

The Coupling Cloud: A community database of megathrust kinematic coupling models
Seismica tracking number: 2314
Oryan et al.

Editor assessment:

Based on reviews I have received, your manuscript may be suitable for publication after some revisions.

We thank the Editor Dr. Wenbin Xu for handling our manuscript and the two anonymous reviewers for their feedback. Our detailed responses are provided below in blue, with additions to the main text indicated in italics.

We would also like to note a few authorship and affiliation updates. Julie Elliott identified issues in her projected block model that warrant further work on a longer timeline than this revision and therefore requested at this point that her name be removed from the author list. In addition, Akemi Noda's affiliation has changed from the Japan Meteorological Agency to the National Institute of Advanced Industrial Science and Technology, Tsukuba, Japan. The group from Grenoble, France also requested minor revisions to their affiliation text. Both affiliation changes are highlighted in the revised manuscript.

Reviewer C:

This manuscript introduces the *Coupling Cloud*, a web-based platform designed to aggregate, standardize, visualize, and distribute published megathrust kinematic coupling models derived from geodetic observations. The platform compiles nearly one hundred models from more than fifty studies and provides standardized formats (NetCDF, VTU, YAML) together with interactive visualization tools. The development of a centralized repository for coupling models addresses a genuine need in the subduction-zone community. Coupling estimates are widely used but are currently distributed across publications and stored in heterogeneous formats, making comparison and reuse not easy. A standardized archive with consistent metadata and visualization tools could therefore be a valuable resource.

The manuscript is generally well written and the platform appears technically well implemented. However, several conceptual and technical issues should be clarified before publication. In particular, the manuscript should better address the comparability of heterogeneous coupling models and provide additional details about the standardization procedures. In addition, the submitted manuscript appears to contain an incomplete figure that prevents evaluation of part of the analysis. I recommend publication after moderate revision.

We appreciate the reviewer's constructive comments, in response, we have:

- Added a new paragraph addressing the comparability of heterogeneous coupling models (see lines 367-380).

- Provided more comprehensive details on the interpolation and standardization procedures in a new supplementary section “S1 - Interpolation to a uniform latitude-longitude grid” including a new supplementary Figure S1
- Included the correct version of Fig. 6 including both panels.

Our point by point detailed responses are provided below:

Major comments

1. Coupling models included in the database differ substantially in their underlying assumptions, including slab geometry, rheology (elastic vs viscoelastic), inversion methodology, regularization strategies, plate convergence models, and geodetic datasets. The manuscript acknowledges these differences but does not sufficiently discuss their implications for cross-model comparison. Because the Coupling Cloud aggregates models derived under different assumptions, coupling values from different studies may not represent directly comparable quantities. The manuscript should more clearly discuss the limitations of comparing heterogeneous coupling models and provide guidance on how users should use the metadata to identify models that are reasonably comparable.

Thank you for this comment, we agree. To address this point, and your third comment below, we added the following paragraph to the main text (lines 367-380):

“These methodological differences also reflect that the quantity referred to as “kinematic coupling” is not defined identically across all studies. For example, in regions experiencing slow-slip events, some studies estimate long-term interseismic coupling, whereas others estimate coupling only during intervals between slow-slip episodes (e.g. Maubant et al., 2023; Michel et al., 2025; Radiguet et al., 2016). In classical backslip formulations (Savage, 1983), coupling is inferred by relating surface deformation to slip deficit through elastic half-space dislocation models. In contrast, viscoelastic earthquake-cycle models infer coupling using forward models that account for time-dependent viscous deformation, which can yield different coupling distributions even for the same geodetic observations. Block-model approaches derive coupling by simultaneously estimating relative block motions and slip deficit on the megathrust interface. To document such differences, we compiled metadata for each model that can be viewed directly on the platform (Fig. 4) or downloaded as YAML files. Users should consult these metadata, particularly the model type, forward-model formulation, inversion framework and other metadata (Table 1), as well as the original publications, before interpreting or comparing models.”

