The concept for a new error score "SAL" for the verification of high-resolution QPF

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Motivation

(1) NWP development goes towards towards still higher spatial resolution and reveals many small-scale structures
2006: ECMWF ~ 25 km, LMK (German Weather Service) 2.8 km
(2) Standard verification measures like e.g. RMSE suffer from double-penalty problem and do not show QPF improvement for high-resolution models
(3) Limit of predictability of intense, small-scale precipitation events is not well known (and strongly dependent upon large-scale flow)

→ New approaches are developed for the verification of high-resolution QPF, e.g.

Ebert and McBride 2000 (JH):	comparison of object pairs
Davis et al. 2005 (MWR):	comparison of refined object pairs
Casati et al. 2004 (Met. Appl.):	wavelet filter approach

→ Difficulty of object pairing in case of many small objects (e.g. convective cells)

Requirements for new quality measure

(1) It can be used for
- measuring the quality of an individual QPF in a previously specified area integrated over short time periods (e.g. for model sensitivity experiments)
- statistical evaluation of model QPF performance

(2) It is close to a subjective visual judgment of the accuracy of a regional precipitation forecast
(3) It takes into account the "structure" of the precipitation field (which is regarded as a "fingerprint" of the meteorological phenomenon)

Definition of SAL (Structure - Amplitude - Location)

- 3 independent components, S, A and L
- considers QPF in pre-specified area (e.g. river catchment)
- definition of QPF objects via precipitation threshold Rc (taken as Rmax/15)

$$A = D(Rmod) - D(Robs) / 0.5*(D(Rmod) + D(Robs))$$

D(…) denotes the area mean precipitation in the catchment
→ A corresponds to the relative error of the area mean precipitation [-2 … 2]

$$L = |\mathbf{x}(Rmod) - \mathbf{x}(Robs)| / r$$

x(…) denotes the center of gravity of the precipitation distribution in the catchment, r the radius of a circle with the same area as the catchment
→ L corresponds to the displacement of the center of gravity [0 … about 2]

$$S = (V(Rmod^*) - V(Robs^*)) / v$$

V(…) denotes the averaged volume of all scaled precipitation objects in the catchment (see Fig. 1), v is a convenient scaling factor

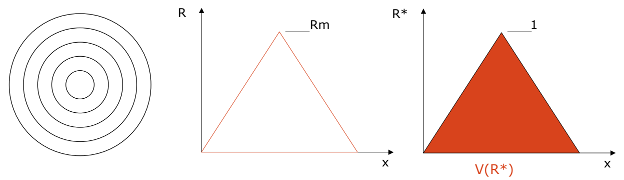

Fig. 1: Definition of the volume of a scaled precipitation object used for the calculation of the structure component S. Precipitation object (left), section across precipitation object with maximum value Rm (middle), section across scaled precipitation field R* = R/Rm and volume V(R*) (right).

Idealized examples

SAL distinguishes between large/small, weak/intense precipitation objects via the components S and A (see Fig. 2).

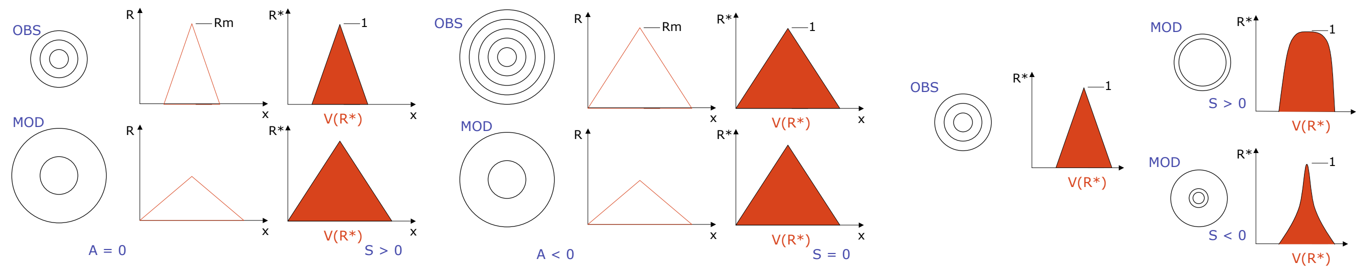

Fig. 2: Idealized examples that illustrate the concept of SAL
Left: in case of an observed small/intense and modeled large/weak objects, the amplitude might be correct (A = 0), but the the structure error is positive (S > 0)
Middle: in case of equally large observed intense and modeled weak objects, the amplitude error is positive (A > 0), but the structure error might be zero (S = 0)
Right: the volume definition used for the computation of S is sensitive to the shape of the precipitation objects (S > 0 for too flat and S < 0 for too peaked objects)

First implementation

SAL distinguishes between large/small, weak/intense precipitation objects via the components S and A (see Fig. 2).
Data sets: MOD: operational LM forecasts from DWD (7 km horizontal resolution) and ECMWF forecasts (T511 spectral resolution)
OBS: gridded data set based upon ~3000 German 24-h rain gauge measurements (presentation by Paulat et al.)
Time periods: DJF and JJA 2001-2003
Area: German part of Danube catchment (~ 400 x 200 km^2)

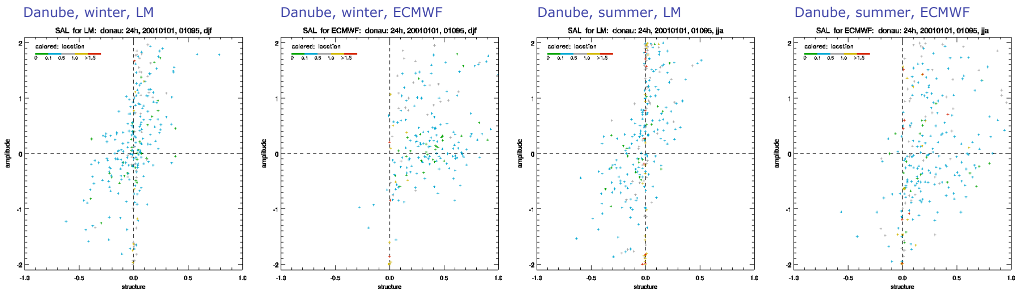

Fig. 3: SAL statistics (A vs. S and color for L) for the performance of the LM and ECMWF over the German part of the Danube catchment for winter (DJF) and summer (JJA). Typical results are:
- SAL provides a different picture of the QPF quality of the two models
- ECMWF: S > 0, A > 0 (winter only)
- LM: S closer to 0 than ECMWF, tendency for correlation with A (i.e. overestimation A > 0 goes along with too broad objects S > 0), A and L are larger in summer than winter

Caveats and preliminary conclusions

Caveats:
- "artifact cases": imperfect forecasts can yield S=A=L=0 !!
- not yet tested: how sensitive is SAL to resolution of OBS/MOD data sets?

Preliminary conclusions:
- SAL is fairly simple 3-component quality measure for high-resolution QPFs that captures the essence of precipitation fields in predefined areas (e.g. river catchments)
- SAL does not require object matching (which is difficult for small objects)
- implementation of SAL for LM from DWD (7 km hor. resolution), ECMWF (T511 spectral resolution) and gridded data set based upon ~3000 rain gauge stations reveals:
  (1) LM: a correlation between S and A (overestimation caused by too broad objects)
  (2) LM: seasonal variations with larger values for A and L during summer
  (3) ECMWF: S generally positive (too broad precipitation objects), A frequently positive during winter
  (4) ability of SAL to identify specific QPF qualities/deficiencies of models and their seasonal variation