PHOENICS NEWS

Editorial

Spring 2012

CHAM is working on a new application for PHOENICS relating to Heat Islands in response to the need for a way of modelling the increase in temperatures in urban areas caused by the absorption and emission of radiation by buildings, roads and other man-made objects prevalent in cityscapes. This application is particularly relevant as the size of urban areas increases.

If you are interested in this particular use of PHOENICS please contact sales@cham.co.uk.

If you are a maintained PHOENICS User and have not yet received *PHOENICS 2011* please contact Michelle Lyle (mjl@cham.co.uk) to arrange delivery.

CHAM would like to wish PHOENICS Users – present, past and potential – a Happy Easter.

2) PHOENICS News

2.1 Agent News

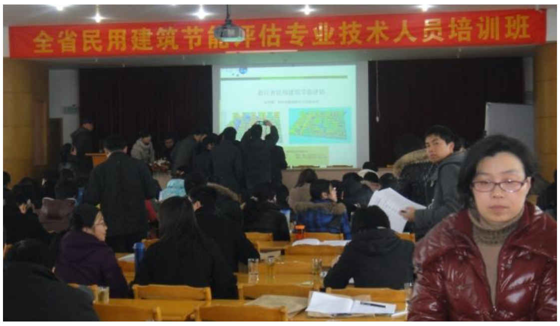
2.1.1 Shanghai Feiyi

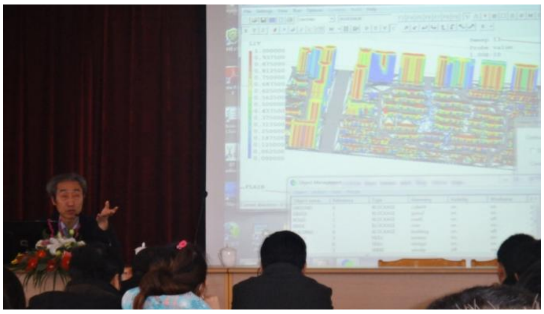
Shanghai Feiyi promoted PHOENICS at the Hunan Province Architecture Exhibition in December which concentrates on matters of building energy conservation. Some 500 persons took part in the Conference all of whom received PHOENICS information; some 250 visited the PHOENICS stand.

Engineers' introduction PHOENICS software

In February the Zhejiang Province Department of Construction organised a meeting based on PHOENICS Applications for Heat Islands (see 3.1 below). All key companies in Zhejian Province interested in building energy conservation took part in the training and demos to strengthen the province's civil building management and reduce energy consumption in such buildings.

In March (1-8) the Zhejiang Province Department of Construction organized a first stage training course to evaluate rules to be introduced to govern energy consumption in civil buildings. Shanghai Feiyi was invited to conduct the heat island and ventilation elements of the course. Over 300 engineers took part; second stage training was held March 19 and third and fourth stage training will follow.



