Log of HMF-Geophysics Activities

AUGUST 2005

Defined special session around goal of HMF-Geophysics for SAGEEP Symposium on Application of Geophysics to Environmental and Engineering Problems, 2-6 April 2006, Seattle:

Special Session for SAGEEP, April 2006:
Watershed Geophysics

There is growing recognition of the need to better understand and quantify the occurrence, distribution, quality and movement of water at the watershed scale; especially with increasing societal pressures making ever-greater demands on this resource. In recognition of this need, the National Science Foundation is exploring the idea of undertaking focused studies within a number of watersheds throughout the U.S over the next 10 to 20 years. While geophysical methods exist that have been, or could be, applied to such watershed scale studies, there are many challenges to be faced as we try to optimize geophysical methods for a wide range of applications. Such applications include characterizing the vadose zone; delineating aquifers and aquitards; estimating recharge; locating subsurface hydrological flow pathways; quantifying the volume of water exchanged between surface water, groundwater and atmospheric interfaces; determining the impact of land cover on precipitation run-off and infiltration; determining the spatial and temporal variation in the quality of groundwater. This session is designed to be a forum for the exchange of ideas and information among those in the private sector, government, and academia so that we, in the geophysical community, can determine how our community can best contribute to watershed scale studies in the U.S and elsewhere throughout the world. We invite papers illustrating examples of the use of airborne, surface and borehole geophysical methods for applications related to groundwater and surface water at all scales; with specific interest in those methods that could be applied at the watershed scale.

Session Organizers:
Rosemary Knight, Stanford University; rknight@stanford.edu
Victor Labson, US Geological Survey; vlabson@usgs.gov
Norman Carlson, Zonge Engineering; norm@zonge.com
David Robinson, Utah State University; darobinson@cc.usu.edu

Assembled **HMF- Geophysics Advisory Group**:

Estella A. Atekwana
Office Address: Department of Geological Sciences and Engineering, University of Missouri-Rolla, 125 McNutt Hall, Rolla, MO 65409-0410
Phone: (573) 341-6104, Fax: (573) 341-6935; E-mail:atekwana@umr.edu
Internet: Internet http://campus.umr.edu/geo-geop/Prof-sites/EsAtekwana/atekwana.htm
Research interest: Biogeophysics- investigating the effects of microbial processes/activity on geophysical properties. Geophysics applied to contaminant and remediation studies.
Scales at which research conducted: lab scale-to field scale
Major techniques used: dc resistivity, induced polarization.

Experimentalist Laboratory
Experimentalist Field

Andrew Binley
Department of Environmental Science, Lancaster University, Lancaster, LA1 4YQ, UK.
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Web page: http://www.es.lancs.ac.uk/es/people/teach/amb/
Tel +44 1524 593927, Fax +44 1524 593985
Research interest: General hydrological characterization using geophysical methods, particularly the use of geophysical data to constrain subsurface flow and transport models. Vadose and saturated zone applications of geophysical tracers. Groundwater-surface water interactions. Preferential flow in soils. Inverse methods in hydrology and geophysics.
Scales at which research conducted: pore scale to small watershed scale
Major techniques used: Electrical resistivity tomography (particularly cross-hole). GPR (particularly cross-hole). SIP and IP (lab and field).
Areas of emphasis: Major: Theoretical modeling, applied modeling, experimental field; Minor: Experimental lab.

William P. Clement
CGISS, Boise State Univeristy, 1910 University Drive, Boise, ID, 83725.
Email: billc@cgiss.boisestate.edu
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Tel (208) 426-4307, Fax (208) 426-3888
Research interests: Using Ground Penetrating Radar to determine water content in the vadose and the saturated zones; tomographic imaging; inverse theory; reflection imaging and characterization.
Scales at which research conducted: few meters to small aquifer scale (100x100x20 m)
Bandwidth of EM techniques: 25 MHz – 250 MHz
Major techniques used: Ground Penetrating Radar, Tomography.
Areas of emphasis: Major: Experimental field, Applied modeling.