2. To standardize datasets, coupling models are mapped onto a regular latitude–longitude grid when gridded outputs are not available. However, many coupling models are originally defined on irregular fault meshes or patch geometries.

Interpolation to a regular grid may alter spatial patterns or introduce artifacts. The manuscript should clarify: 1) the interpolation method used, 2) the spatial resolution of the standardized grid, 3) how irregular fault geometries are handled since only a triangulated surface will properly honor complex geometries, and 4) whether interpolation errors were assessed. Providing this information would help users understand how closely the standardized products represent the original models.

Thank you for raising these points. We have added a new supplementary section describing the procedures used to interpolate and standardize coupling datasets (new Text S1). We summarize the approach here:

(1) When coupling values are available only as scattered points, they are linearly interpolated onto a regular grid restricted to an alpha-shape boundary constructed from the original data points. This ensures that interpolation is limited to the region actually constrained by the respective published dataset. Linear interpolation is chosen to minimize the introduction of artificial spatial structure.

(2) The spatial resolution of the Coupling-Cloud grid is determined adaptively, whereby the grid is progressively refined until the relative difference between two successive interpolated fields falls below 0.5% (new Fig. S1).

(3) If only scattered coupling values are published, the original fault mesh geometry is typically not available, so only the gridded representation can be constructed. Therefore, interpolation errors relative to the original discretization cannot be evaluated directly. However, the interpolation naturally adapts to variations in the spacing of the original data points, which generally reflect the resolution of the original mesh and inversion.

(4) If coupling models are provided on triangular meshes, coupling values are interpolated onto grid points using triangular linear interpolation. In this case, interpolation is performed only for grid points located inside the published mesh. Comparison between the published mesh values and the standardized gridded representation indicates differences on the order of ~1% coupling (RMSE).

We have also added the following sentence to the main text to direct readers to this new supplementary material (lines 272-274):

“When gridded outputs are not provided, coupling fields are interpolated onto a regular grid with adaptively refined resolution using linear or triangular interpolation (Text S1, Fig. S1).”

3. Different studies estimate “coupling” using different conceptual frameworks, including classical backslip inversions, viscoelastic earthquake-cycle models, and block-model approaches. Although the database documents methodological information in metadata, the manuscript should more clearly emphasize that coupling values across studies may not represent strictly equivalent physical quantities. For example, in regions where slow slip events (SSEs) occur, coupling estimates may represent either long-term interseismic coupling or coupling inferred between SSE episodes. These different definitions can lead to significant differences in the inferred spatial distribution of coupling. A short discussion highlighting these conceptual differences would help prevent misinterpretation of the aggregated datasets.

Thank you for the comment. This point overlaps with your first comment, and we addressed it by adding a new paragraph to the main text clarifying that “kinematic coupling” is not defined identically across all studies, including differences between long-term interseismic coupling, coupling estimated between slow-slip episodes, classical backslip formulations, viscoelastic models, and block-model approaches. We also now state more clearly that users should consult the metadata and original publications before comparing models. Please see our response to your first comment for a full description of our revisions.

4. Figure 6 appears to be incomplete in the manuscript provided for review. The text describes two panels: (A) maps of the Cascadia coupling models and, (B) probability density function deviations used to compare along-strike segments. However, panel (B) is not present in the submitted figure. Because much of the interpretation of the Cascadia example relies on the PDF deviations shown in panel B, the absence of this panel prevents proper evaluation of the analysis and the conclusions drawn from it. The authors should include the missing panel and ensure that all figure components referenced in the text are present in the manuscript. The manuscript is also uploaded in the repository Eartharxiv and in that version is also missing panel B.

We sincerely apologize for this mistake. The omission of panel B in Figure 6 was an unfortunate submission error: we inadvertently uploaded a partial version of the figure rather than the complete composite figure. The revised manuscript now includes the full Figure 6 with both panels A and B. We have also corrected the EarthArXiv version.

Minor comments

- The manuscript should clarify the criteria used to select coupling models for inclusion in the database.

Thank you for this comment. We now clarify the selection criteria in the Data Selection section, stating that the Coupling Cloud includes all published coupling models for which datasets were available and that use geodetic observations to infer the spatial distribution of coupling along megathrusts.

