

Igor Markelov

PhD Student in Ecohydrology Research Group
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RESEARCH INTERESTS

- Contaminant mobility (radionuclides, toxic chemicals) and organic matter degradation in redox-dynamic argillaceous and calcareous systems.
- Coupled biogeochemical cycles in redox gradient and energy-limited zones.
- Thermodynamics, bioenergetics, and microbial behaviour in energy limited environments.

SKILLS PROFILE

- Modeling of physical and biogeochemical process across media (e.g. a/biotic redox reactions, sorption, precipitation, dissolution, equilibrium phases) and scales (sediment, lake, aquifer, catchment).
- Knowledge transfer of fluid dynamics and advanced mathematics to describe biogeochemical observations from experimental to field scale studies.
- Programming skills using variety of scripting and compiled programming languages (e.g. MATLAB, Python, Ruby, C/C++, FORTRAN) using UNIX tools and version control systems (git, svn).
- Development of user-friendly reactive-transport models in MATLAB / Python / FORTRAN / C++ and coupling with geochemical code PhreeqC.
- Development of frameworks for calibration, statistical and sensitivity analysis for specific case studies (e.g., organic matter degradation, uranium sorption, redox transformations of toxic chemicals).
- Nuclear power plant (NPP) design including complete equipment and fuel cycle from production to decommissioning and conservation.
- Interpersonal skills: successful in self-education (completed more than 30 courses via Coursera and Edx); experienced in trouble-shooting within short deadlines; proven in problem-oriented management; initiative in multidisciplinary group projects.
- Communication skills: published one (plus three under review) scientific paper in peer-reviewed journal; gave invited talks in Norway and Japan.

EDUCATION

- 09.2015-present **Ph.D. Student**, Ecohydrology Research Group, University of Waterloo, Canada
PhD advisors: Dr. Philippe Van Cappellen (UWaterloo) and Dr. Raoul Couture (NIVA)
Thesis (flexible): “Long-term prediction of water quality in response to changes in climate, ice phenology, carbon and nutrients’ inputs using coupled water column-sediment model”.
Relevant courses: “iCP workshop”, “Reactive transport modeling”, “Biogeochemical cycles”, “Integrated water management”.
- 2005-2007 **Ms.Eng. in Nuclear Engineering**, Moscow Power Engineering Institute (TU), Russia
Thesis: “Design of passive emergency core cooling systems for Water-Water Energetic Reactor (VVER)” .
Relevant courses: “Nuclear power plant (NPP) decommissioning and radioactive waste treatment”, “Physical and chemical processes in NPP equipment”, “Checkout and maintenance of NPP equipment”, “Accident prevention at NPP”.
- 2001-2005 **B.Eng. in Technical Physics**, Moscow Power Engineering Institute (TU), Russia
Thesis: “Challenges associated with water level measurements in horizontal steam generator PGV-1000”.
Relevant courses: “Heat and mass transfer in NPP equipment”, “Computational fluid dynamics and mechanics”, “Mathematical methods for physics”, “Methods of solving engineering problems”, “Physics of nuclear reactors”, “Engineering thermodynamics”, “Engineering of construction materials”, “Mathematical statistics”, “NPP steam-generators”, “NPP turbines”.

ONLINE EDUCATION

- 09.2012 **On-line education platform Coursera**
- present Selected examples: “Advanced Chemistry” (Kentucky), “Statistical Mechanics: Algorithms and Computations” (École normale supérieure), “High Performance Scientific Computing” (Washington), “Algorithms: Design and Analysis” (Stanford), “Machine Learning” (Stanford), “C++ For C Programmers” (California), “Databases” (Michigan), “Analytic Combinatorics” (Princeton), “Cloud Computing” (Illinois), “Statistical Molecular Thermodynamics” (Minnesota), “Software Engineering for SaaS” (Berkeley).
- 09.2012 **On-line education platform Edx**
- present Selected examples: “Water and Climate” (Delft), “Principles of Biochemistry” (Harvard), “The Chemistry of Life” (Kyoto), “Artificial Intelligence” (Berkeley), “Statistics and R” (Harvard), “Agile Development Using Ruby on Rails” (Berkeley), “Distributed Machine Learning and Big Data analysis with Apache Spark” (Berkeley), “Statistical Thinking for Data Science and Analytics” (Columbia).