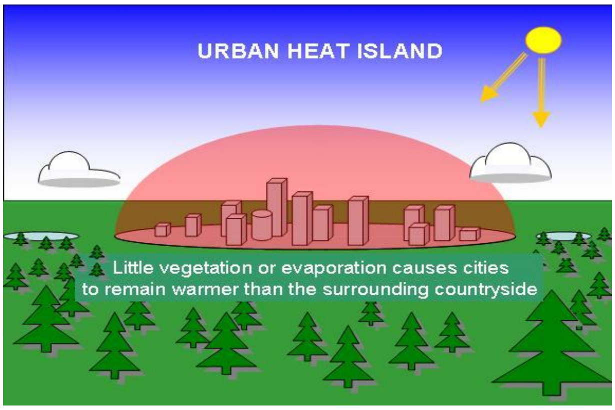


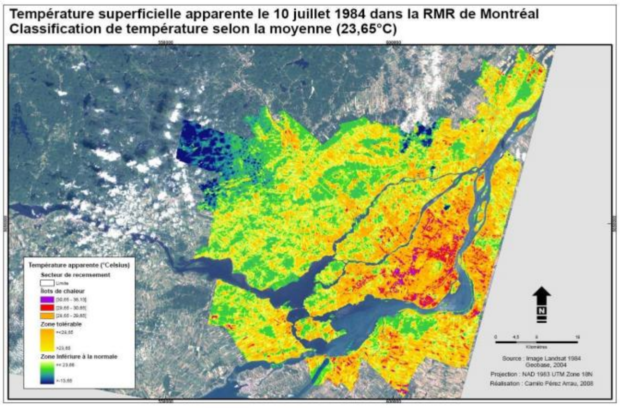
2.2 PHOENICS Activities

Dates	Activity
April 16 – 17	*PHOENICS Basic Training at CHAMPION. Contact sales@c-h-a-m-p-i-o-n.com.tw*
April 17 - 19	*PHOENICS Training Course at ACFDA in Toronto. Customized one-to-one courses can be arranged in Toronto, at client sites or over the internet. Contact acfda@sympatico.ca.*
April 24 - 26	*PHOENICS at ICCI 2010, Istanbul Expo Centre. Contact INORES, serkin.us@inores.com*
May 3	*PHOENICS Presentation at Universite de Clermond-Ferrand. Contact ARCOFLUID: arcofluid@arcofluid.fr*
May 7 – 9	*PHOENICS at ARBS (Air Conditioning, Refrigeration & Building Services Exhibition) presented by ACADS-BSG, Melbourne, Contact ACADS: acadsbsg@ozemail.com.au*
May 14 - 15	*Advanced Training (HVAC). Contact sales@c-h-a-m-p-i-o-n.com.tw*
May 17	*Seminar at Institut Polytechnique de Marseilles. Contact arcofluid@arcofluid.fr*
May 29 – 31	*Training Course at CHAM Head Office information from sales@cham.co.uk.*
June 18 - 19	*Basic Training at CHAMPION. Contact sales@c-h-a-m-p-i-o-n.com.tw*
July 1 – 6	*Advances in Heat Transfer 5th Int Symposium, Bath, UK. Keynote Lecture: Brian Spalding*
July 16 - 17	*Advanced Training (Flow Around Buildings). Contact sales@c-h-a-m-p-i-o-n.com.tw*
July 16 – 18	*Heat Transfer, Fluid Mechanics & Thermodynamics, 9th Int Conference, Malta, Keynote Lecture: Professor Spalding*
August 3 – 5	*PHOENICS Demonstration & Presentation at the CFD Conference of the R.O.C. Contact sales@c-h-a-m-p-i-o-n.com.tw*
August 13 - 14	*Basic Training at CHAMPION. Contact sales@c-h-a-m-p-i-o-n.com.tw*
September 9	*PHOENICS @ Semi-Conductor & Processing Equipment Conference R.O.C. Contact sales@c-h-a-m-p-i-o-n.com.tw*
September 17 - 18	*Advanced Training (Fire, Smoke and Safety in Buildings) at CHAMPION Contact sales@c-h-a-m-p-i-o-n.com.tw*
October 15 - 17	*Basic Training at CHAMPION. Contact sales@c-h-a-m-p-i-o-n.com.tw*
November 12 - 13	*Advanced Training (CFD in Semi Conductors & Opteoelectronic Processing Equipment) Contact sales@c-h-a-m-p-i-o-n.com.tw*
November 16 – 17	*Demonstration & Presentation at the National Conference of Theoretical and Applied Mechanics, R.O.C. Contact sales@c-h-a-m-p-i-o-n.com.tw*

3) PHOENICS Applications

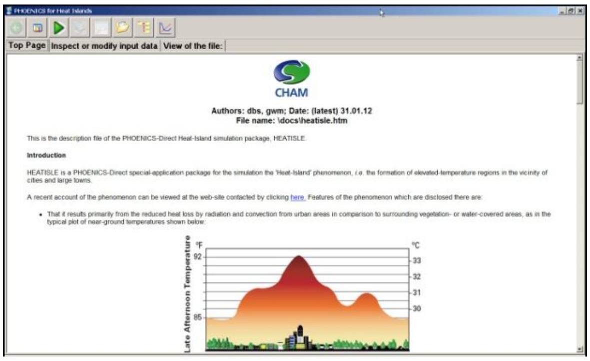
3.1 Heat Island Application by Brian Spalding





Introduction

Heat islands are large-scale phenomena in which the general urban temperature level rises above that of the rural surroundings. The main cause of the heat-island effect is the absorption by, and emission of, radiation by hard-surfaced man-made objects (buildings and roads). The sun falls on vegetation and on cities at the same rate; but the vegetation absorbs the incoming radiation in depth, is better cooled by the air in which it is immersed and can lose heat by evaporation. Hard surfaces by contrast quickly attain the temperatures which enable them to emit nearly as much radiant heat as they gain (the difference being lost by convection).