Frederick D. Day-Lewis (Fred)
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Storrs CT 06269
Email: daylewis@usgs.gov
Web page: http://water.usgs.gov/ogw/bgas
Tel: 860.487.7402 x21; Fax: 860.487.8802
Research interest: Time-lapse geophysical monitoring of hydrologic processes; aquifer characterization; geostatistics; resolution and volume support of geophysical measurements; inverse problems.
Scales at which research conducted: Field to watershed scale
Bandwidth of EM techniques: 50Mhz – 1 GHz for GPR; much lower (~D.C.) for ERT
Major techniques used: Cross-hole GPR; electrical resistivity tomography; borehole logs.
Categories: Modeling applied; modeling theoretical; field experimental.

Ty P.A. Ferré
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Web page: http://www.hwr.arizona.edu/~ty/ferre.htm

Tel (520) 621-2952, Fax (520) 621-1422
Research interest: Spatial sensitivity distributions and spatial averaging of indirect methods in the presence of sub-sample volume heterogeneity; optimization of measurement networks for hydrologic monitoring.
Scales at which research conducted: Hand sample scale to watershed scale
Bandwidth of EM techniques: DC – 2 GHz
Major techniques used: Borehole ground penetrating radar, electrical resistivity tomography, electromagnetic induction, gravimetry, near infrared aerial photography, neutron moderation, temperature profiling, time domain electromagnetics, time domain reflectometry, time domain transmission.
Areas of emphasis: Modeling theoretical, applied modeling, experimental lab, experimental field.

Michael Knoll
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Tel (208) 426-4003, Fax (208) 426-3888
Research interests: identifying, characterizing and monitoring the controls on fluid flow and mass transport in porous media, aquifers and watersheds using hydrogeophysical methods; relating geophysical observables to hydrologic parameters of interest; wave propagation and diffusion in heterogeneous media; signal processing and inversion; geostatistics; rock and soil physics (petrophysics).
Scales at which research conducted: Pore scale to small watershed scale
Bandwidth of Geophysical Techniques: Electromagnetic: 0.1 Hz - 2 GHz; Seismic: 8 Hz - 20 kHz
Major techniques used: surface and borehole ground penetrating radar (GPR), electromagnetic and seismic methods; well logging; laboratory measurement of electrical and hydraulic properties of porous media (impedance spectroscopy, porosimetry, permeameters, etc.); tomography; time-lapse geophysical imaging of infiltration and tracer tests; flow and transport modeling.
Areas of emphasis: Major: Experimental field, Experimental lab; Minor: Applied modeling, Theoretical modeling.

Venkat Lakshmi, PhD PE
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Tel (803)-777-3552, Fax (803)-777-6684
Research interest: Remote sensing of the land surface hydrology; interactions of land surface with the atmosphere; microwave, visible and infrared remote sensing of soil moisture, precipitation, surface temperature and vegetation
Scales at which research conducted: field scales to global scales
Bandwidth of EM techniques: visible 0.4 □m -microwave [40GHz]
Major techniques used: Remote sensing analysis included radiative transfer modeling and other data analysis techniques

John W. Lane, Jr. (John)

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Tel: 860.487.7402 x13; Fax: 860.487.8802
Research interest: Time-lapse geophysical monitoring of hydrologic processes; surface, borehole and cross-hole geophysical characterization of fractured rock, karst, and unconsolidated aquifers
Scales at which research conducted: Laboratory to watershed scale
Bandwidth of EM techniques: 1Hz– 1 GHz (DC to high-frequency radar)
Major techniques used: Surface (Resistivity, EM, GPR, Seismic); Borehole (conventional, imaging, and flowmeter); Cross-hole radar and ERT; Marine seismic and resistivity
Categories: Modeling applied; field experimental.

