HD(CP)[2]
High definition clouds and precipitation for advancing climate prediction

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

S8 Development of evaluation methods

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The evaluation strategy developed in S8 is based on a synergy of methods and tools. At a very first step, the radar forward operator[1] is applied to model simulation outputs to obtain the prognostic reflectivity (Z**)**. With these 3D simulated data and the observations at 15 radar stations covering the whole Germany, the comparison and verification methods are carried out[2]. Results show that:

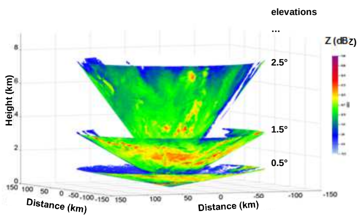
(1) Contoured Frequency by Altitude Diagrams[3] (**CFADs**) constitutes an instructive method to extract information on the general characteristics of the vertical cloud structure.

(2) An object-based quality measure **SAL**[4], which contains three distinct components that consider aspects of the **structure (S), amplitude (A), and location (L)** of the precipitation field, is modified to reveal the complex 3D characters of precipitation-object with an added aspect **Height (H)**.

(3) Furthermore, a fuzzy **SAL**[5] is also applied which tries to estimate objectively a potential time shift between the observed and simulated precipitation.

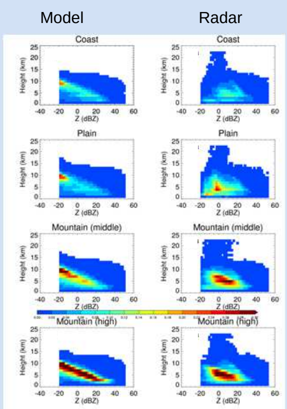
Example 3D Radar/Model Data

124 Ranges (km)
360 Azimuths (°)
18 Elevations (°)
(Model data is from COSMO-DE and interpolated from 2.8km to the radar data structure. The shown case study is 31_{th} May 2011, 24 hours starting at 12:00.



(1) Vertical structure of precipitation-object

CFADs[3] (Contoured Frequency by Altitude Diagrams):
Histograms are computed for each altitude (1km) in the radar volume, and the single-level histograms for each altitude are normalized to the number of pixels at all levels in the radar volume.



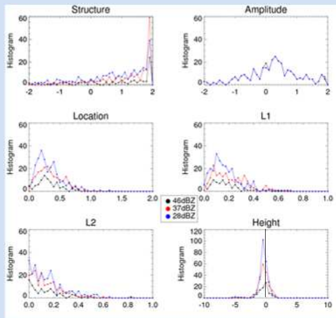
General characters:
- With increasing height, Z is decreasing
- The skewness of CFADs in model is more obvious than in radar
- At each height level, Z has wider widths in model compared to radar

From coast area to south mountain area:
- There is more precipitation
- Radar has increasing frequency of high reflectivity Z
- Model has lower P-objects centers

Fig.1 The 15-station-averaged reflectivity (Z) CFADs from model (*left*) and radar (*right)* data at different geographical areas. The binsize is 5 dBZ.

(2) 3D characters of precipitation-object

Standard SAL[4]:
S (Structure): the volume of the normalized P-objects, [-2,2], + indicates too large/ too flat simulated P-objects, - indicates too small/too peaked simulated P-objects
A (Amplitude): normalized difference of the domain averaged P-values, [-2,2], + indicates model overestimattion and – indicates model underestimation
L (Location): L = L1/248 + L2, [0,2]
L1: distance btw. centers of mass of simulated and observed P-field, [0,248], km
L2: avg. distance btw. centers of the mass of the total P-fields and individual P-objects (distribution), [0,1], large value indicates more sporadic P-objects
H: A new component added by authors to adjust SAL to the shown 3D radar structure): the height difference btw. centers of mass of simulated and observed P-fields, [-67.3, 67.3], km



Model validation:
- Too flat simulated precipitation-objects (structure)
- Overestimation of precipitation amplitude
- Most distances to observed precipitation-object center are within 50km (L1)
- Slightly lower precipitation-objects centers (height)

Fig.2 Histograms of SALH (Structure, Amplitude, Location and Height) at different reflectivity (Z) thresholds

(3) Time shift

Fuzzy SAL[5]:
Instead of being compared with one simulated precipitation, the observation is compared to a set of forecasts within a time window of [-2,-1,0,+1,+2] hours. For the time shift Δt leading to the smallest value of L (best location), the values of S, A and L, and the corresponding Δt constitute the final result of the verification (Figure 3 is from Ref.[6]).

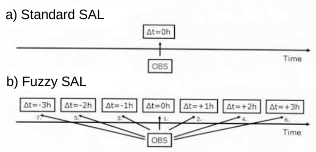
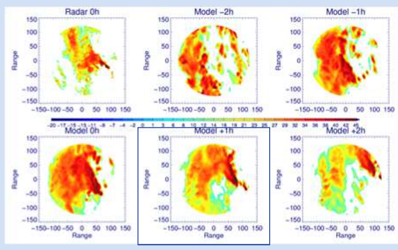


Figure 3: Schematic illustration of (a) the standard verification approach where observations and model forecast are valid at the same time, and (b) of the fuzzy approach proposed in this study, which tries to estimate objectively a potential time shift Δt between observations and the forecast.



Value of SAL from standard and fuzzy approach (best match in box, see method)

	Standard	Fuzzy
S	1.64	1.3
A	0.82	0.88
L	**0.52**	**0.27**
Δt	----	*+1h*

Fig.4 One example of fuzzy SAL to illustrate timing errors: Reflectivity (Z) from one radar station at 12am (0h) and from model within a time window of ±2 hours

- The Fuzzy SAL can lead to fairly different verification results (Fig.4), confirming the hypothesis that timing errors significantly impact upon the results from the standard appoarch
- The interquartile range of S/A are substantially reduced with the fuzzy approach, indicating timing errors are manifested as particularly large errors
- Furthermore questions: what metric should be used to identify the best match? And how large of Δt is meaningful?

References: 1, Blahak et al. 2011. Radar forward operator for data assimilation and model verification for the COSMO model.
2, Wapler et al. 2012. Comparative verification of different nowcasting systems to support optimisation of thunderstorm warnings.
3, Yuter and Houze, 1995. Three dimensional Kinematic and microphysical evolution of Florida cumulonimbus. Part II: frequency distributions of vertical velocity, reflectivity, and differential reflectivity.
4, Wernli et al. 2008. A novel quality measure for the verification of quantitative precipitation forecasts.
5, Zimmer and Wernli, 2011. Verification of quantitative precipitation forecasts on short time scales: A fuzzy approach to handle timing errors with SAL.