1. Introduction:

The established impact diagnostic originally introduced by Langland and Baker (2004) have been further partitioned into two components related to different aspects of the observations and their use in the data assimilation (DA) system. Following largely Kahay et al. (2012), these components can be computed from the model error covariances in observation space which we estimate using the ensemble of our LETKF. This poster focuses on the first component (displayed below by the blue curves) which can be regarded as a cross-validation diagnostic, indicating the consistency between first guess departures (o-fg) of an observation type and those of the verifying data. Here we use observations for verification and restrict to the case of forecast time t=0 (impact on the analysis) which allows us to focus on issues related to the DA—rather than the forecast system.

2a. Partitioning EFSO type statistics in 2 components

a) Forecast Sensitivity to Observation Impact (FSOI) diagnostics are computed from a verification function \( J \) which reflects the impact of assimilated observations \( y_o \) on the fit to some verifying data \( y_v \). For this \( J \) is written as a sum over contributions \( J_{xy} \) which are linked to the individual observations \( y_o \).

b) In this work the terms \( J_{xy} \) are further partitioned into 2 components.

c) Varying against observations and using the diagonal R-matrix elements \( r_{xx} \) as metric, these components can be written in the form:

\[
\begin{align*}
J_{xy} &= \frac{1}{2} \left( \frac{w_{xy}}{w_{x}} \right) \left( \frac{y_v - y_o}{y_v - y_o} \right) \left( \frac{y_v - y_o}{y_v - y_o} \right) \left( \frac{y_v - y_o}{y_v - y_o} \right) \\
&= \frac{1}{2} \left( \frac{w_{xy}}{w_{x}} \right) \left( \frac{y_v - y_o}{y_v - y_o} \right) \\
&= \frac{1}{2} \left( \frac{w_{xy}}{w_{x}} \right) \left( \frac{y_v - y_o}{y_v - y_o} \right) \\
&= \frac{1}{2} \left( \frac{w_{xy}}{w_{x}} \right) \left( \frac{y_v - y_o}{y_v - y_o} \right)
\end{align*}
\]

2b. Interpretation of \( J \) and \( \alpha \)

i. Consider \( J_{xy} = \frac{1}{2} \left( \frac{w_{xy}}{w_{x}} \right) \left( \frac{y_v - y_o}{y_v - y_o} \right) \) which can be written as the sum

\[
J_{xy} = \frac{1}{2} \left( \frac{w_{xy}}{w_{x}} \right) \left( \frac{y_v - y_o}{y_v - y_o} \right) \\
\]

Note that \( J_{xy} > 0 \) to have to hold if analysis pullp model towards verifying data

\[
J_{xy} > 0 \quad Q: \text{ Are } \left( y_v - y_o \right) \text{ and } P_{\text{ens}} \text{ consistent?}
\]

ii. One can show that if either

- analysis increments \( \left( y_v - y_o \right) \) are optimal w.r.t. the verification function \( J \)
- \( \alpha \) covariances used in Kalman gain matrix are all correct

Then

\[
J_{xy} > 0 \quad Q: \text{ Do the ana increments contain obs info "optimally"?}
\]

3. Applied to local ("in situ") measurements (t=0)

Blue curves always:

a) determination of localization height "peel" (b) mostly similar magnitude as green curves

i.e., in situ measurements generally show good agreement between (o-fg) departures and ensemble covariances.

Unless for large separation distances, anas contains less obs-info than "optimized" (red lines clearly below blue lines).

EnVar anas contains substantially more optimal (not shown). Probable explanation: LETKF of global system is less able to capture small scale information than EnVar

4. Application to satellite radiances:

a) determination of localization height "peel"

The first trials to apply the method to satellite radiances emphasized the importance of a good peel level assignment.

3 Methods to compute peel (from the Jacobian \( \mathbf{H} \)) have been tested:

- centre of mass of \( \left| \mathbf{H} \right| \)
- take the maximum of \( |\mathbf{H}| \)
- take \( \mathbf{H} \) instead of \( \mathbf{H} \)

Here: Statistics are collected with vertical localization "switched off"

4b. Tropospheric Channels of AMSU A

AMSU A shows clearly beneficial impact (though less ideal than in situ obs)

Channel 5 : bias problems (obs-fg) bias opposite sign as for TEMPS or GPSRO (not shown)

Bias (particular model bias) strongly varies with:

- location (e.g. latitude),
- season,
- weather regime,
- other conditions.

5. Concluding Remarks

A new verification method has been introduced

- for checking the consistency of obs types (i.e., individual channel)
- under predefined conditions (latitude, height, etc.)
- which is very sensitive to impact of biases
- and directly related to an impact measure
- it divides established impact measure into parts related to different aspects of the data usage/quality
- most suitable for testing new methods / tuning parameters.

Interpreting statistics requires some experience / comparisons. Starting with in situ observations permitted:

i) testing of method
ii) Benchmark for more complex observations

Testing consistency of:

- (obs-fg) obs1
- (obs-fg) obs2

Further work: 1) t > 0

Check for ensemble covariances at different times. Involves impact of dynamics (balances, spin up/down)

Author: Olaf Stillier, Olaf.Stiller@dwd.de