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Phone 303-273-3510, Fax 303-273-3478
Research interest: Application of geophysical methods and inverse theory in resource exploration including mineral, petroleum, and water, and in environmental problems such as UXO clearance.
Scales at which research conducted: 1m – 10km
Bandwidth of EM techniques: 0 – 10 kHz
Major techniques used: gravity, magnetics, DC resistivity and induced polarization, electromagnetic induction in time- and frequency- domains, and applied geophysical inversion.
Areas of emphasis: Major: applied geophysical inversion, methods for processing and interpretation of geophysical data; Minor: physical properties and their relationship to subsurface processes

Dr. Jonathan E. Nyquist
Weeks Chair in Environmental Geology
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Research interest: I have a strong interest in geophysics applied to groundwater problems. I have dabbled in many areas, including airborne geophysics, but most of my work over the past few years has been applying DC resistivity to the characterization of karst environments. Recently, I become interested in using resistivity with underwater cables (streams) and deployed from a boat as a marine stream.
I see my interests in watershed characterization focusing on the following areas:
1. Application of resistivity in lakes and streams to characterize groundwater-surface water interaction.
2. Application of airborne geophysics and remote sensing to watershed-scale characterization.
3. Application of multifractal methods to characterizing measurements made at many scales.

Scales at which research conducted: Predominately small-scale field measurements scale up to large airborne surveys.
Bandwidth of EM techniques: DC-GPR (0 Hz - 1GHz)
Major techniques used: DC resistivity tomography, EM induction, SP, GPR, Magnetics, Airborne geophysics.
Areas of emphasis:
Major: Experimental field.
Minor: Applied modeling, Theoretical modeling

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Web: www.greeninc.us
Research interest: Application of electrical and electromagnetic methods to hydrological and groundwater investigations with an emphasis on structural framework, lithology and aquifer characterization.
Scales at which research conducted: meters to large watershed scale
Bandwidth of EM techniques: 10^{-4}Hz – 300kHz
Major techniques used: Electromagnetic (EM) and electric methods including ground and airborne based, time and frequency domain, controlled-source and plane-wave (magnetotelluric (MT), audioMT (AMT) and radioMT (RMT)) EM, and galvanic and capacitively-couple electrical resistivity
Areas of emphasis: Major: Experimental field; Applied modeling and interpretation Minor: Theoretical modeling

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Research interest: Electrical properties of soils, sediments and rocks with an emphasis on water content determination; small watershed scale process hydrology; soil mapping using electromagnetic tools, and structural characterization of porous media and mineral physics.
Scales at which research conducted: Grain scale to small watershed scale
Bandwidth of EM techniques: 1kHz – 6 GHz
Major techniques used: Time domain reflectometry (TDR), capacitance probes, network analyzer, Electro magnetic induction (EMI), electron microscopy, x-ray diffraction.
Areas of emphasis: Major: Experimental lab, Experimental field; Minor: Applied modeling, Theoretical modeling.

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Tel (814) 863-6649, Fax (814) 863-7823
Research interest: integration of flow and transport modeling with geophysical imaging of hydrogeologic processes, accounting for spatially variable geophysical resolution when quantifying geologic parameters, parameter estimation and geostatistics
Scales at which research conducted: Tens of meters to small watershed scale
Bandwidth of EM techniques: DC - 1 GHz
Major techniques used: Ground penetrating radar (GPR), electrical resistivity tomography (ERT), electromagnetic induction, self potential (SP), very-low frequency electromagnetics (VLF), seismic refraction, standard wireline logs, groundwater concentration sampling.
Areas of major emphasis: Theoretical modeling, applied modeling, field experimentalist.

Lee Slater
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Research interest: Low-frequency electrical properties of soils, sediments and rocks; geophysical estimation of hydraulic properties; geophysical characterization of chemical and microbial interfacial processes in porous media; geophysical investigation of peatlands to improve understanding of peatland hydrology and carbon cycling.
Scales at which research conducted: Pore scale to small watershed scale
Bandwidth of EM techniques: mHz-MHz
Major techniques used: Complex resistivity, induced polarization, electrical resistivity imaging, ground penetrating radar.
Area of major emphasis: Lab experimentalist, Field experimentalist

SEPT 2005.

