American Institute of Hydrology
Bulletin
The Society for Certification of Hydrology Professionals

Volume 32 Issue 1 (Spring)

April 8, 2016

AIH is here to serve the profession and the members

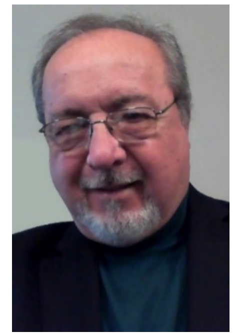
• AIH is the only organization that certifies professionals in the fields of surface water and groundwater hydrology, and water quality both nationally and internationally.

• AIH provides educational training venues to the professionals in the field of hydrologic sciences.

• AIH speaks to lawmakers on behalf of you and the profession as an advocacy

Inside This Issue

Message from the President



Dear AIH Members:
The first few months of 2016 has passed with the election of new members to the AIH Executive Committee (EC). I would like to welcome the following new members to the Executive Committee and thank to those who took the time to register their vote. The outcome was unanimous approval of all candidates.

Treasurer: **Gregory Bevenger**
Vice President for International Affairs: **Zhuping Sheng**
Vice President for Institute Development: **Jamil S. Ibrahim**
Vice President for Communications: **Rahul Ranade**

I also would like to thank to our departing EC members for their dedicated service to AIH during their term.

Looking ahead to the rest of 2016, as our first activity will focus on the development of AIH sponsored Short Courses, Field Courses and Webinars organized by AIH members. We will use the AIH mailing list to share the programs on activities with you. These educational material not only will satisfy the Continuing Education requirements of our members, but also they will help our members refresh their memories on interesting topics such as Hydrology, Geohydrology, Watershed Hydrology, Climate Change, Surface Water and Groundwater, Well Hydraulics, Sediment Transport and Contaminant Transport topics. We are hoping that we will be able to provide these webinars **free of charge** to our members and with nominal fees to outside professionals.

Our Executive Committee is working on these procedures to standardize the presentation of these material on our web portal and the fee structure. Please consider this as an open invitation to our members and let us know if you would like to participate and contribute to this activity. The details of this process will be outlined on the document "**Invitation to Submit Qualifications and Proposals to Conduct Technical Seminars, Short Courses and Webinars in the Field of Hydrology and Hydrologic Engineering for AIH Web Based Education**." This document will be ready for downloading from the AIH web site shortly. The main reason for us to try to make these webinars free to our members is because AIH's main aim is to provide service to our members. (…continued)

Message from the President (...continued from Page 1)

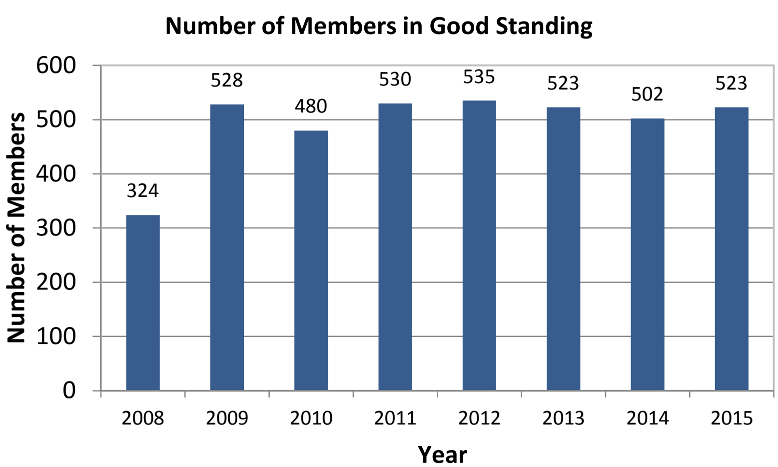
We are hoping that you will pass the word among your colleagues for them to benefit from this service by becoming a member of the AIH community. In that sense we are looking at this activity as a win-win effort for both AIH and also our members. As I have indicated earlier, through these activities our goal is to make AIH a valuable organization to join. We at AIH are open to your suggestions and recommendations and we seek your support. Please do not hesitate to contact our Executive Director or me (directly) to share your ideas and recommendations. I would like to take this opportunity to thank all of you for your contributions in advance and wish our membership a productive year.