Authors: dbs, gwm; Date: (latest) 31.01.12
File name: \docs\heatisle.htm

This is the description file of the PHOENICS-Direct Heat-Island simulation package, HEATISLE.

Introduction

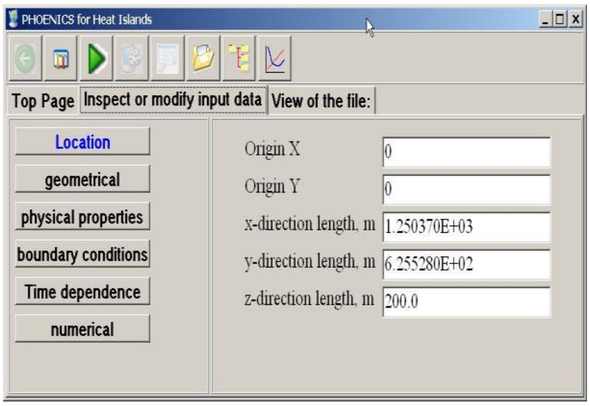
HEATISLE is a PHOENICS-Direct special-application package for the simulation the 'Heat-Island' phenomenon, *i.e.* the formation of elevated-temperature regions in the vicinity of cities and large towns.

A recent account of the phenomenon can be viewed at the web-site contacted by clicking here. Features of the phenomenon which are disclosed there are:

- That it results primarily from the reduced heat loss by radiation and convection from urban areas in comparison to surrounding vegetation- or water-covered areas, as in the typical plot of near-ground temperatures shown below:

Unlike the large-scale Air Ventilation Assessment (AVA), heat island simulation does not require that the detailed geometry of buildings is captured; rather it is the amount of solid surface per unit volume, and its emissivity, which is decisive. The 'sunlight' object in PHOENICS can compute the intensity and direction of incoming radiation and its distribution upon surfaces, and the Immersol feature is ideally suited to handling the redistribution of radiation between buildings by reflection and re-radiation.

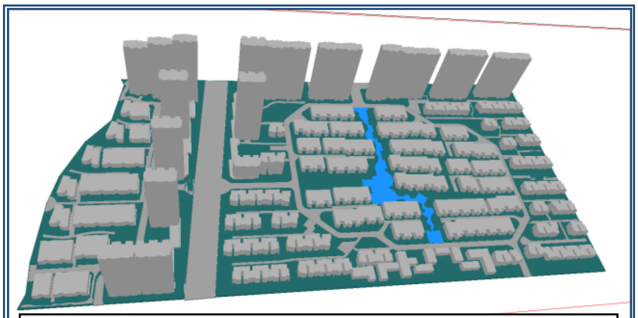
To date, little simulation of heat island phenomena has taken place. However, investigation into heat islands, their causes and effects, is becoming increasingly important across the globe, especially, as one might expect, in highly urbanised environments. The new PHOENICS-based prototype heat-island model has been developed in response to that demand and forms a flexible template for investigative engineers.



Origin X: 0
Origin Y: 0
x-direction length, m: 1.250370E+03
y-direction length, m: 6.255280E+02
z-direction length, m: 200.0

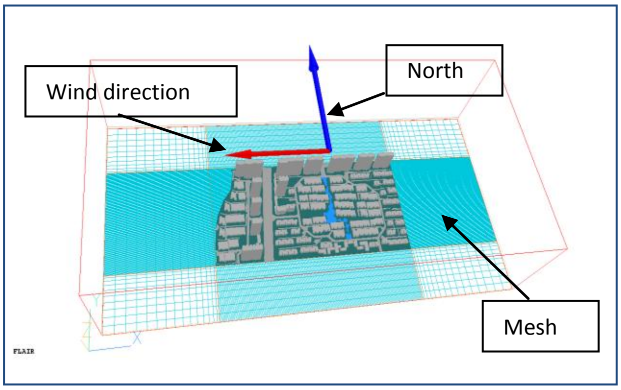
There is a new menu-driven interface designed for potential users who do not have time to learn to use the standard VR-Editor or VR-Viewer but want to enjoy the benefits of CFD. It is the creator of the Q1 and the associated soc.xml who decides which parameters will be made easy for these users to set and which default views it will be made easy for them to display.

