## SIOG 231: Geomagnetism and Electromagnetism

Winter Quarter 2024, 9:30–10:50 am Tues/Thur in Munk 303. Instructors: Steven Constable and Catherine Constable sconstable@ucsd.edu; cconstable@ucsd.edu

SIOG 231 *Geomagnetism and Electromagnetism* will cover the theory of geomagnetism and electromagnetic induction, instrumentation, forward and inverse modeling of data, properties of Earth materials, and applications. Earth's magnetic field shields life, and even the atmosphere itself, from the solar wind, and is used by organisms from bacteria to birds for navigation (humans too). Observations of Earth's internal and external magnetic fields are used to understand how the core geodynamo works, and to image the electrical conductivity structure of the crust and mantle by means of the magnetotelluric method. The magnetotelluric method has become an important tool, often used alongside seismic methods, to study a variety of geological processes, and is used extensively on land and at sea both commercially and academically.

Topics to be covered are listed below. Students will be expected to complete homework assignments designed to develop hands-on skills in manipulating geomagnetic and electromagnetic data. Grading will be based on active class participation, homework, and a final project.

- 1. Introduction, motivation, history of the physics and geophysics, overview of the applications.
- 2. Vector calculus basics, Maxwell's equations, constitutive relationships, scalar and vector potentials.
- 3. Lorentz force, diffusion equations, skin depth.
- 4. Instruments, observatory networks, satellite observations.
- 5. Gauss' theory and the main field.
- 6. Spherical harmonic representation, internal/external separation, upward and downward continuation.
- 7. Geomagnetic power spectra, secular variation.
- 8. Earth's external geomagnetic and electromagnetic environment.
- 9. Geomagnetic depth sounding + Fitting data: Least squares, errors, parameter estimation.
- 10. Main field modeling, regularization.
- 11. Lithospheric fields, magnetic remanence, Runcorn's theorem.
- 12. Core processes and the internal field.
- 13. Geodynamos, toroidal and poloidal fields, frozen flux approximation.
- 14. The magnetotelluric method.
- 15. Electrical conductivity of rocks, minerals, and melts. The crust, mantle, and core.
- 16. Modeling induction in one dimension.
- 17. Forward modeling using finite differences and finite elements.
- 18. Inverse modeling MT and GDS data.
- 19. TBD
- 20. TBD