# IGRF-14: Call for Candidate Models

Date: 05-Mar-2024; Version: 1; Authors: Ciaran Beggan and Clemens Kloss

Dear modellers and evaluators,

Please consider contributing to the 14th generation International Geomagnetic Reference Field (IGRF-14). We seek candidate models for the following products:

*1) Internal field (main field) for 2025.0 to spherical harmonic (SH) degree and order 13.*

*2) Predicted average secular variation for 2025.0-2030.0 to SH degree and order 8*

*3) Internal field (main field) for 2020.0 to SH degree and order 13*

The requested numerical resolution of the coefficients is 0.01 nT for all products. This will allow calculation of the final models to a resolution of 0.1 nT for IGRF-2025 and SV-2025-2030 and 0.01 nT for DGRF-2020.

Each team that plans to submit candidate models is requested to provide a list of the products they intend to submit and a description of their methodology by 1st June 2024. Each team should also prepare a more extensive description of their product for the time of their submission, 1st October 2024, that will help with the evaluation of the IGRF candidate models. The intention is to finalise the models by late November and release them by mid-December.

Further details are given below. We thank you for your contributions.

Regards,

Ciaran Beggan (ciar@bgs.ac.uk) and Clemens Kloss (ancklo@space.dtu.dk)

## Deadlines

1st June 2024: Brief notice of intent to IGRF task force chairs (Ciaran Beggan, ciar@bgs.ac.uk and Clemens Kloss, ancklo@space.dtu.dk)

1st October 2024: Deadline for submission of candidate models and description of product and methodology

## Publication: EPS Special Issue

Earth Planets and Space has agreed to provide a special issue for IGRF-14 related publications. Note that Earth Planets and Space is an open access publication. For an example of papers from previous IGRF generations, see the IGRF-13 special edition: https://www.springeropen.com/collections/igrf13.

# Team Rules

For the sake of clarity, the following conventions have been adopted from previous generations of the IGRF.

## Definitions

· A *team* is a group of individuals from one or more institutions that will propose one or more candidate models

· A team is led by an individual, called the *team leader*

· An institution is said to lead a team if the team leader belongs to this institution

## Rules

· Each team can submit only one candidate model per product

· Every lead institution/consortium can have only one team per product

· An individual can lead only one team

In order to facilitate collaboration (for example sharing of pre-processed data), it is possible for an individual to be a member of several teams.

# Evaluation of Candidates

The candidate models will be assessed by the IGRF Task Force in co-operation with representatives from the teams submitting the candidate models.

· Any scientifically plausible method of testing/analysis/validation is acceptable.

· See: https://earth-planets-space.springeropen.com/articles/10.1186/s40623-020-01281-4 for a summary article on the evaluation of the previous IGRF-13 candidate models.

· A Github repository with Jupyter Python Notebooks will be set up to allow standardized code for initial checking of candidates against each other and the IGRF-13 model.

As an example, here is a repository that allows evaluation of the IGRF-13 candidate models: https://github.com/IAGA-VMOD/IGRF13eval

## Further Comments and Information:

1. The MAGNETIC REFERENCE RADIUS for the spherical harmonic expansion remains at 6371.2 km. This is an arbitrary reference radius and simply a convention.

2. We ask all modellers to submit models in the following format (6 columns):
# < institution>
# Candidate for <product>
# n m gnm hnm uncertainty_gnm uncertainty_hnm

- <Product> shall be one of the following: DGRF-2020, IGRF-2025, SV-2025-2030
- Here, *n* runs from 1 to 13 for DGRF/IGRF and 1 to 8 for SV, and *m* runs from 0 to n
- No additional header lines (3 lines only)
- The estimated uncertainty should, where possible, be a realistic estimate of the true uncertainty and not simply the formal error. A null entry (0) should be made if no uncertainty estimates are available.
- Precision should be 0.01 nT for all coefficients and uncertainties
- Any coefficients not set to this precision will be *truncated* to two decimal places before further processing

Example coefficient files are given in the IGRF-13 GitHub repository https://github.com/IAGA-VMOD/IGRF13eval (under /data/coefficients/)

3. Further information concerning the Division V working group V-MOD can be found on the web site of IAGA at: http://www.ngdc.noaa.gov/IAGA/vmod/index.html and at: https://www.ncei.noaa.gov/products/international-geomagnetic-reference-field

## Suggested additional information about candidate models

We ask all teams to provide additional accompanying information about their models. Here are some example questions which should be answered where appropriate:

· Which satellite, observatory and/or repeat station data sets were used?

· What were the data selection and rejection criteria?

· What weights were allocated to the different kinds of data?

· Was data weighted for equal spatial or temporal coverage?

· How was the forward extrapolation from October 2024 to 2025.0 carried out?

· How is the average secular variation from 2025.0 to 2030.0 predicted?

· If iterating using a least squares process, what starting model used and how many iterations were needed?

· If scalar data were used that required linearization of the inversion, what starting model used and how many iterations were needed?

· What, if any, regularization was used, e.g., use of an a-priori model with specified (co-variance, or addition of some quadratic penalty function to the sum square deviation?

· What, if any, sources were co-estimated and removed? Were any a-priori models or information used in the co-estimation (for instance mantle conductivity models in the estimation of induced magnetospheric and/or ionospheric fields)?

· What was the method used to solve the least squares equations?

· What was the fit to the data?

· Please give some indication of the uncertainties of the resulting set of coefficients and how these were inferred (e.g., (co-)variances, possible known biases, etc)

· If possible, provide an estimate of the uncertainties in the spatial domain.

## Submission of candidates

Documents describing the models can be sent by email to Ciaran Beggan and Clemens Kloss.

Candidates can be submitted to Ciaran Beggan and Clemens Kloss either **by email** or through the **IAGA-VMOD GitHub** repository.

For this generation of IGRF, we wish to allow new software tools to be used so have developed an open repository for evaluation and storage of the candidate models, allowing everyone to help evaluate or examine the models if desired.

The candidates can be submitted through forking, then pushing a branch to the GitHub IGRF-14 repository: https://github.com/IAGA-VMOD/IGRF14eval

The moderators will check the branch before merging into the main repo. Further instructions will be placed on the IGRF14eval repo before the submission deadline.