

University of Kasdi Merbah Ouargla

Faculty: **Hydrocarbons, Renewable Energies, Earth & Universe Sciences** ·

Department: **Earth & Universe Sciences**

Master 1 Applied Geophysics · Academic year 2026–2027 · Semester 1



Advanced Electrical Methods and Field Data Processing - M1 Syllabus

Course information

Item	Details
Programme	Master 1, Applied Geophysics
Semester	15 weeks (13 teaching weeks + 2 assessment weeks)
Weekly load	Lecture 1h30 · Practical (TP) 1h30
Total hours	45h
Coefficient	2
Teaching language	English
Instructor	Dr. Zoubida Nemer
Prerequisites	Bachelor-level electrical resistivity course (VES, profiling, 2D ERT)

Instructor

Item	Details
Name	Dr. Zoubida Nemer
Position	Associate Professor, University of Kasdi Merbah Ouargla
Research areas	Near-surface geophysics (ERT, EM, VES, GPR, microgravity, AMT, borehole logging); Saharan groundwater systems
Other roles	Visiting researcher, University of Bremen (TWAS Fellowship); IGRAC Groundwater Correspondent for Algeria; Chair, QGIS Algeria User Group
Email	Nemer.zoubida@univ-ouargla.dz
Office and office hours	Saturday to Monday
Questions	Moodle course forum (answered within 48 hours)

Course description

This course builds on the bachelor-level resistivity fundamentals in two directions: complementary electrical methods, and the processing of real field datasets. Students study induced polarization (time-domain and spectral), self-potential, mise-à-la-masse, and advanced ERT (3D, cross-hole, time-lapse).

For each method, the course covers the physical basis, acquisition design, and typical applications in hydrogeology, environmental monitoring, mineral exploration, and engineering. About half of the contact time is spent on real datasets: quality control, error estimation, inversion, model appraisal, and integrated interpretation with borehole and geological data.

Learning outcomes

By the end of the course, students will be able to:

1. Explain the physical principles of IP, SP, mise-à-la-masse and advanced ERT, and the rock properties each one senses.
2. Choose the method and survey design best suited to a given geological or engineering problem.
3. Import, inspect and clean raw field data, including outlier removal, reciprocal error analysis and topographic correction.
4. Run 2D, 3D and time-lapse inversions and justify the choice of regularisation and error model.
5. Assess model reliability using sensitivity, depth of investigation (DOI) and synthetic tests.
6. Integrate electrical models with borehole, geological and other geophysical data.
7. Report results in a clear, well-argued technical report.

Weekly schedule

The semester runs in four blocks: a refresher, complementary methods, advanced ERT, and integrated case studies.

Week	Lecture (1h30)	Practical – TP (1h30)
1	Course overview; review of resistivity theory, array sensitivity and 2D ERT	Software installation; loading and plotting a 2D ERT dataset
2	Data quality: noise sources, reciprocals, stacking, error models	Cleaning a real 2D dataset: outliers, bad electrodes, reciprocal error
3	Inversion theory: least squares, regularisation, L1 vs L2	Inverting the cleaned dataset; comparing damping and smoothness choices

Week	Lecture (1h30)	Practical – TP (1h30)
4	Model appraisal: sensitivity, DOI index, resolution	Synthetic tests: forward model, add noise, invert, compare
5	Induced polarization I: physics, chargeability, time-domain IP	Processing a real time-domain IP dataset
6	Induced polarization II: spectral IP, Cole-Cole model, applications	Joint resistivity–chargeability interpretation
7	Self-potential: sources (streaming, redox, thermoelectric), drift and reference corrections	Mapping and interpreting a real SP profile in QGIS
8	Mise-à-la-masse: principle, expected potential patterns, applications	Processing an MALM dataset
9	Midterm test	Mini-project assignment and group formation
10	3D ERT: survey design, electrode layouts, pseudo-3D vs true 3D	3D inversion of a real grid dataset
11	Borehole and cross-hole ERT: geometry and sensitivity	Processing a cross-hole dataset
12	Time-lapse (4D) ERT: difference, ratio and 4D inversion; monitoring applications	Time-lapse inversion of a monitoring dataset
13	Integrated interpretation and case studies (groundwater, salinity, mining, engineering)	Mini-project work session
14	Mini-project presentations	Mini-project presentations; final report submission
15	Final exam	—

Practical work and datasets

Every practical uses real field data, supplied as raw instrument exports so students handle the full chain from raw file to interpreted model.

- **Dataset sources:** field surveys from the department's own research projects, plus the example datasets distributed with ResIPy and pyGIMLi.

- **Field day (optional):** a half-day acquisition of a 2D ERT/IP profile near campus, used as the dataset for weeks 2–5 if weather and equipment allow.
- **Mini-project:** groups of 3–4 students receive one unprocessed dataset with a short geological brief. They clean, invert, appraise and interpret it, then submit a report (10–15 pages) and give a 15-minute presentation in week 14.
- **TP notebooks:** each practical ends with a short worksheet (figures + 3–5 questions) uploaded to Moodle within one week.

Software

All software used in the course is free and open source, so students can install it on their own computers and keep using it after the course.

Software	Use in the course	Download
ResIPy	2D/3D resistivity and IP processing and inversion (graphical interface)	gitlab.com/hkex/resipy
pyGIMLi	Scripted forward modelling, inversion, time-lapse and synthetic tests	pygimli.org/installation
QGIS	Mapping survey lines and SP data; integration with borehole and geological layers	qgis.org/download
Python	Data cleaning, error analysis, custom plots (NumPy, Matplotlib)	python.org/downloads
JupyterLab	Interactive notebooks for the TP worksheets	jupyter.org/install

Assessment

The final mark combines the end-of-semester exam (60%) with continuous assessment (40%).

Component	Weight	Timing
Final written exam	60%	Week 15
Mini-project (report +	20%	Week 14

Component	Weight	Timing
presentation)		
TP worksheets	10%	Weekly, weeks 1–13
Midterm test	10%	Week 9

Attendance at practical sessions is compulsory; unjustified absences follow the faculty's regulations.

References

Core textbooks

- Binley, A. & Slater, L. (2020). *Resistivity and Induced Polarization: Theory and Applications to the Near-Surface Earth*. Cambridge University Press.
- Reil, A. & Jardani, A. (2013). *The Self-Potential Method: Theory and Applications in Environmental Geosciences*. Cambridge University Press.
- Reynolds, J. M. (2011). *An Introduction to Applied and Environmental Geophysics* (2nd ed.). Wiley-Blackwell.

Further reading

- Everett, M. E. (2013). *Near-Surface Applied Geophysics*. Cambridge University Press.
- Telford, W. M., Geldart, L. P. & Sheriff, R. E. (1990). *Applied Geophysics* (2nd ed.). Cambridge University Press.
- Loke, M. H. *Tutorial: 2-D and 3-D Electrical Imaging Surveys*. Geotomo Software (latest revision).

Software papers

- Rücker, C., Günther, T. & Wagner, F. M. (2017). pyGIMLi: An open-source library for modelling and inversion in geophysics. *Computers & Geosciences*, 109, 106–123.
- Blanchy, G., Saneian, S., Boyd, J., McLachlan, P. & Binley, A. (2020). ResIPy, an intuitive open source software for complex geoelectrical inversion/modeling. *Computers & Geosciences*, 137, 104423.