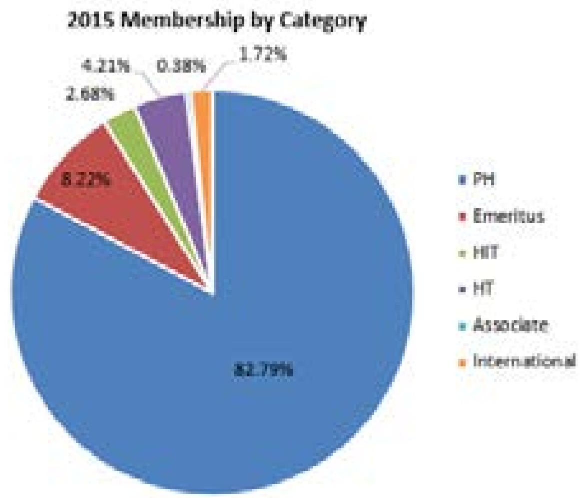
My best regards.

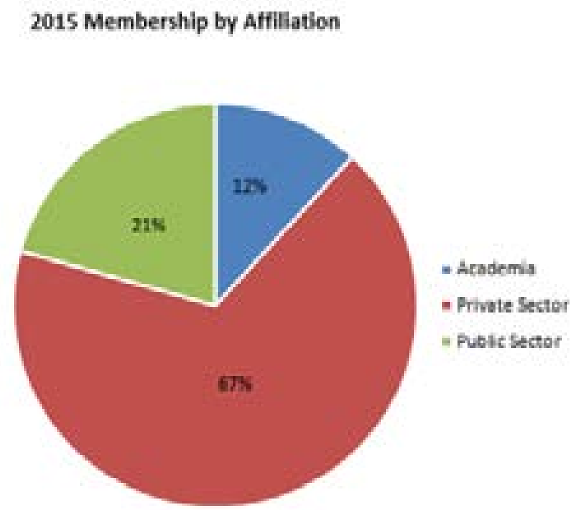
Mustafa M. Aral
President AIH
maral@ce.gatech.edu
March 8, 2016

From the Executive Director's Desk

From your headquarters at SIU Carbondale, it is a great honor for me to write this note for the Spring 2016 Bulletin. In this issue I would like to report the status of membership until the end of 2015. The first chart shows the change in number of the total members in good standing since 2008. At the end of 2015, there are 523 members in good standing.
During 2015 we welcomed 17 new Hydrologist, 3 Hydrologic Technicians and 1 Hydrologist in Training. The composition of 523 members and statistics about the distribution of the membership according to their affiliation is shown in figures below.







Within the first quarter of 2016, we have welcomed two more member Hydrologists.

Name	Certification	City	State
Coe, Matthew A.	16-H-8001	Oklahoma City	OK
Sahoo, Debabrata	16-HWQ-8001	Columbia	SC

As of March 31, 2016, 321 members (61% of the total number of members) have already paid their 2016 dues, of which 218 did it using the AIH website.

You may have also noticed that we continue including some articles from our members in our Bulletin. Please continue sending the material you would like to publish in our future Newsletters. The articles should be related to our hydrological practice and not already published elsewhere. Please try to keep it short and informative, appropriate for a Bulletin. An extended abstract with no more of three pages is suggested. All prospective articles will be reviewed by our VP for Publications. If there is not enough room for all the articles submitted, we will publish them in the following issues. Moreover, in our Bulletin we would like to include some news that you may want to share with the AIH members. You are cordially invited to do so. The news should be related to promotions, moving, new hiring, new grants or contracts, presentations on professional topics, etc.
It is very important to maintain our records updated. Please send an email to your headquarters if you are changing your affiliation and/or your contact information. Maintaining our communication is paramount.
Any requests or suggestions to improve our services will be greatly appreciated.

Respectfully,
Rolando Bravo

Technical Paper

Where Does Free Convection (Buoyancy And Density Driven) Flow Occur?

By K. Udo Weyer and James C. Ellis, WDA Consultants Inc. (Corresponding author: weyer@wda-consultants.com)

Summary

Close physical analysis of free convection and the associated vertical buoyancy and density forces shows that they do not exist in a natural continental subsurface environment. All density and buoyancy derived forces need to be included by modifying the length of the pressure potential forces of fresh water force fields regardless if fresh water is present at that position. As a consequence, adjustments should be made in dealing with the migration of hydrocarbons and CO_2 as well as in regard to our understanding of present day and past geological processes as for example dolomitization. The chemical and hydrodynamic pattern at the Abu Dhabi sabkhas are determined by groundwater flow systems, not by free convection.