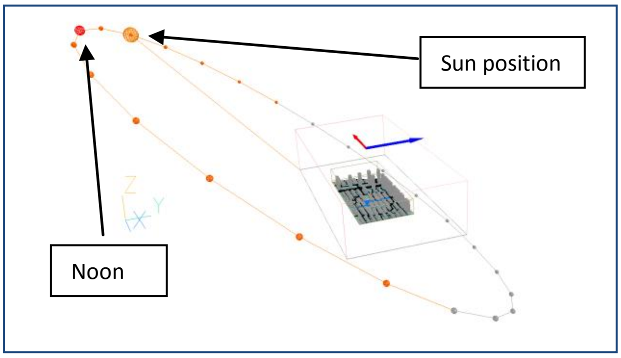
This optional menu transmits the Q1 and frommenu.htm to the working directory, runs the case there and leaves its files there. At that point, users have the option to start to run PHOENICS *via* VR in the usual way, ie without further use of the menu.



Geometry – comprising buildings, roads, hard ground, grass and water way

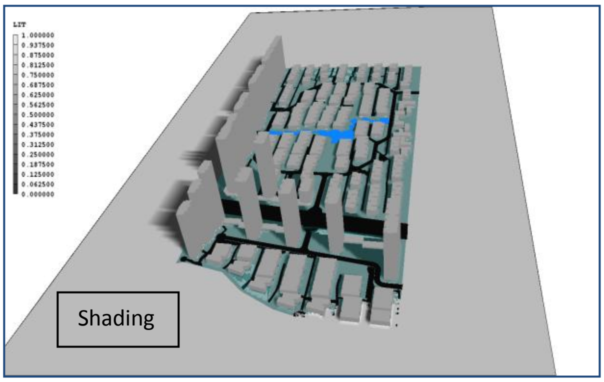
The idealised geometry shown above contains many of the components of interest to the "Heatisle" engineer; viz, concrete and glass high rise buildings, tarmac roadways, hard terrain and vegetation, and a water course. Each component responds differently to solar radiation.





In our test case, the wind and sun conditions are representative of the UK (Gatwick) in April.

- Wind direction – East
- Wind speed - 2.5 m/s at 10m
- Logarithmic wind profile
- Roughness height - 0.1m
- Ambient temperature - 12˚C
- Ground temperature - 9˚C
- Sun latitude 51deg
- Direct radiation 400 W/m2
- Diffuse radiation 100 W/m2



In this example, the ground surrounding the buildings, road, grass and river all have a Z depth of 2m. The ground temperature of 9˚C is applied at the lower face of the ground. This represents the constant earth temperature underground.

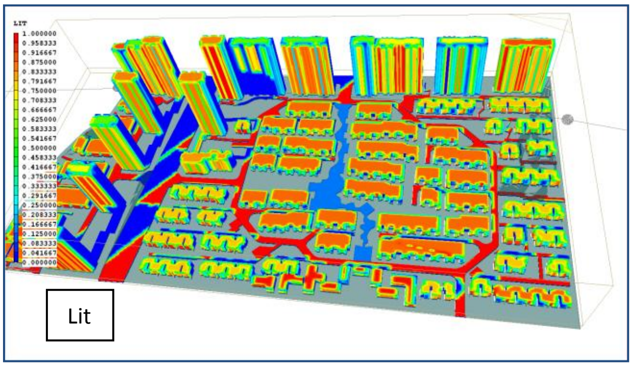
The radiative heat transfer is handled by IMMERSOL. The surface emissivities are set as follows:

