

Project: **1428**

Project title: **Joint inversion of gravimetric and electromagnetic satellite observations to infer global time series of oceanic volume transport (GREMLIN)**

Principal investigator: **Jan Saynisch-Wagner**

Report period: **2025-05-01 to 2026-04-30**

After working in the PhD Janina Schröder, we did set up the X3DG EM-solver from Kuvshinov (et al., 2009) and in parallel the solver from Kruglyakov (et al., 2019). Both run now on Levante and are used to calculate EM fields from an ensemble of oceanic reanalyses (ECCO, GLORYS, etc.). The results have been compared.

We did set up the MPIOM ocean model and included it into the workflow of the EM solvers to be able to calculate magnetic fields along the ocean model run.

We did set up the data assimilation framework PDAF (Nerger 2023), and coupled it to MPIOM and the EM solvers. The EM assimilation side is now technically running.

Currently, we restrict/refine the assimilation by using the ocean focussed “observability criteria” formulated by Finlay et al. 2024.

Next we aim to run full EM assimilations and step-wise include the GRACE assimilation schemes.

We published several articles, preprints, conference contributions and data sets:

Schroth, E., Forbriger, T., Westerhaus, M., Müller, M., Saynisch-Wagner, J., Arbic, B. K., Drach, K., Thomas, M., Gräwe, U., Shriver, J. F., Mehra, A. (2026): The annual variation of the M2 gravimetric tidal parameters investigated with nonlinear, time-stepping ocean models. - Journal of Geodesy, 100, 6. <https://doi.org/10.1007/s00190-025-02013-w>

Ciaran D Beggan, C Kloss, P Amblard, T Amezza, H Amit, J Aubert, J Baerenzung, J Bregnhøj Lauridsen, W Brown, S Califf, SA Campuzano, L Chauvet, A Chulliat, R Claveau, P Coisson, M Da Silva, C Davies, R Deborde, M Dobrovolsky, M Fillion, CC Finlay, I Firsov, A Fournier, L Gailler, N Gillet, N Gomez Perez, A Grayver, K Gwartz, M Hamoudi, R Holme, M Holschneider, G Hulot, T Jager, Y Jiang, M Kada, M Korte, R Krasnoperov, W Kuang, D Kudin, JM Leger, A Lemgharb, V Lesur, P Liu, PW Livermore, Frederik Dahl Madsen, M Mandeia, M Matsushima, J Matzka, I Michaelis, T Minami, M Nair, S Nakano, JF Oehler, N Olsen, FJ Pavon-Carrasco, S Prenyakov, B Qian, X Rang, HF Rogers, M Rother, D Rouxel, T Sabaka, S Sato, J Saynisch-Wagner, M Schanner, M Serrano, N Shakespeare-Rees, Y Shi, A Smith, A Soloviev, F Terra-Nova, E Thebault, L Toffner-Clausen, H Toh, J Wang, I Wardinski, C Watson, Kathy Whaler, C Xiong, Q Yan, Y Yang, H Yao, Z Zeren, K Zhang, B Zhou (2025): International geomagnetic reference field: the fourteenth generation, accepted, in Press, Earth, Planets and Space