Introduction

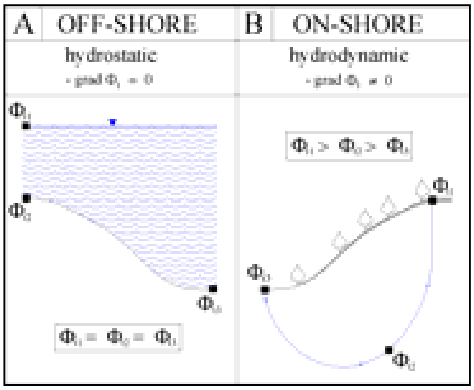
In northeastern Alberta, free convection has been postulated by Bachu et al. (1993) and Bachu and Underschultz (1993) disguised as buoyancy-driven downdip flow in deep aquifers opposing gravitationally-driven updip flow within groundwater flow systems. This postulate is based on the assumption that the buoyancy of heavier fluids is directed vertically downward and then obliquely reflected downdip within the bottom part of dipping aquifers on top of underlying aquitards. At first glance this concept seems to be reasonable and could thereby be handily applied to determine the fate of saline water as subject to downdip flow directions, while lighter fluids such as hydrocarbons or sequestered CO_2 would be subject to buoyancy-driven updip flow moving along the upper parts of aquifers underneath an overlying aquitard.

Theory

Buoyancy-driven downdip flow of saline water and updip flow of lighter material exists under hydrostatic conditions in resting water bodies as represented by the conditions A in Figures 1, 2, and 3. In these water bodies, gravitational force vectors g and the pressure potential forces vector $-(1/\rho)$ grad p have the same magnitude but opposite directions (Figure 2A). Hence no gravitationally-driven flow occurs. The calculation of pressure potential forces for fluids with lower densities than the host fluid increases the pressure potential force for the lighter fluid and, as a consequence the resultant force is directed vertically upwards and the lighter material moves accordingly. The calculation of pressure potential forces for fluids heavier than the host fluid leads to a pressure potential vector smaller than g and thus the heavier fluid moves vertically downwards.

While gravitationally-driven flow does not exist under hydrostatic off-shore subsurface conditions, it exists under the hydrodynamic on-shore conditions B shown in Figures 1, 2, and 3. The host fluid is not at rest but flows driven by unbalanced gravitational and pressure potential force fields.These force fields are created in response to the upper boundary conditions of the fresh groundwater body, the groundwater table. All other fluids are subject to the fresh water pressure potential force field (Hubbert, 1940, 1953).

All density-related modifications of pressure potential forces are calculated along and in the direction of the fresh water pressure potential vector. Vectorial addition then follows the procedures outlined in Figure 4.



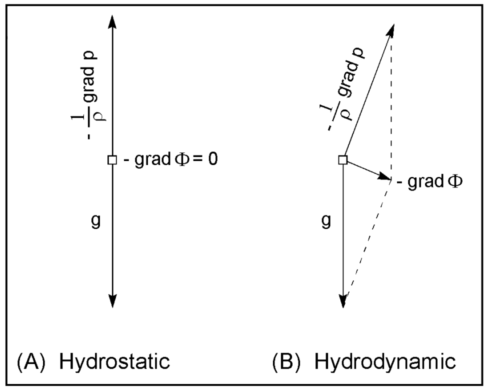
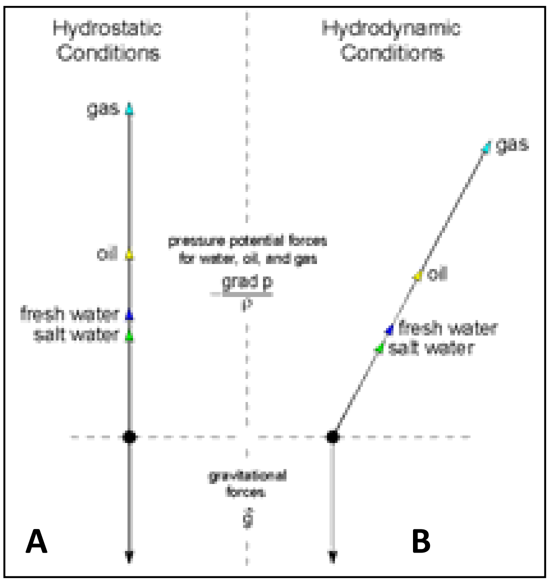


Figure 1 (left): Comparison of hydrostatic and hydrodynamic conditions in subsurface fluid flow (from Weyer, 2010. [Φ: hydraulic potential; grad Φ: hydraulic force]

Figure 2 (right): Hydrostatic forces versus hydrodynamic forces (after Hubbert, 1953).