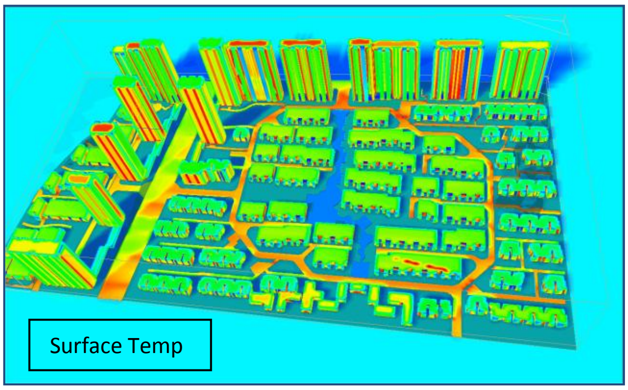
Ground	-	0.9
Grass	-	1.0
Road	-	0.5
River	-	1.0
Building	-	1.0

The radiative heat loss to the sky is represented by a radiative heat loss to an external temperature of -2˚C with an emissivity of 1.0.

It should be noted that in order to radiate 500w/m^2 to an external temperature of -2˚C, the required temperature is 72˚C. After around 1200 sweeps the average temperature over the entire ground plane just below the surface is 67˚C. The temperature of the road which has a lower emissivity is higher, again in line with expectation. However, given that the surface temperatures are not actually that high in reality, there must be some other mechanism for heat loss.

Although in this case the model is set with user-defined inputs, both the sun and wind parameters can be imported from an EPW weather file (eg the public domain Energy Plus database.)





Conclusion

The prototype heat island module demonstrates adequately the ability of PHOENICS to simulate processes of this type. Whilst there is already connectivity with weather mapping data bases, the module still remains as a working template, relying upon the user to specify appropriate materials, and their emissivity and absorptivity values.

3.2 *CHAM Case Study – Numerical Simulation of an Air-to-Air Cross-flow Heat Exchanger*

by Peter Spalding, CHAM Limited

A CFD model of a cross-flow heat exchanger was created following receipt of a specification from the Roads and Maritime Service (RMS) of New South Wales. RMS personnel were carrying out a numerical simulation study to predict air flow and temperature distribution in the air-to-air type heat exchanger installed in their Variable Message Sign (VMS) system.

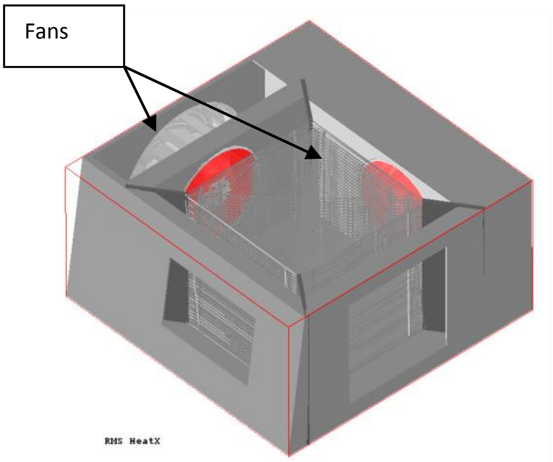


Figure 1: Cross-Flow Heat Exchanger

The electronics inside the VMS generate heat, under normal operating conditions, due to energy losses. In summer time, the temperature inside the VMS can be as high as 75˚C. The internal re-circulating air and the external cooling air are circulated by fan at a flow rate of 600m^3/h. The ambient temperature is 25˚C and the temperature of internal inlet air is 75˚C. A 2% inlet turbulence intensity was specified. The size of the heat exchanger element is 0.2m X 0.2m X 0.2m and it is epoxy coated aluminium. The rest of the enclosure is aluminium alloy grade 5005 H34 with 2.0mm thickness.

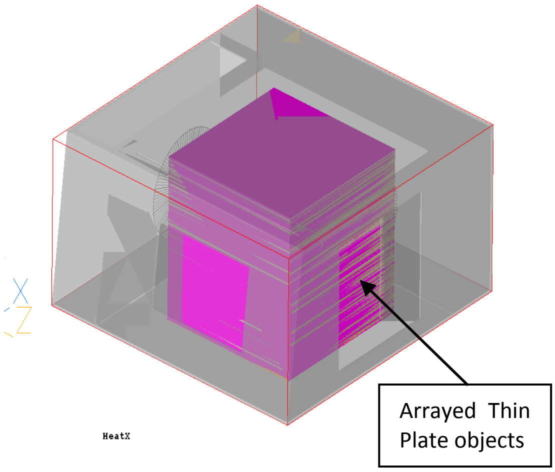


Figure 2: Cross-Flow Heat Exchanger

RMS engineers were primarily interested in using the CFD model to calculate and predict the thermal performance and effectiveness of the VMS heat exchanger under different boundary conditions (such as different internal or external inlet temperature, different air flow rate for exhaust fan etc) and how would they affect the results.