Knight and Robinson submitted abstract for invited paper to Watershed Characterization session, Hydrology Section, AGU Dec 2005:

Invited paper, Watershed Characterization session, AGU meeting, Dec 2005:
An Emerging Role for Geophysics in Watershed Hydrologic Investigations
Rosemary Knight and David Robinson

There is growing recognition of the challenges we face, in many parts of the world, in finding and maintaining clean sources of water for human consumption and agricultural use, while balancing the needs of the natural world. Watershed hydrologic investigations can be used to develop an improved understanding of the controls on the quantity, movement and quality of water, thus enhancing our ability to better protect and manage our water resources. Geophysical methods can play a central role in these investigations. CUAHSI (Consortium of Universities for the Advancement of Hydrologic Sciences) is developing, with the support of the National Science Foundation, a Hydrologic Measurement Facility (HMF), which contains a Geophysics Module. Through the HMF-Geophysics Module our objective is to determine how best to utilize geophysical instrumentation and engage geophysical expertise in addressing key challenges in watershed-scale characterization.

We approach the development of HMF-Geophysics with the following questions:

1) What are the parameters that need to be measured in order to adequately describe the quantity, movement and quality of water, and at what spatial and temporal scale do these parameters need to be measured?
2) What can we measure with our geophysical instruments and methodologies, and what are the relevant spatial and temporal scales?
3) Given the answers to 1) and 2) above, what can we do today with geophysics that integrates with hydrological monitoring and modeling approaches, and provides a significant advancement over other forms of measurement?
4) What are the critical research needs in advancing the use of geophysics for watershed hydrologic investigations?

When we consider the state-of-the-science in the use of geophysics for all near-surface applications, we identify four cross-cutting areas of research activity that complement the goals of HMF-Geophysics. One area of research is focused on improving the accuracy of our estimates of hydrologic properties from geophysical data. An assessment of the impact of spatial resolution and heterogeneity on property estimates has led to new ideas about site-specific methods that can be used to better constrain the relationship between geophysical and hydrologic properties. A second area of research involves quantifying spatial heterogeneity with geophysical images. Theoretical and field studies of the scale-dependent nature of both natural systems and geophysical images are allowing us to find ways of extracting information about the correlation structure of the subsurface from geophysical data. This leads to a third active area of research, which is improving the quality of subsurface images. New forms of sensors and new approaches to the processing and inversion of data are providing dramatic improvements in our imaging abilities. The fourth area of research seeks to find new forms of geophysical measurement that are sensitive to the biogeochemical processes that can impact water quality. Recent studies have shown a close link between biogeochemical processes and the electrical properties and nuclear magnetic resonance response of geological materials. Through HMF-Geophysics our goal is to build on these active areas of research to advance the use of geophysical methods in developing new strategies for the improved protection and management of our water resources.

Oct 2005

Oct 1, 2006 – David Robinson joins Stanford as Research Scientist with HMF
Survey design – initial draft expanded and improved
reviewed by HMF PI's and Advisory groups
Loaded with CUAHSI survey software and "launched" Oct 28, 2005

Arranged to hold HMF-Geophysics townhall at SEG meeting, Houston, Nov 05

SAGEEP: Symposium on Application of Geophysics to Environmental and Engineering Problems
1) 34 papers submitted to Watershed Geophysics session at SAGEEP:
Completed review of abstracts and program selection – one full day of Watershed Geophysics (Tuesday April 4 ,3 oral sessions, 1 poster session, beer and poster viewing 5:30-6:30)
2) arranged for room for HMF Geophysics townhall, April 4, 6:15-7pm

AGU Spring 2006: submitted special session:

Characterizing the Subsurface in Watersheds, using Geophysical and Hydro-pedological Methods.

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Rosemary Knight, Dept of Geophysics, Stanford University, 397 Panama Mall, Stanford CA 94305, Phone: (650) 723-3522; E-mail: rknight@pangea.stanford.edu

Mark Seyfried Northwest Watershed Research Center USDA-ARS, 800 PARK BLVD., STE 105 BOISE, ID, 83712-7716, Phone: (208) 422-0715; E-mail: mseyfrie@nwrc.ars.usda.gov

