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## Reply on RC2

Mark Jessell et al.

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Author comment on "Automated geological map deconstruction for 3D model construction using *map2loop* 1.0 and *map2model* 1.0" by Mark Jessell et al., Geosci. Model Dev. Discuss., <https://doi.org/10.5194/gmd-2020-400-AC4>, 2021

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### Response to reviewer's comments RC2

We would like to thank the reviewer for their careful reading of the text and numerous suggestions, most of which we have incorporated into the manuscript. Specific responses are included below.

Line numbers after each comment refer to the line numbers of the new clean version of the manuscript.

### Stuart Clark Review

This article is in an important area for geology  building models of the subsurface quickly, using all or most available data and highlighting uncertainties. The paper is an important contribution in terms of the software that it is offering for the community and demonstrating this software with a series of datasets in a case study. However, the article suffers from a number of issues that mean that I would advise the authors reorganising the paper, running some additional benchmarking and documenting how efficient the code is as well as how it works in terms of datatypes and inputs and outputs. The paper would also benefit from a better review of the literature in places, especially the introduction and discussion. The comments below are as detailed as I could be to improve the paper and should not require a lot of additional scientific work, mainly rewriting and organising the text.

### General Comments

The article is poorly organised and confusing in its current state, mixing a several terms, data types, layer types, categories, inputs and outputs without clearly structuring their relationship. Parts of the writing leave a lot to be desired  there are a lot of unscientific terms and quite a lot of referencing missing. New paragraphs are not always given a line in between (or alternatively indented), making the article hard to read at points. The use of caplock text is annoying (e.g. heading 2.1, line 121)

The structure has been revised with additional tables and figures to make it clearer. As it was not clear that the caplock text was referring to specific data types, we have changed them all to capitalized forms. (Throughout text)

A development and technical paper "usually include[s] a significant amount of evaluation against standard benchmarks, observations, and/or other model output as appropriate." I would not consider the example dataset given a significant amount of evaluation □ other datasets such as NSW etc. are mentioned and it is also said that the time to build such models is very small ("The example map and associated data used in this paper took just over 3 minutes to deconstruct with map2loop and a further 4□15 minutes to build with the three target modelling engines, running on a standard laptop computer." □ lines 456□7) so I'm not sure why more examples are not given. In addition, the inclusion of a very imprecise single runtime should not be considered a benchmark. The architecture of the machine needs to be mentioned as well ("standard laptop" does not suffice).

As there are no other codes (to our knowledge) that undertake equivalent data extraction from maps, the concept of benchmarking seems odd, however we have added a comparison with the manual extraction of the same data. We have also specified the computer used for the calculations. (From Line 540)

I suggest that the examples of data given in 5,7,9 and 10 are actual results of the model run against a particular dataset rather than just examples of inputs/outputs. Therefore, I would split the results section as a case study and describe the model separately. Even better, the results from this dataset could be used as an example and several case studies used to show different run□times etc. for benchmarking the results and the difficulties/comparisons drawn between these models discussed.

We agree with this suggestion and separated the text into Method and Results sections. (New sections 4 & 5)

## Introduction

The introduction reads more like an abstract (and indeed is rather similar to most of the abstract) rather than a detailed review of the literature in this area. There are not enough papers cited and the introduction seems to define new concepts rather than base those concepts clearly on previous work. The second half of the introduction (Lines 75□104) reads more like it belongs in the methodology section.

Agreed, and this has been fixed. (From Line 28)

Line 53□54: "Unfortunately, away from basins and mines, drill□holes are often too shallow to provide constraints at the regional scale, and also often lack stratigraphic information." It would be great to specify in which context your proposed solution is targeted at and what other solutions for other regions would work (e.g. in basins). This might be in the introduction or in the discussion or both.

This has been added (Line 65)

Lines 52-62: This paragraph is difficult to read and no references are given as examples of the types of data or on alternative methods of validation mentioned, e.g. via gravity and magnetic data (line 62).

References have been added and the text clarified. (Line 110)

## Input Data

The introduction to this section does not let the reader know that the following 6 subsections correspond to the six input data types on Figure 1. The lack of consistency between headings of the subsections and the titles of the datatypes from Figure 1 makes this also difficult to understand. The text should additionally specify what constraints each of the input data types have - it mentions which datasets were used to derive them for this example but not what other similar datasets (e.g. are there easily available WAROX or ASUD equivalent databases in other parts of the world? If so give us some examples)

The text has been revised to clarify and or build upon these points (Line 142)

More details could be provided about how they were generated for this case (e.g. data type 5). Why are some of the polygons mentioned in input 1 missing from input 5 (e.g. Hardey Formation)?

Caption clarified that this is a subset of the full extract from the ASUD. (Figure 1 caption)

How is the operation coded and where is that handled? Is it a preprocessing step or is it included in the current code? If it is preprocessing, how is this calculated? (e.g. array sorting?).

Method is explained more clearly. (Line 205 onwards)

It is difficult for the reader to understand the difference between input data types and how they relate to the three categories of data mentioned in the introduction (position, gradient and topological) as well as how they map to the subsections in Section 2 on input data (e.g. 2.1 Chronostratigraphic layer)

This has been clarified by adding introductory text to each section.

Programming terms related to classes in the code (such as POLYGON) should be introduced in some form in the introduction and demarcated from the regular word polygon (which might suffice in any case because I think your programming classes are also regular shapes with 3 or more sides. Multipolygon/Polyline/Multipolyline could just be defined in the intro as well. Again, the headings of 2.2 seem to indicate layers contain a single type of shape (e.g. polyline) that is appropriate to a single datatype (e.g. a fault). It would be good to indicate in a table of some kind which types can be associated with which layers/datatypes etc.