RESEARH EXPERIENCE

- 09.2015 – **Doctoral Researcher**, Ecohydrology Research Group, University of Waterloo, Canada
present
- Modelled physical (e.g. temperature, ice formation, light adsorption and attenuation), chemical (redox reactions, sorption, precipitation, dissolution, equilibrium), and biological (hydrolysis, organic matter degradation, microbial dynamics) processes in lakes and reservoirs.
 - Developed and coupled pelagic and benthic MATLAB models with mass conservation.
 - Developed kinetic reactive transport (advection, diffusion, non-local transport, chemical reactions) models in MATLAB and C++ coupled with equilibrium reactions in PhreeqC to predict C, N, P, O, Fe, S, and Mn cycling.
 - Designed new bioenergetics concept to model redox zonation with fewer user-defined parameters to overcome challenges associated with Monod's inhibiting terms.
- 08.2011 – **Internship Researcher**, Department of Computational Fluid Dynamics, Institute of
11.2011 Safety Research Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany
- Applied computational fluid dynamics codes (CFD) for multiphase flow.
 - Statistically analyzed data produced by developed in HZDR equipment to measure multiphase flow characteristics.
- 09.2006 - **Internship Researcher**, Department of the Reactor Physics in All-Russian Research
02.2007 Institute for NPP Operation, Moscow, Russia
- Designed a nuclear reactor and applied computational fluid dynamics (CFD) codes to test the design.
 - Designed core, fuel, and biological shield for the reactor.
 - Estimated heat transfer in and designed alloy material for the nuclear reactor.
- 01.2005 - **Internship Researcher**, Reactor unit “Water boiling reactor (VK) – 50”, JSC State
06.2005 Scientific Center – Research Institute of Atomic Reactors, Dimitrovgrad, Russia
- Designed a steam generator and estimated boiling flow dynamics using computational fluid dynamics (CFD) codes.
 - Investigated problems associated with water-level measurements techniques in the horizontal steam generator.
 - Estimated heat transfer and designed alloy material for the steam generator.

INDUSTRIAL AND RELATED WORKING EXPERIENCE

- 01.2015 - 09.2015 **Researcher**, Institute of Earth Science (ISTerre), Grenoble, France
- Wrote a code in Python to model, calibrate and perform statistical and sensitivity analysis of the multi-reaction sorption of U, As, Cr, and Sb in argillaceous and calcareous systems under oxic and anoxic conditions.
- 01.2014 - 09.2015 **Scientific programmer**, Norwegian Institute for Water Research (NIVA), Norway
- Wrote a code in MATLAB and C++ to model transport (advection, diffusion, non-local transport) and reaction cycles of C, N, S, Fe, and Mn in response to seasonal climate changes in water-column and sediment of lake Langtjern. Coupled both models at sediment-water interface with conservation of mass principle.
- 03.2013 - 09.2015 **Scientific programmer**, Ecohydrology Research Group, Canada
- Applied advanced mathematical (spectral methods and Fourier analysis) and statistical (principal component analysis with dimension reduction) methods for analysis of nutrient (C, N, P, and Si) distribution in aquatic environments.
 - Assisted ecohydrology group in developing and conducting computer simulations of complex ecosystems.
- 05.2013 - 09.2015 **Software Developer**, “Printchomp” start-up, Waterloo, Canada
- Designed, built and deployed scalable and highly available systems using Ruby On Rails, CSS, JavaScript, AJAX and PostgreSQL.
 - Applied scrum agile methodology.
 - Performed data analysis/mining using large relational databases.
 - Fixed and tested errors (bugs) in application using RSpec.
- 03.2007 – 08.2011 **Engineer**, Department of the reactor systems, JSC «Atomenergoproekt», Russia
- Designed reactor emergency core cooling (high/low pressure coolant injection, isolation cooling) and containment (core catching) systems for NPP Kudankulam, Belene and Novovoronezh-2.

