2011)
- Equivalent Potential Temperature  $\Theta_e$  [K], (black lines, left side)
- horizontal component of true wind speed [ $\text{ms}^{-1}$ ] (black lines, right side)

7 July 2014, 08:00 – 10:00 UTC, WRF: Left: Negative EPV [PVU =  $10^{-6} \text{K}^2 \text{m}^2 / \text{kg}^2 \text{s}$ ], horizontal minimum projection, layer between 900 and 700 hPa; Right: Symmetric Available Potential Energy SCAPE [J/kg], integrated from 950 hPa, calculated after Dixon (2000)

## Resulting DMC in satellite imagery and WRF model simulations



### Conclusions for 7 July 2014:

- 1 • DMC development in the vicinity of pronounced horizontal and vertical  $\Theta_e$  gradient and wind shear
  - 2 • Distinctive values of SCAPE and lower mid-level negative EPV, prior shallow convective towers reaching these levels before DMC evolution
  - 3 • Coexistence of CI, II and CSI along the UTMG seems plausible
- Release of SCAPE leads to possible slantwise convection associated with indicators in model in layers between 700 and 500 hPa and below
  - Mid-tropospheric slantwise convection mechanism seems to be similar to "downscale development" after Xu (1986)