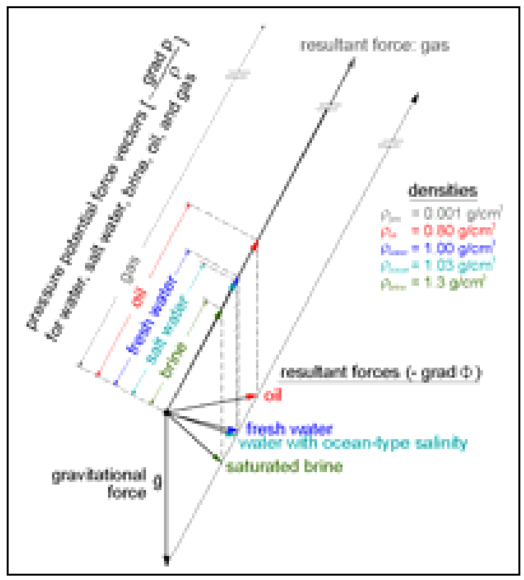


Figure 3 (left): Comparison of forces under hydrostatic and hydrodynamic conditions (from Weyer, 2010).

Figure 4 (right): Resultant calculation of flow directions for fluids of different density within the fresh water force field. From Weyer (2010).

The resultant calculation leads to different flow directions for the various fluids of differing density (compare Figure 4). Thus ocean-type salt water (ρ = 1.03 g/cm3) has nearly the same flow direction as fresh water, saturated brine (ρ = 1.3 g/cm3) flows under the depicted situation downward in an oblique direction, whilst oil and CO_2 (density ρ = 0.8 g/cm3) would flow upwards in an oblique direction.

It is important to point out that hydrostatic conditions, the conditions of no flow, are a special case of hydrodynamic conditions. Under both conditions the density modification is calculated along the direction of the pressure potential force. In nature, hydrostatic conditions prevail under oceans (Figure 1A), hydrodynamic conditions in the subsurface of landmasses (Figure 1B).

Free Convection

Bear (1972, p. 642) defined convection as follows: “Convection imposed by internal means is known as forced convection, while fluid motion caused by density differences due to temperature variations in the field of flow is called free, or natural convection.”

While Bear (1972) related free convection to heat from inside a flow field, Simmons (2011) related it, in a laboratory setting, to heat added from outside the flow field (Figure 5) and Van Dam et al. (2009) see free convection as a density dependent flow driven by heavier fluids above lighter fluids causing fingering (Figure 6). The examples in Figure 5 and 6 relate to hydrostatic conditions, not to on-shore hydrodynamic field conditions. That was noted by Simmons (2011) when he stated "Hundreds of papers on theory, modelling & laboratory experiments on finger instabilities associated with free convection … BUT A COMPLETE LACK OF CONCLUSIVE FIELD BASED EVIDENCE AND DATA !" (emphasis by Simmons, 2011). Van Dam et al. (2014) claim that fingering had now been shown to exist in the sabkha (Arabic: salt flat) areas of Abu Dhabi, based on geophysical field data which had been taken in 2008 and 2009. They attempted to support their interpretation with a simple vertical 2D-mathematical model of 30 m width and 10 m depth with oversimplified boundary conditions and parameters representing a hydrostatic case in a closed box with no-flow boundaries at the two sites and at the bottom of the model.

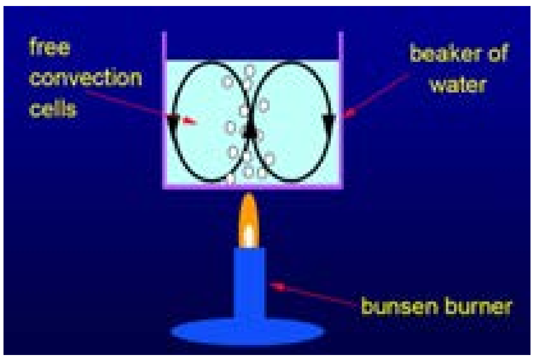


Figure 5 (above): Simple explanation of free convection in a beaker above a source of heat (after Simmons, 2011).