New text has been added to illustrate this point (lines 246-247):

“These represent all published coupling models for which datasets were available and that use geodetic observations to infer the spatial distribution of coupling along subduction megathrusts.”

- Table 1 provides a useful set of recommended metadata fields, but additional parameters such as rake constraints or smoothing length scales could further improve reproducibility.

Good suggestion. We added smoothing length scales to Table 1 and note that the direction of rake is already defined under Kinematic constraints (renamed from “other kinematic constraints” to “kinematic constraints”).

- The performance benchmark could be complemented with more user-oriented metrics such as typical page load times or dataset sizes.

We thank the reviewer for this suggestion. We have added a brief description of typical page load times to the Performance section, noting that the initial page load transfers only a small amount of data, resulting in page load times of approximately ~1 second for up to about ten simultaneous users (lines 382-385). Regarding dataset sizes, the underlying NetCDF files used by CC are typically only a few megabytes and do not vary substantially between coupling models. In practice, TiTiler reshapes these datasets into standard web map tiles of fixed dimensions before serving them to the client, so the amount of data transferred per request is similar across datasets. While higher-resolution NetCDF files could in principle require more server-side processing during this step, we do not observe substantial performance differences between datasets with different resolutions. For brevity, this additional clarification is provided here but was not added to the manuscript text.

- Comparing two or more color-coded coupling maps for the same region can be difficult, particularly when subtle spatial differences are of interest. For the 2D viewer, it may be useful to include an option to overlay coupling contours, which could facilitate visual comparison between multiple models. For the 3D viewer, using a grayscale or shaded representation for the background topography–bathymetry could help reduce color saturation and make the coupling patterns easier to distinguish.

Thank you for this suggestion. We have added a grayscale colormap to the 3D viewer. Implementing coupling contour or additional shading requires further development and may be considered in future versions of the Coupling Cloud.

Recommendation: Revisions Required

Reviewer D:

This is an introduction to the community database of seismic coupling models for the world's subduction zones. The authors (contributors of models) made significant efforts to create a standardized database, that will be useful for subduction-zone studies and/or future seismic or tsunami forecast. My comments are not for the data base (Coupling Cloud) itself, but on this paper.

The paper is concise yet fully describes the database, including various parameters for the inversion of coupling that are compiled as metadata in the database. I only have two comments that can be considered for the final manuscript.

- The number of coupling models (95, 96 or 97) and publications (55 or 56) are different among Abstract (page 5), Data selection (page 7) and Conclusions (page 15).

We thank the reviewer for noting this inconsistency and apologize for the confusion. We have corrected the numbers across the Abstract, Data Selection, and Conclusions sections, and now consistently report 96 coupling models from 55 publications. We note that, as the Coupling Cloud continues to grow, the most up-to-date numbers are automatically updated in the "About" section of the platform.

- For the comparison of Cascaida models (Figure 6), it is not clear which is A and B (Figure 6B is missing?). In addition, color scalebar should be provided the coupling amount. Does "contours" in the caption refer to dashed blue lines? What are their depths? The caption refers to depth of 60 km, while the text says 20 km. Are the referring to different matters? Finally, the abstract says, "synthesizing eight full-margin models reveals along-strike patterns that are not apparent when models are examined

individually.” It is not clear to me what patterns (north, central and south?) the authors are referring to. It should be mentioned in the main text (Pages 12 and 13).

We inadvertently included an incorrect version of Figure 6 in the original submission, which did not include Panel B and was missing parts of the figure text and annotations. We apologize for this error. The revised manuscript now includes the complete Figure 6 with both panels A and B. The updated figure also corrects the color scale and contour information, including their associated depths, and resolves inconsistencies between the Figure and the text. The revised figure also explicitly shows the northern, central, and southern segments, which are defined and discussed in the main text (L. 432 “We define three commonly used along-strike subsections of the Cascadia margin...”), making the connection between the figure, main text, and abstract clearer and easier to follow.

Recommendation: Revisions Required