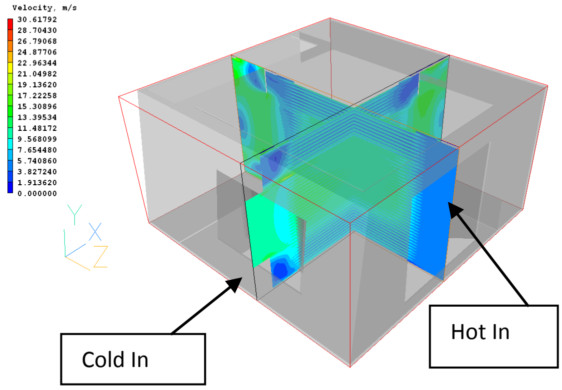


Figure 3: Velocity

The above plot shows velocity of the hot air (near right to far left) and the cooling air (near left to far right). The next plot shows the temperatures of the two air streams, and shows the heat-exchange mechanism clearly.

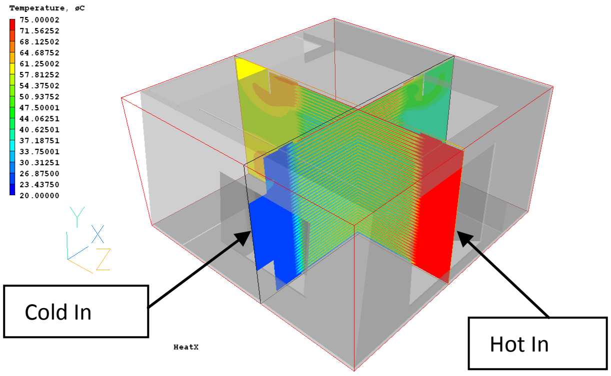


Figure 4: Temperature

Two methods of modelling the heat exchanger were considered. The first, more simplistic, option was to import the geometry from CAD and then apply a sufficiently fine mesh to capture the 80 x 2mm cross-sectional slots in the heat exchanger. However, a second, more pragmatic, method was adopted involving the replacement of this section with an array of "thin plate" objects using the same dimensions. The advantage of doing so is to remove the possibility of incorrectly defined geometry and to ensure that the heat transfer is based on the correct plate thickness, whilst using a much smaller computational mesh.

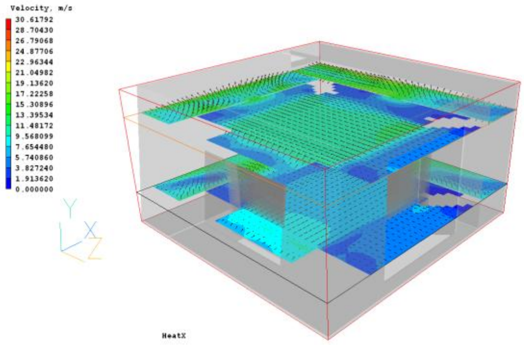


Figure 5: Velocity Vectors and Contours

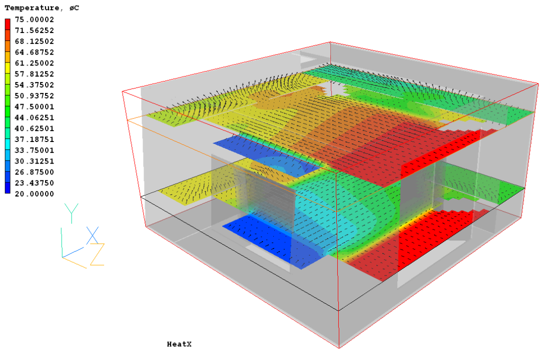


Figure 6: Velocity Vectors and Temperature Contours

The above two plots show velocity and temperature respectively, in a hot-air channel (above) and a cooling-air channel below. The cooling of the hot air and the warming of the cold air within the heat exchanger are clearly shown.

