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# **News on EMVORADO**

# **Ulrich Blahak, Jana Mendrok**



# The radar forward operator EMVORADO







#### Simulated moments on radar grid:

- → Z (Mie, optionally including attenuation, partial melting, beam broadening)
- $\rightarrow$  V<sub>r</sub> (optionally Z-weighted beam broad.)



# The radar forward operator EMVORADO





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### **Various implementations**









#### → Operational assimilation

→ 3D volume scans of radial wind and reflectivity in COSMO-D2-EPS and ICON-D2-EPS since 2020 in addition to LHN (thanks to E. Bauernschuberth, C. Welzbacher, K. Stephan, A. de Lozar, K. Khosravian, R. Potthast, A. Seifert and many others)

### → Experimental applications in SINFONY ICON-D2-RUC:

- → Assimilation of 3D radial wind and reflectivity
- Simulated cell objects (KONRAD3D) from ensemble forecasts to enable "seamless" combination with cell object ensemble nowcasting (KONRAD3D-EPS) over forecast lead time for observed
- → Forecast and hindcast verification (experiments with and without DA):
  - → Spatial precipitation verification in reflectivity space (in add. to precip)
  - →Space-time PDFs of reflectivity (CFADs)
  - →PDFs of properties of convective cell objects (KONRAD3D)



# Example of spatial reflectivty verification in SINFONY: FSS of SINFONY experiments for May/June 2016







## EMVORADO in ICON-LAM Microphysics-Tests "Hindcasts"



- → "Free" 3-months runs starting 26.5.2016, simulated volume scans of 17 radars every 5'
- ➔ No data assimilation, shows "model climate"
- → Movie: Comparison 1-moment vs. 2-moment cloud microphysics





### **CFADs of radar reflectivity**



➔ Comparison 1-moment vs. 2-moment cloud microphysics

#### **Observations**



- ➔ For 1-moment scheme we lack the high reflectivities
- These are much better with the 2-moment scheme
- → But there too much "thin" clouds (~10 dBZ) in the upper troposphere



# **Ongoing: polarimetric upgrade to EMVORADO**



➔ Within DFG Priority Program



, Jana Mendrok currently adds:

- $\rightarrow$  Z<sub>H</sub>, ZDR, RHO<sub>HV</sub>, K<sub>DP</sub>, A<sub>H</sub>, A<sub>DR</sub> based on oblate spheroids (T-matrix)
- Building on polarimetric operators of Uni Bonn and NSSL Oklahoma, cooperation with people from NSSL (J. Carlin, J. Snyder, A. Ryzkhov) and Uni Bonn (S. Trömel, P. Shresta)
- Particle shapes (asymetry as function of size) at the moment based on NSSL group, but we are aware of D. Wolfensberger's shape and canting angle parameterizations for snow particles (EPFL Lausanne)
- → At the moment: not really efficient because T-Matrix is directly applied.
- → Later: efficiency by lookup tables along the lines of existing Mie-scattering option
- → <u>https://www2.meteo.uni-bonn.de/spp2115</u> → Projects → Operation Hydrometeors
- ➔ Planned applications:
  - Model verification



 Direct assimilation of polarimetric volume scans in ICON-LAM, DFG Research Group RealPeP

<u>https://www2.meteo.uni-bonn.de/realpep</u> → Projects → P3 QPF





### PoleMVORADO



- → Some images from the very first testing from end of 2019
  - Radar parameter curtains of "warm bubble" scene: Reasonable patterns & values







- → Tangent-linear operator, necessary for EnVAR. Current general ideas:
  - $\rightarrow$  For reflectivity Z:
    - → 1-mom:  $Z = \sum_{x=c,i,r,s,g} Z_x(q_x, T)$
    - $\rightarrow$  2-mom:  $Z = \sum_{x=c,i,r,s,g,h} n_x Z_{x,norm}(m_x,T)$ ,  $m_x = q_x/n_x$
    - → For now, set explicit T-dependence  $\partial Z_x / \partial T = 0$
    - $\rightarrow$   $Z_x$  and  $Z_{x,norm}$  are tabulated as lookup tables
    - → Use cubic instead of linear interpolation for table lookup in  $q_x$  and  $m_x$  direction and compute  $Z_x$ ,  $\partial Z_x / \partial q_x$  and  $\partial Z_x / \partial n_x$  from the cubic approximation polynome
    - → Efficient, differentiable and consistent at the same time
  - → For radial wind  $v_r = u \sin \varphi + v \cos \varphi v_{term}(q_x) \sin \varepsilon$ :
    - → Set  $\partial v_r / v_{term} = 0$  to avoid weak but cumbersome dependence on hydrometeors
    - $\rightarrow \partial v_r/u$  and  $\partial v_r/v$  are straight forward
- → Need help and advice to clarify issues with superobservations and interface to DACE.





### → Reader for OPERA-hdf5 volume data from more countries

→ up to now only Italy, Switzerland



### Summary



- ➔ EMVORADO implemented in official COSMO and ICON versions
- ➔ Operational assimilation of 3D volume scans of radial wind and reflectivity in COSMO-D2-EPS and ICON-D2-EPS since 2020 in addition to SINFONY:
- Many different applications in SINFONY for model verification and "seamless" combined products with radar Nowcasting up to +12 h
- → Currently work on polarimetric upgrade within DFG project
- ➔ Next steps: tangent linear operator





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