Amblard, P.-O., Amezza, T., Amit, H., Aubert, J., Baerenzung, J., Brown, W., Califf, S., Campuzano, S. A., Chulliat, A., Claveau, R., Davies, C., Dobrovolsky, M., Finlay, C., Firsov, I., Fournier, A., Gailler, L., Gillet, N., Gomez Perez, N., Grayver, A., Gwartz, K., Hamoudi, M., Holme, R., Holschneider, M., Jiang, Y., Kada, M., Korte, M., Krasnoperov, R., Kuang, W., Kudin, D., Lauridsen, J. B., Lemgharbi, A., Lesur, V., Liu, P., Livermore, P., Madsen, F., Matsushima, M., Matzka, J., Michaelis, I., Minami, T., Nair, M., Nakano, S., Oehler, J.-F., Olsen, N., Pavón-Carrasco, F. J., Presnyakov, S., Qian, B., Rang, X., Rogers, H., Rother, M., Rouxel, D., Sabaka, T., Sato, S., Saynisch-Wagner, J., Schanner, M. A., Serrano, M., Shakespeare-Rees, N., da Silva, M. V., Soloviev, A., Terra-Nova, F., Thébault, E., Tøffner-Clausen, L., Toh, H., Wang, J., Wardinski, I., Watson, C., Whaler, K., Xiong, C., Yan, Q., Yang, Y., Yao, H., Zeren, Z., Zhang, K., Zhou, B. (2024): IGRF-14. <https://doi.org/10.5281/zenodo.14012303>

Beggan, C., Kloss, C., Amblard, P.-O., Amezza, T., Aubert, J. (., Baerenzung, J., Balasis, G., Brown, W., Califf, S., Campuzano, S. A., Chauvet, L., Chulliat, A., Claveau, R., Davies, C., Dobrovolsky, M., Fillion, M., Finlay, C., Firsov, I., Fournier, A., Gailler, L., Gillet, N., Gomez Perez,

N., Grayver, A., Gwirtz, K., Hamoudi, M., Holme, R., Holschneider, M., Hulot, G., Jiang, Y., Kada, M., Korte, M., Krasnoperov, R., Kuang, W., Kudin, D., Lauridsen, J. B., Lemgharbi, A., Lesur, V., Liu, P., Livermore, P., Madsen, F., Manda, M., Matsushima, M., Matzka, J., McCreadie, H., Michaelis, I., Minami, T., Nair, M., Nakano, S., Oehler, J.-F., Olsen, N., Pavón-Carrasco, F. J., Presnyakov, S., Qian, B., Rang, X., Rogers, H., Rother, M., Rouxel, D., Sabaka, T., Sato, S., Saynisch-Wagner, J., Schanner, M., Serrano, M., Shakespeare-Rees, N., da Silva, M. V., Smith, A., Soloviev, A., Terra-Nova, F., Thébault, E., Tøffner-Clausen, L., Toh, H., Wang, J., Wardinski, I., Watson, C., Whaler, K., Xiong, C., Yan, Q., Yang, Y., Yao, H., Zeren, Z., Zhang, K., Zhou, B. (2024): IGRF-14 Evaluation. <https://doi.org/10.5281/zenodo.14205635>

CHIAKI MITA, Takuto Minami, Jan Saynisch Wagner et al. (2025): Detecting tsunami-generated magnetic fields using machine learning, 17 July 2025, PREPRINT (Version 1) available at <https://doi.org/10.21203/rs.3.rs-6441319/v1>

J. Schröder, A. Hornschild, J. Saynisch-Wagner (2026): Satellite-Based Monitoring of Global Ocean Circulation: Assimilating Electromagnetic Signals, Ocean Sciences Meeting 2026, Glasgow, UK, Session: OT14C - Codesigning Synergistic Ocean Observing Systems for Impact: Addressing End User Needs in Ocean and Climate Monitoring and Prediction II Poster, Poster No. OT14C-1367. <https://agu.confex.com/agu/osm26/meetingapp.cgi/Paper/2038858>

A Hornschild, J Saynisch Wagner, J Baerenzung M. Thomas (2024): Kalman filter-based Rescaling of Ocean-induced Electromagnetic Signals by Assimilating Swarm Satellite Observations, AGU Fall Meeting 2024, held in Washington, D.C., 9-13 December 2024, Session: Geomagnetism, Paleomagnetism and Electromagnetism / Frontiers in Electromagnetic (EM) Geophysics II Oral, Poster No. 3564, id. GP14A-02. <https://ui.adsabs.harvard.edu/abs/2024AGUFMGP14A..02H/abstract>