Details of the model set-up

A 3D Cartesian mesh was employed with 40 x 168 x 40 cells. PARSOL was not activated, as it is not required for the rectangular geometry of the heat exchanger. The LVEL turbulence model was used because of its suitability for flows through narrow channels, with a sparse grid resolution across the channels. The runs were reasonably converged after 1000 sweeps; this required a 75 minute run time on a single-processor 3GHz system.

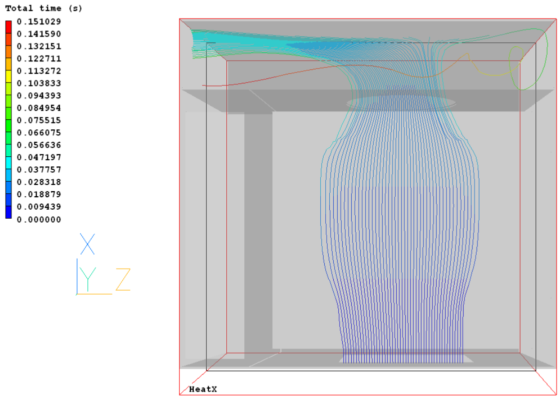


Figure 7: Streamlines x

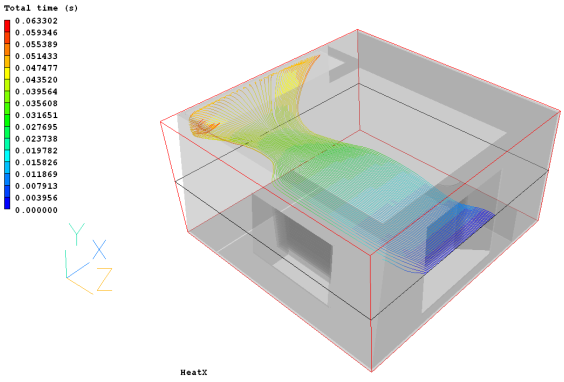
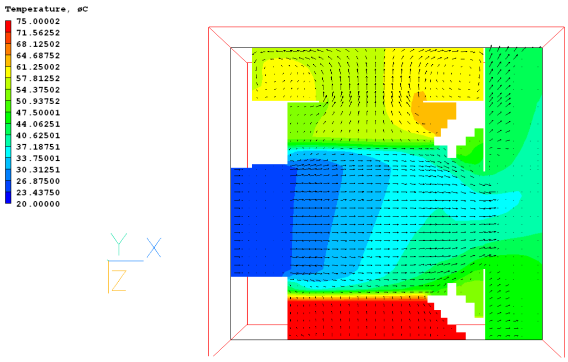