PUBLICATIONS: Peer-reviewed journals

Couture, R.-M., de Wit H. A., Tominaga K., Kiuru P., and **Markelov I. (2015)**, Oxygen dynamics in a boreal lake responds to long-term changes in climate, ice phenology, and DOC inputs, *J. Geophys. Res. Biogeosci.*, 120, 2441–2456, doi:10.1002/2015JG003065.

Géhin A, **Markelov I**, Crancon P, And Charlet L. Thermodynamic and kinetic properties of U(VI) sorption on chalk substrates (in review).

Markelova E., Couture R-M, Parsons C.T., **Markelov I.**, Made B, Van Cappellen P., Charlet L. Contaminant (As, Sb, and Cr) and nutrient (NO₃⁻) mobility in argillaceous suspensions under redox-oscillating conditions (in review).

Markelova E., Couture R-M, Parsons C.T., **Markelov I.**, Made B, Van Cappellen P., Charlet L. Contrasting As, Sb, and Cr mobility in topsoil and subsoil: influence of Fe- and Mn-oxyhydroxide minerals (in review).

PUBLICATIONS: Peer-reviewed abstracts - International Conferences

Markelov I, Van Cappellen P & Couture R-M (2016). Predicting Lake Anoxia Using a Coupled Water Column-Sediment Diagenesis Model. Goldschmidt conference (Yokohama, Japan)

Géhin A, **Markelov I**, Crancon P & Charlet L. (2016) Thermodynamic and Kinetic Properties of U(VI) Sorption on Chalk Substrates. Goldschmidt conference (Yokohama, Japan)

Markelova E, Couture R-M, Parsons C, **Markelov I**, Made B, Van Cappellen P & Charlet L. (2016) Interplay between As, Sb, Cr and N in Argillaceous Suspensions Under Redox Oscillating Conditions. Goldschmidt conference (Yokohama, Japan)

Markelov I and Van Cappellen P. (2016) Microbial Competition during Organic Matter Decomposition. World Wetlands Day Symposium (Waterloo, Canada)

Markelova E, Couture R-M, Parsons C T, **Markelov I**, Van Cappellen P, Benoit Madé, Laurent Charlet (2015) The contrasting redox behaviour of antimony and arsenic in soil and argillaceous environments. Third International Workshop on Antimony in the Environment (Leipzig, Germany)

Markelov I and Van Cappellen P (2015) Modeling the Sequence of Oxidant and Reductant Utilization during Organic Matter Decomposition. Goldschmidt conference (Prague, Czech Republic)

Couture R-M, De Wit H, Tominaga K, Kiuru P, **Markelov I** (2015) Modelling the impact of increasing dissolved organic carbon load on seasonal anoxia in a boreal humic lake. 2015 Joint Assembly AGU-GAC-MAC-CGU (Montréal, Canada)

Couture R-M, **Markelov I**, Van Cappellen P, Wright RF, Kaste Ø (2014) Modeling the biogeochemical response of lakes to catchment-scale changes in nutrient dynamics: the case of sulfur-controlled eutrophication. Am. Chem. Soc 247th National Meeting and Exposition (Dallas, USA)

Couture R-M, Shafei B, **Markelov I**, Tominaga K, Starrfelt J, and Kaste Ø. (2013) Linking the benthic cycling of P to its surface water dynamics in lakes. IPW7 International Phosphorus Workshop (Uppsala, Sweden)

LANGUAGES

Russian – mother tongue (level C2)

English – fluent scientific writing and speaking (level C2)

French – basic (level A1)

REFERENCES

- (1) **Dr. Philippe Van Cappellen**, PhD advisor, Ecohydrology Research Group, Waterloo, Canada.
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- (2) **Dr. Raoul-Marie Couture**, PhD advisor, Norwegian Institute for Water Research, Oslo, Norway.
Email: raoul.couture@niva.no; Tel: +47-982-86478
- (3) **Dr. Laurent Charlet**, Employer, ISTerre, University of Université Grenoble Alpes and CNRS, Grenoble, France. Email: charlet38@gmail.com; Tel: +33(0)675-878266