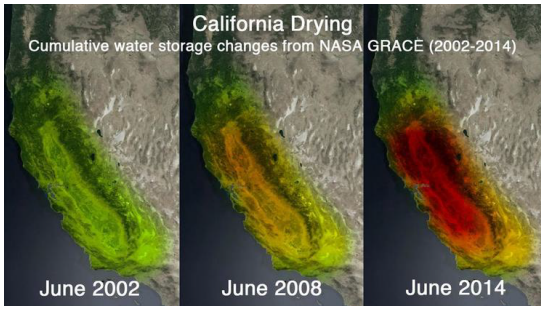
Interactions of Groundwater with Climate & Humans

Extended Title: **GW responses to climate variability and human influences: Theory & Methods**

Syllabus, Spring 2017

SES 494/598, GPH 494/598

Course dates:	Tuesday/Thursday, 10:30-11:45
Location:	STAUF A 241
Professor:	Susanna Werth
Office:	Coor Hall, Room #5647
Office Hours:	Thursday, 11:45-12:45 pm, Location: TBA
E-mail:	swerth@asu.edu
Web:	hydrogeodesylab.asu.edu/teaching_GW.html



Courses Description

As the world's largest distributed store of fresh water, ground water plays a central part in sustaining ecosystems and enabling human adaptation to climate variability and change. The strategic importance of ground water for global water and food security will probably intensify under climate change as more frequent and intense climate extremes (droughts and floods) increase variability in precipitation, soil moisture and surface water. In this course, we review observational and analytic methods available to assess the impacts of climate on ground water through natural and human-induced processes as well as through groundwater-driven feedbacks on the climate system. The interdependent system changes will be analyzed on three levels:

- Influence of climate on groundwater systems
- Human and indirect climate impacts on groundwater systems
- Groundwater impacts on the climate system

For observational methods, a focus will lie on remote sensing techniques. Furthermore, we examine the possible opportunities and challenges of using and sustaining groundwater resources in climate adaptation strategies. And finally, we will discuss global science and policy related to transboundary groundwater aquifers.

Topics of the class will be: Groundwater, Hydrological Cycle, Climate Change, Water resources and drought monitoring, Remote sensing of Groundwater, Groundwater Modeling, Sustainable Water Use, Groundwater Policies. The class will be presented as a combination of lectures and seminars and exercises. About 20% of the courses will consist of Matlab-based exercises on analysis of different remote sensing data and groundwater modeling.

Courses Goal

By the end of this course, students will have an overview of the global distribution and state of groundwater resources around the word. Students will learn about relevant factors of climate variability and change and how they impact groundwater resources. A separate consideration of indirect climate and human impacts on groundwater will provide knowledge about further possible causes of changes in groundwater processes or stocks. Ideas of sustainable groundwater management and policy will be discussed. All topics will be approached through theoretical knowledge as well as through case studies around the globe.

Finally, students will be introduced to tools that allow quantification and understanding of interactions between climate, human and groundwater. These tools are 1) up-to-date remote sensing techniques that facilitate the observation of groundwater from space, as well as 2) groundwater modeling that allow improved process understanding and prediction. During practical computer-based exercises students will get their hands on remotely sensed data to study groundwater processes and interactions with climate and human. Students will also acquire skills of how to make such data useful for groundwater modeling and with that deepen their understanding of the material.

Courses Requirements

Students are expected to have a basic knowledge of Mathematics, Physics, Earth Science and reasonable computer literacy. Knowledge of programming and Matlab is very advantageous.

Course Format

This course meets twice weekly for 75 minutes on Tuesdays and Thursdays. During most weeks, classes on Tuesday will consist of lectures about theoretical knowledge or of discussions of case studies. Literature on case studies will be provided one week in advance. Thursday's classes will be a combination of revision of theoretical material, problem-solving exercises, learning through science in the media or of further case studies. Four weeks will focus on computer-based exercises to practice the gained knowledge with real data. A term paper summarizing a scientific article has to be prepared. The article will be provided during the first class. Students are expected to come to class having done the readings and prepared to participate in discussions and in-class exercises. I strongly encourage people to work together on problems and projects but each student is ultimately responsible for their own work and their own grade.