The development of a Hydrological Measurement Facility (HMF) is a strategic goal for the: Consortium of Universities for the Advancement of Hydrological Sciences Inc. (**CUASHI**). The projected facility will support hydrological measurement across the US. Fundamental to this is that the HMF develop, and provide access to, relevant measurement techniques, which will provide data to both support and advance hydrological characterization and forecasting in watersheds. Geophysical methods have the potential to provide improved characterization of the subsurface in terms of both reservoirs and flow pathways and networks. We seek presentations that demonstrate cutting edge geophysical and soil measurement techniques used to advance hydrologic sciences, especially in watersheds. We are not only keen to see 'hard' data but also 'soft' data that could be used to determine dominant processes in the watershed or confine parameters in hydrological models. Examples include characterizing soils and the vadose zone; delineating aquifers and aquitards; estimating recharge; locating subsurface hydrological flow pathways; quantifying the volume of water exchanged between surface water, groundwater and atmospheric interfaces; determining the impact of land cover on precipitation run-off and infiltration; determining the spatial and temporal variation in the quality of groundwater. We invite papers ranging from the use of hydro-pedological techniques in the vadose zone to the use of airborne, surface and borehole geophysical methods for applications related to groundwater and surface water at all scales; with specific interest in those methods that could be applied at the watershed scale

Began outline of Whitepaper; invited participation from Advisory Group with proposed meeting the weekend before AGU at Stanford.

Completed design of HMF-Geophysics logo.
Developed HMF-Geophysics webpage
Posted page inviting Watershed Partners

Completed first HMF Geophysics brochure

NOVEMBER 2005

Society of Exploration Geophysicists Meeting, Houston, Nov 7-12:
Knight attended Nov 7-11.
Distributed ~40 copies of handout
Nov 8: Near-Surface Geophysics Section meeting: Brief introduction of HMF; handouts distributed

Nov 9, 5-6 pm: HMF-Geophysics townhall: Wednesday November 9th from 5-6pm at the George R. Brown Convention Center, room number 318D.
in attendance: Rick Miller, Mike Knoll, Partha Routh, John Bradford, Roelof Versteeg, David Lesmes, Ben Sternberg, David Alumbaugh, Christina Chan, Chet Weiss
Discussed possible models of providing equipment
It is not clear the benefit of buying/maintaining an equipment pool. A better idea might be to negotiate good research-rates with equipment companies. Private sector OK with reduced rental rates for academics if used for research; but academics must not be using this equipment pool in competing for contracts. A lot of equipment out there already that is unused for large amts of time– how to organize this?
Strong support for ensuring that experienced geophysicist is part of data acquisition
Discussion of sites for educational initiatives – teaching non-geophysicists about geophysical methods – so there is an awareness.
Data Storage – (Roelof Versteeg, INEL, as possible lead) Before we start acquiring data, need to think about format for archiving, retrieval etc
We must determine the value-added in using geophysics for watershed scale studies.
To do: contact Peter Annan, Lawrence Gochioco re equipment rental rates.

JAN/FEBRUARY 2006

Jan and Feb 2006 – worked on White paper.
Reviewed submitted papers for SAGEEP, organized oral and poster sessions.
Began data base of geophysical contractors or equipment rental companies.

Knight submitted NSF proposal (PI Venkat Lakshmi) in collaboration with Roelof Versteeg, INEL, to develop cyberinfrastructure for data repository for satellite and geophysical data. Stanford Computational Center for Earth and Environmental Sciences willing to host data and provide staff support. Nigel Crook will work on this if no NSF funding; this has to be in place before we starting collecting watershed geophysical data.

Discussions and visits with John Nimmo's group (USGS Menlo Park) about best use of ERT for vadose zone applications. Discussed use to complement standard infiltration tests. Defined project for use in imaging preferential flow paths

Feb 1 – Nigel Crook joins Stanford as research scientist; will replace David R. as HMF-Geophysics staff person Oct 1, 2006.

Nigel starts researching data formats for various systems to think about how best to set up data archiving.

Continued discussions to plan field work in watersheds for the summer.Reynolds Ck is a definite, David and Nigel to visit OSU after SAGEEP to assess possible applications of geophysics there.