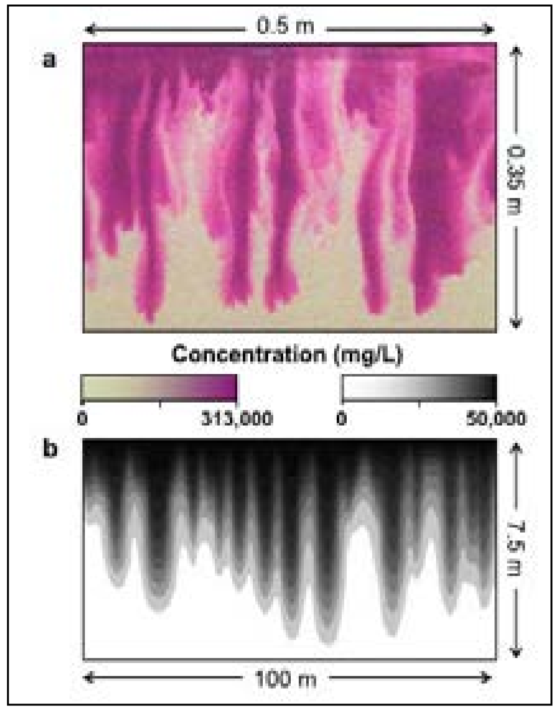
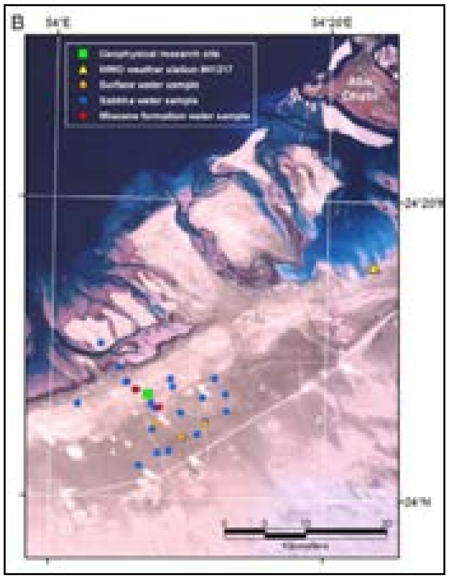


Figure 6 (right). "Representative examples of fingering associated with unstable free convection in groundwater from (a) laboratory experiments and (b) numerical modeling." Figure from Van Dam et al. (2009). In the experiment a heavier saline fluid is positioned upon the less saline water under hydrostatic conditions. The numerical calculation relies upon similar conditions.

Abu Dhabi Sabkha field case

Van Dam et al.'s (2009, 2014) assumption has been that the Abu Dhabi field site (Figures 7 and 8) is regularly flooded by the sea water of the Gulf which would create a natural condition of heavier saline water overlying less dense water. According to their concept, fingering would then occur as had been interpreted from electrical geophysical field data taken in 2008 and 2009. Figure 6a reports the results of laboratory tests with brines close to a density ρ ~ 1.3 g/cm3 and Figure 6b reports mathematical model results with a concentration of 50,000 mg/l, both situated over fresh water. The situation at the Abu Dhabi field site is systematically different in that the sabkha areas are endpoints of regional flow systems discharging very salty water, not fresh water, from greater depth (Wood et al., 2002). Therefore denser water would occur under less dense water, contradicting the assumption taken by Van Dam et al. (2009, 2014). During the strong rain events before the 2008 measurements local recharge of fresh water occurred at the little hills of the hummocky terrain shown in Figure 8 giving rise to small local groundwater flow systems, which led then to the presumed 'fingering' reported by Van Dam et al. (2009). The difference is that in this scenario, it is the fresher less dense water which penetrated into salty water driven by the force field of groundwater flow systems. That leaves open the question: where does the briny water below the penetrating fresher water come from?



