Interactive comment on “Technical note: Transit
time distributions are not L-shaped” by
Earl Bardsley

Anonymous Referee #3

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This technical note has one single subject; that the authors is dissatisfied with travel
time distributions which have a nonzero value at time t=0 (the moment of tracer applica-
tion). The authors seems to use a causality argument - travel velocities are finite, and
therefore not a single tracer particle could have reached the outlet in no time. However,
the travel time distributions, expressed as probability density functions, of Kirchner et
al. (2001) which he criticizes explicitly cover the case of spatially distributed tracers,
e.g. natural tracers in rainfall or a homogeneous sprinkler system. Thus, there are
tracer particles which are precisely at the outflow at t=0, which do not disperse, leading
to sharp peak, and others further away which do disperse and lead to long tails in the
distribution which is the central focus of the Kirchner et al. work. The author seems
to be uneasy with divergent pdf’s. They are rather common and not problematic as

long as the singularity is not too strong - more precisely, if the integral over any finite
time interval is always finite. In one dimension, this it the case when the singularity is
weaker than 1/t - e.g. the 1/t^{0.5} of eq. 11 in the Kirchner et al. article. The reviewer
cannot see that the printed equation (11) contains an error with brackets - there could
have been an extra pair of brackets around the argument of the second exponential,
but this is optional and does not change the equation. The current author uses units
where the mean travel time, \(\tau_0\), is set to 1 (why?), but then there is a factor 1/2 missing
in the definition of \(z_0\). This is an error, but since he does not develop that further, it is
overall not an important one. Unfortunately, the author does not provide a framework
to mitigate the "problem" of \(f(0) > 0\) (if this is a problem at all). Arbitrary changing
integration limits can’t do the trick. He also does not demonstrate (analytical or, if not
easily possible, numerically) that whenever \(A < x^*\) (line 24 on page 5), then \(f(0) = 0\).

The problems we have in evaluating and interpreting tracer studies are not here. One
has to tackle instationarities, differences in hydraulic conductivity, imperfect recovery
(e.g. detection limits at high dilution) etc., which is a can of worms in many cases.
Honorable approaches like the CXTFIT software are restricted to 1D, whereas Hydrus-
3D suffers from too many parameters. It is here where we should put our emphasis in
tracer hydrology; the "problem" discussed in this contribution is not significant and does
not lead to problems with causality or ill-definedness of the expressions obtained. The
primitive exponential distribution is for demonstration purposes only - like the harmonic
oscillator in physics - and is to be found in textbooks and reviews on tracer hydro-
logy, but the research field is far beyond this. For pointwise tracer injections away from
the stream / outlet with your detector, you will have \(f(0) = 0\), but this is not what is
discussed in Kirchner et al. (2001).