Table 2 has been added to clarify geometric data types used by each feature.

## Augmented Data Outputs

Each of the subsections of this section are poorly written, full of jargon and hard to understand what is being discussed or why. For example "For regional geological models[,] a high resolution topography model is usually not needed" □ under what conditions is "usually" applied?

Clarified (Line 260)

The subsections miss introductory sentences that explain how this datatype fits into the broad categories of data outlined in the intro to section 3 (positional/gradient/topological) or why it exists and the intro to section three does not let us know why these particular datatypes exist either. This section also includes quite a bit on methodologies used to create the outputs □ so perhaps this could be a methodology section? Or a separate section on methodology and then a section on outputs showing how generated data could be outputted from the code. Also could be clearer which datatype corresponds to map2model / map2loop by organising them under those headings or mentioning this in the introduction (e.g. map2model can generate x,y,z while map2loop can generate x,a,b,c).

A new flow diagram explaining the overall program flow has been added (Figure 2) and introductions to each section have been added.

Lines 216□218: "This paper focuses on two libraries, map2model (C++), and map2loop (Python).

map2model performs a spatial and temporal topological analysis of the geological map, and map2loop further refines this analysis by including information from non□map sources, such as stratigraphic databases, acts as a wrapper for map2model and performs all other calculations."

I'm not sure if this belongs at the end of this section or was cut and paste from the introduction at some point. It seems out of place here and I'm not sure how it relates to either the preceding or following paragraphs.

Text has been edited and moved to correct location in introduction to input data section. (Line 240)

## 3D Modelling of map2loop outputs

Confusingly the title suggests that only map2loop should be included here, but line 439 immediately mentions map2model. This section is very brief and needs to be expanded or integrated into the discussion section or a results section created.

Section title have been changed, and sections restructured for clarity.

Line 447: "Of course the whole system relies on the quality of the input data" □ why "of course" and how is this handled?

Remind us of any quality checks and how the quality of the input data might affect results (or papers that show how this can be handled). Why is the integration of geophysics beyond the scope of the paper (see my comments in the introduction about basins □ this should be tightly linked here)?

Additional text added to clarify this point in the discussion

Immediately, it seems that DEM might be considered a geophysical dataset already and if certain shapes can be extracted from geophysical data (polygons/polylines) then why can't they be included?

Additional text added to discuss use of geophysics in this context.

## Discussion

This section reads like an uncertainty section. However, a lot of the discussion fails to discuss uncertainties very scientifically, with terms like "reasonably robust" (line 464) or "'reasonable' results" (line 469). The discussion fails to identify ways to handle the uncertainties in a well-defined way. Since there is "no unique solution" (line 470) and many choices are "arbitrary" (line 505), it seems impossible to quantify model errors or uncertainties. However, the workflow nature of the model generation and mapping of particular choices should make error estimation possible. I would have liked to have seen a more robust discussion of the literature in this regard.

A paragraph refereeing to previous uncertainty work in the 3D domain has been added to Section 6.3.

Section 5.3 mentions wrapping the workflow in a Bayesian network but it would be good to have this discussion linked back to the previous sections on different kinds/sources of uncertainty in the models and what the implications for these different kinds/sources are on the Bayesian framework.

The sensitivitiy analysis is mentioned to be essentially trivial (line 565), so why not

perform it for the current dataset?

This is an ongoing study by our group so will be treated in a separate paper.

## Conclusions

I'm not sure that all the conclusions are carefully based on the results of the paper. In particular:

It has not been proven (only claimed) that the model reduction is significantly reduced.

A comparison with manual data extraction has been added to the first part of the Discussion

Priors (a Bayesian concept) is first mentioned in the conclusion

The explicit mention of conceptual priors is added to the discussion in section 6.2.4

And see my remarks about uncertainty above, that this provides a homogeneous pathway to sensitivity analysis etc □ since these are only claimed to be in development.

This assertion is expanded upon in the first part of the discussion section.

## Minor Issues:

All minor issues have been fixed, except where noted

Line 52: New paragraph or not?

Line 56: In a 3D workflow; (, should replace ;)

Line 56□59: Difficult to understand what is meant here:

In a 3D workflow; spatial and temporal topological data, such as the age relationships between faults and stratigraphic units, we combine all of these direct observations with conceptual information, based on our understanding of the tectonic history of the region, including assumptions regarding the subsurface geometry of faults and plutons, to provide sufficient constraints to build a 3D geological model.

Lines 206□208: These are the same types as input data. Why not refer readers back to the definition of these types in the introduction.

These outputs are grouped by type: positional outputs, which provide information on the location and shape of features; gradient outputs, which provide information on the orientation of features; and, topological outputs that provide information on the spatial and temporal relationships between features.

Line 248 and Line 258: are essentially the same: "Processing of X geometries consists essentially of extracting the x,y location....".

We have left this as is as we believe it makes things clearer for the reader.

POLYGON vs polygon (etc.): An alternative is just to use "Polygon" after defining it. However, the word polygon with lower case could probably suffice in most cases. In some cases, the capslock is not used consistently, e.g. line 172 (POINTS) and 173 (point) or in heading 2.1 ("Chronostratigraphic POLYGON and MULTIPOLYGON layer") and Figure 1 ("1. chronostratigraphic polygons"). Consistency is a problem, e.g. Line 288: Is the series of x,y,z points □ are these POINTS or points? Also, for example, Figure 3 references POLYGONS etc. in caption by "polylines" in the figure insert.