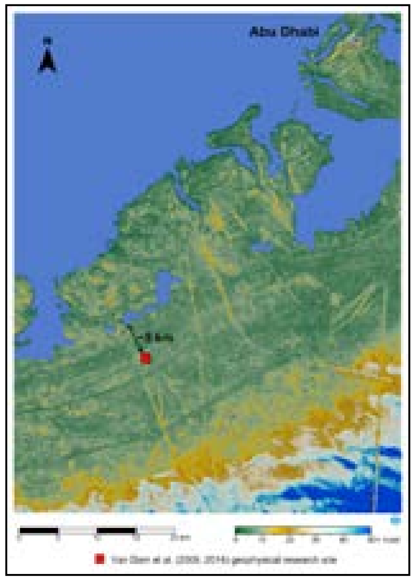


Figure 7 (left): Figure from Van Dam et al. (2009, Fig 2c) showing the positioning of the geophysical research site and surrounding study points.

Figure 8 (right): DEM based on SRTM topographic data. The position of the Van Dam et al. (2009, 2014) geophysical research site is shown to be approximately 5 km from the coastline.

Fortunately, the sabkha area of Abu Dhabi has been seen by sedimentologists of the petroleum industry as a natural present day laboratory to explain the huge amount of dolomitization which has occured in the geological past. Several schools of thought were proposed to explain the migration of magnesium into the carbonates, such as the "seawater-flooding model" (Kinsman, 1969; Butler, 1969; Butler et al., 1973; Patterson and Kinsman, 1977, 1981, 1982) and the "evaporative-pumping model" (Hsü and Siegenthaler, 1969; Hsü and Schneider, 1973; McKenzie et al., 1980; Müller et al., 1990). None of the two schools concerned themselves with the actual physics of the flow processes they proposed. Wood et al. (2002) were the first authors conducting actual hydraulic field work in the Abu Dhabi sabkha area by drilling 450 shallow (<5 m), 21 intermediate depth (<15 m), and 6 deep (~ 100 m) piezometers as shown in Figure 9.

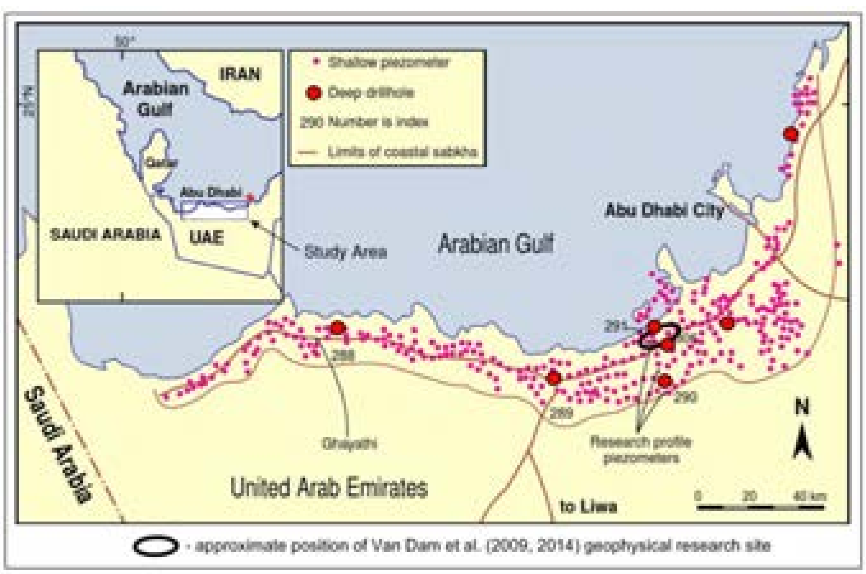


Figure 9: Map showing the location of shallow, intermediate, and deep piezometers on the coastal sabkha of Abu Dhabi. Modified from Wood (2011), after Wood et al. (2002).

All six deep piezometers were artesian, with flowing briny water. It was thereby established that the source of the magnesium, needed for dolomitization, was continental and not seawater. By establishing the sabkha region as a regional discharge area, Wood et al. (2002) also established that free convection was not operational at the Abu Dhabi sabkhas. Seemingly Van Dam et al. (2009, 2014) overlooked Wood et al.'s (2002) work whilst positioning their investigation site in the general area of Wood et al.'s (2002) deep flowing wells 291 and 306.

