Let there be N measurements *Mmeas*, with each measured point being approximated well by a fitted value *Mfi*t dependant on L fitting or/and input variables :

In the case of a small error in a measured input variable , the change in a fitted value of Mi can be approximated by a Taylor expansion:

As we always fit the model to the original fitted measurement values, and we assume a good fit:

and

such that

Thus, any error caused by is compensated by variations in the other fitted parameters :

For qMT, the measurement we are interested in as a possible source of error is B1, and the fitted parameters are F, kf, T2f and T2r (T1,f is omitted, it’s simply a function of T1,meas, F, and kf)

The sensitivity function is defined as:

Such that the previous equation can be writing compactly as:

From this equation, we can provide the following general observations:

1. The larger the sensitivity functions , the less variation (e.g. is required for (e.g.to compensate the error caused by (e.g.) .
2. The smaller the sensitivity function for the measurement (e.g. ) , the less overall compensation is required by all the (e.g..
3. will depend on the T1 mapping method (e.g , ), due to the B1 dependence of VFA and B1 independence of IR T1 maps.

For a set of N measurements (for our qMT protocols, N=10), this equation expands to:

Which can be written in matrix form:

where S is the matrix of sensitivity functions, is the vector of changes in fitted parameters, and is the vector of .

As the equation is an overdetermined set of linear equations of the form:

The optimal changes in parameters can be solved through the following minimization:

for different protocols, B1 mapping methods, etc. and can be calculated analytically (possible, but cumbersome to do so), or estimated through simulations.

From this analysis, and from my qMT B1-insensitivity measurements, we can make the following general predictions:

* for most measurements (if not all), since 0 and
* for most measurements (if not all) (most of the error is dumped into kf)
* since less is required for VFA and IR. (This one is less strong, since is smaller for IR and VFA, but for it’s the opposite. Possibly a more complicated relationship to the solution of minimization instead of this simple relation)