Weekly Topics (subject to change)

Week	Date	Topic
1	1/10,12	Courses information, groundwater around the world
2	1/17,19	Basics of groundwater science (GW)
3	1/24,26	Basics of climate variability and change
4	1/31, 2/2	Interactions of groundwater with climate
5	2/7,9	Indirect climate and human impact, management & policies
6	2/14,16	Guest lecture: Detecting GW changes via surface deformation: InSAR
7	2/21,23	Measuring GW from space via gravity field: Satellite Gravimetry
8	2/28 **3/2**	Case study: Groundwater stress evaluation from space **Midterm Exam**: 10:30-11:30, STAUFF A241
9	3/14,16	Computer Exercises: GRACE data analysis
10	3/21,23	Computer Exercises: InSAR data analysis
11	3/28,30	Case study: Monitoring of groundwater resources around the world
12	4/4,6	Case study: Interaction of GW with climate
13	4/11,13	Case study: Interaction with human, management
14	4/18,20	Computer Exercises: Study GW interactions through GW modeling
15	4/25,27	Computer Exercises: Approaching integration of RS data into modeling
16	**5/2**	**Final Exam**: 9:50-11:40, STAUFF A241

Major References (not required to buy, available in library or online)

Anderson, M. P., W. W. Woessner, and R. J. Hunt (2015), *Applied Groundwater Modeling - Simulation of Flow and Advective Transport*, 2nd ed., Elsevier, London.

Chech, T. V. (2005), *Principles of water resources: history, development, management, and policy*, Wiley.

Fares, A. (Ed.) (2016), *Emerging Issues in Groundwater Resources*, Springer International Publishing.

Fitts, C. R. (2013), *Groundwater Science*, 2nd ed., Elsevier Academic Press.

Foster, S., and D. P. Loucks (Eds.) (2006), Non-Renewable Groundwater Resources: A guidebook on socially-sustainable management for water-policy makers, UNESCO.

Herring, T. (Ed.) (2015), *Treatise on Geophysics: Volume 3 (Geodesy), Ch. 1&8*, 2nd ed., Elsevier, Amsterdam.

Ilk, K. H. et al. (2005), *Mass Transport and Mass Distribution in the Earth System*, GeoForschungsZentrum Potsdam, online available at: http://www.iapg.bgu.tum.de/mediadb/21768/21769/programmschrift-Ed2.pdf.

Margat, J., and J. van der Gun (2013), *Groundwater around the world: a geographic synopsis*, CRC Press.

Treidel, H., J. L. Martin-Bordes, and J. J. Gurdak (Eds.) (2012), *Climate Change Effects on Groundwater Resources - A global Synthesis of Findings and Recommendations*, CRC Press.

Wright, R. T., D. F. Boorse, and G. College (2017), *Environmental Science: Toward a sustainable future*, 13th ed., Pearson.

Grading

Grades will base upon: attendance and engagement (20%), performance during exercises (20%), writing of a term paper (20%), a midterm exam (20%) and a final exam (20%).

Absence Policy

Attendance and participation are a critical component of this course. If you must miss a class, please let the instructor know in advance. Discussions cannot be made up and it is the students' responsibility to be familiar with the material they miss. Absences due to religious practice or university-sanctioned activities should be discussed with the instructor in advance.

Academic Integrity Policy

Academic honesty is expected of all students in all examinations, papers, laboratory work, academic transactions and records. The possible sanctions include, but are not limited to, appropriate grade penalties, course failure (indicated on the transcript as a grade of E), course failure due to academic dishonesty (indicated on the transcript as a grade of XE), loss of registration privileges, disqualification and dismissal. For more information, see http://provost.asu.edu/academicintegrity.

Cellular phones and pagers should be turned off during the class.

Disability Accommodations

Qualified students with disabilities who will require disability accommodations in this class are encouraged to make their requests to me at the beginning of the semester either during office hours or by appointment. Note: Prior to receiving disability accommodations, verification of eligibility from the Disability Resource Center (DRC) is required. Disability information is confidential.

The information in this syllabus, other than grade and absence policies, may be subject to change with reasonable advance notice.