Conclusions

Close physical analysis of free convection and the associated vertical buoyancy and density forces shows that they do not exist in a natural continental subsurface environment. All density and buoyancy derived forces need to be included by modifying the length of the pressure potential forces of fresh water force fields regardless if fresh water is present at that position. As a consequence, adjustments should be made in dealing with the migration of hydrocarbons and CO_2 as well as in regard to our understanding of present day and past geological processes as for example dolomitization. The chemical and hydrodynamic pattern at the Abu Dhabi sabkhas are determined by groundwater flow systems, not by free convection.

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AIH Section News

We congratulate the new officers of the OR-AIH Section:
President: **Jolyne Lea**
Vice President: **Richard Marvin**
Secretary/Treasurer: **Kyle Dittmer**

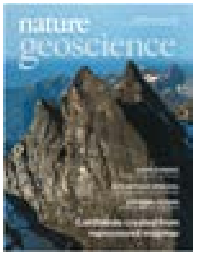
As AIH, we are looking forward to working with the new officers in our joint efforts of introducing new activities to AIH. Also, we encourage other AIH OREGON members to join the activities of our OREGON Section.

This year, the Oregon section is supporting the 2016 Pacific Northwest Water Research Symposium. This conference is hosted by the Oregon State University Hydrophiles, a student organization affiliated with AIH. The Pacific Northwest Water Research Symposium is a two day student centric conference highlighting outstanding student research in the fields of water resources science, engineering, and policy. The conference aims to connect individuals, build skills, and share knowledge between students, university faculty, staff, and professionals. Students, both graduate and undergraduate, travel from universities in Oregon, Washington, and Idaho to present their research. Rich Marvin will represent AIH at a booth during the event, and we hope to bring awareness and interest in AIH to the students attending. For further information, contact:

Jolyne Lea P.H. 02-H-1564
President, Oregon Chapter, American Institute of Hydrology
USDA NRCS National Water & Climate Center
jolyne.lea@por.usda.gov

Hydrology News of Interest

Groundwater as a cooling agent for earth:



An article in *Nature Geosciences* by Henk Kooi presents the findings that groundwater-driven convective cooling exceeds groundwater-driven warming of the Earth's crust, and hence that groundwater flow systems cause net temperature reductions of groundwater basins. The model calculations suggest that the crust and lithosphere beneath groundwater basins can cool by several tens of degrees Celsius where groundwater flows over large distances in basins that consist of crustal rock. For more information:
http://www.nature.com/ngeo/journal/v9/n3/full/ngeo2642.html

Sea level rise slowed by land hydrology changes:

A paper in *Science* by J. T. Reager et al. claims that climate-driven changes in land water storage and their contributions to sea level rise have been absent from Intergovernmental Panel on Climate Change sea level budgets. The authors found that between 2002 and 2014, climate variability resulted in an additional 3200 ± 900 gigatons of water being stored on land, which slowed the rate of sea level rise by 0.71 ± 0.20 millimeters per year. For more information:
http://science.sciencemag.org/content/351/6274/699

Using hydrology to predict malaria outbreaks:

Dynamical malaria models can relate precipitation to the availability of vector breeding sites using simple models of surface hydrology. In an article in *PLoS ONE*, E.O. Asare et al. present a revised scheme for the VECTRI malaria model. Substituting local rain-gauge data with satellite-retrieved precipitation gave a reasonable approximation, raising the prospects for regional malaria simulations even in data sparse regions. For more information:
http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0150626

Water crises deemed to be high-impact, high-likelihood by WEF:

WORLD ECONOMIC FORUM

Now in its 11th edition, The Global Risks Report 2016 published by the World Economic Forum completes more than a decade of highlighting the most significant long-term risks worldwide, drawing on the perspectives of experts and global decision-makers. The 2016 report shows water crises as being among the highest impact events with high likelihood of occurring. For more information:
http://www.unwater.org/news-events/news-details/en/c/277316/

News from Washington:

On February 24, 2016, the House Committee on Natural Resources (Subcommittee on Water, Power, and Oceans) held an oversight hearing on "The 2016 California Water Supply Outlook During the El Niño and Three Years of Restricted Water Deliveries." The hearing focused on the continuing drought in California, its impacts state-wide and nationwide and ways Congress can help overcome it. For more information:
http://naturalresources.house.gov/calendar/eventsingle.aspx?EventID=399940