Kristina Keating(Stanford PhD student) co-ordinating testing of field NMR system in California in summer – can this be used in east Cascades; Kristina and Elliot Grunewald (Stanford PhD student) making lab measurements to assess effect of Fe content on signal. Training on Stanford ERT unit.
Visits to local sites that could be used for proof-of-concept testing of equipment.

Feb – conference call with HMF Advisory group to clarify white paper. We must not endorse specific pieces of equipment.

Two new members of HMF-GAG:
Tien Grauch tien@usgs.gov
Rick Miller rmiller@kgs.ku.edu

March 06: Partha Routh (CGISS at Boise State) visiting Stanford - discussed possibility of CGISS being an HMF node for equipment, expertise, short courses. Will send list of equipment that will potentially be available as a rental/loan pool. Partha will also send a proposal to host educational workshops to introduce non-Geophysicists to geophysics at the Boise site.

March 06 – included notice of search for "Watershed Partners" in CUAHSI newsletter

March 06: Discussion with John Lane (USGS). Very interested in supporting HMF-Geophysics. Their model is very similar to the growing idea for HMF-Geophysics: to get hydrologists to use geophysics by providing equipment, expertise and short courses. They offer ~4 5-days courses in various regions in US each year. Course objective – to expose hydrologists to geophysics. Charge is typically ~$500 which barely covers costs. They also teach methods-specific courses (~1/year). They do lend out equipment to academics but issue is covering cost of repairs. John acts as available expert who hydrologists call with measurement needs; he advises, assists in planning program, writing proposals etc. Possibilities discussed: Could they be an HMF-Geophysics node? increase space in courses from 15-20 participants to allow access for academics?; a course tied to AGU? USGS acts as host for their equipment or NSF-purchased equipment in a way that addresses needs for funds for repairs, other related costs. How to upscale the advice-giving role to serve more, involve more geophysicists?

Ongoing discussions with Louise Pellerin about the idea of NSF support for skyTEM – airborne EM. Talked with DonPool at USGabout science issues in the southwest that could benefit from airborne geophysics.

In prep for townhall at SAGEEP, it is useful to get a better sense of where there is equipment that could be part of the HMF-Geophysics pool. Email sent:

From: Rosemary Knight <rknight@pangea.Stanford.EDU>
Subject: request for equipment lists
Cc: David Robinson <darobinson@cc.usu.edu>

Dear ALL HMF-Geop Advisory Group (HMF-GAG)

Here is what is emerging as a possible model for HMF-Geophysics: a distributed system of "nodes" around the US that could provide equipment and expertise, and short courses/workshops, for other geophysicists and hydrologists. The next step is to figure out what we have, who would be willing to do what, and where the gaps are that we need to address, ideally with funds from NSF or CUAHSI. I see this as involving the academic, government and private sector.

SAGEEP, April 2-5, will be a great opportunity to talk more about this with a cross-section of our community. We have a day of watershed geophysics. I know not all of you will be there, so I would like to collect what information I can before that meeting.

If at all possible, could you please send me, in the next 5 days, a list of equipment that you have that you might be willing to have included in a HMF loan/rental pool? It has become clear that as a community we have much we could share, and many people willing to share! So my feeling is that we do not need a proposal to NSF to buy more equipment, but should rather submit a community proposal to NSF to, as examples, get technical support at the nodes to facilitate the sharing, to cover any costs of maintenance and repair, etc. (The one thing we do not have easy access to as a community is an airborne system - I am getting the impression that many hydrologists and geophysicists would support a request to NSF to provide XXX hours of helicopter/airborne EM time, but let's not get into that now.)

Don't bother at this stage to list the impediments to your lending (e.g. I would want a geophysicist/technician to go out with this equipment at all times etc); we will address those at the next stage. Right now I would like to get a sense of who has what, what they would be willing to share if we can provide some incentives (financial or other).FYI - we do have a research scientist working with HMF-Geophysics, who would be available to help out with deployment, field work etc over the next 2 years.

Sorry for the short notice, but I would like to have at least a partial list to focus our discussions at SAGEEP.
Don't forget the HMF townhall at SAGEEP on Tuesday at 6pm.

thanks all!
Rosemary