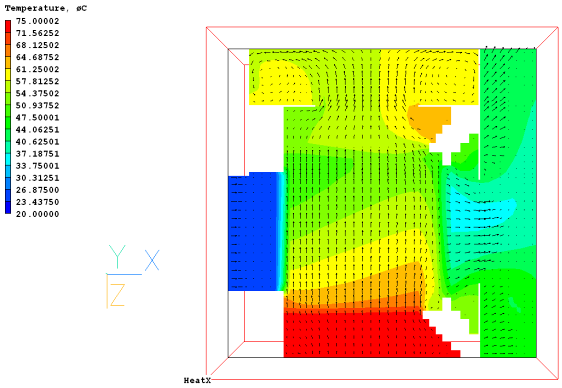
Figure 8: Streamlines -Z

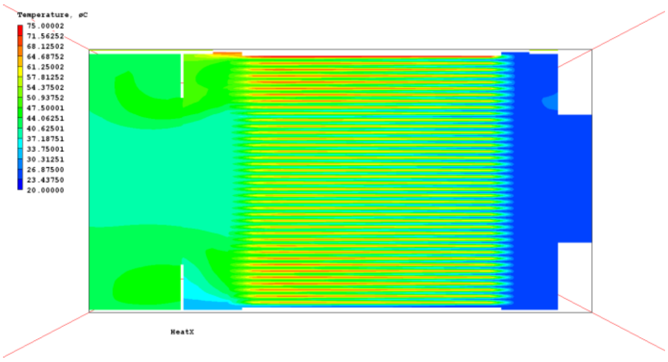
Conclusions

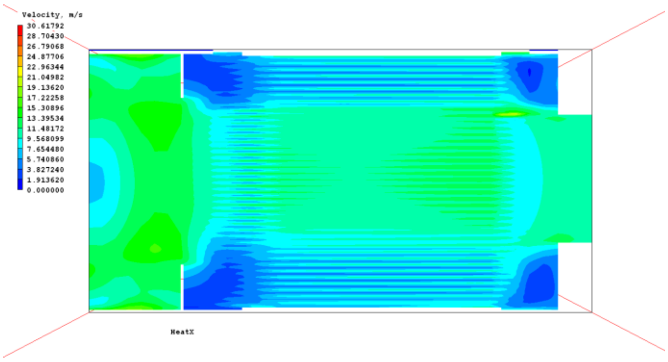
The model provides a good representation of the heat transfer processes in the heat exchanger. Close examination of the model predictions reveal non-uniformities within the heat exchanger. Air from the inlet plena impinges straight onto the central channels, while the outer channels receive air via a more circuitous trajectory. This means that the air velocities in the central channels are somewhat higher, giving better heat transfer. This can be observed directly in the temperature plots. If it were possible to spread the air more uniformly, the overall heat transfer efficiency might be improved. The CFD model can therefore function as a design testbed, which engineers can use to improve the performance of the unit.

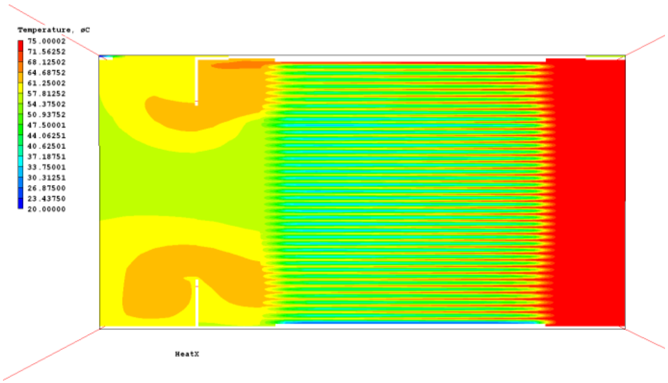
Supplementary Images – Temperature and Velocity @ Y & Z planes

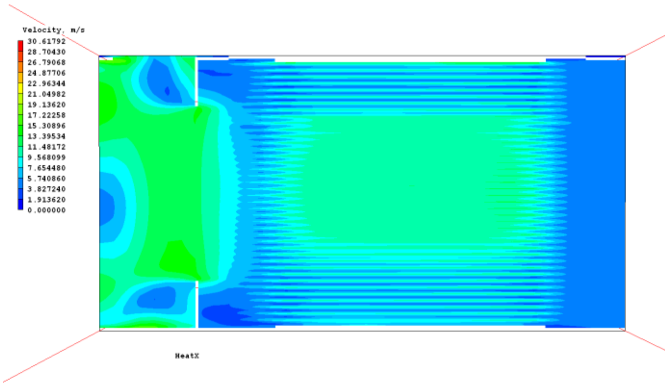












4) User Applications

4.1 F1 in Schools: Update by Fred Stillwell

http://www.f1inschools.com

"We enter 2012 with high hopes for F1 in Schools in the United States. Team Unitus defended their 2010 World Championship at the 2011 championships in Malaysia and finished 3rd overall. Two other US teams, both middle school age, also competed in Malaysia in September.

Shown above is a picture of the 8th grade girls from East Cobb Middle School. They placed 2nd at the 2011 US Nationals and then formed a collaborative team with Germany and participated at the 2011 World Finals in Malaysia. The girls have moved on to different high schools but are actively working towards this year's US Championships.

They also secured sponsorship from Porsche North America. The big news is that we have an excellent series sponsor, the Society of Automotive Engineers (SAE.) This will allow us to expand our base and also to make connections with the college level Formula SAE teams.

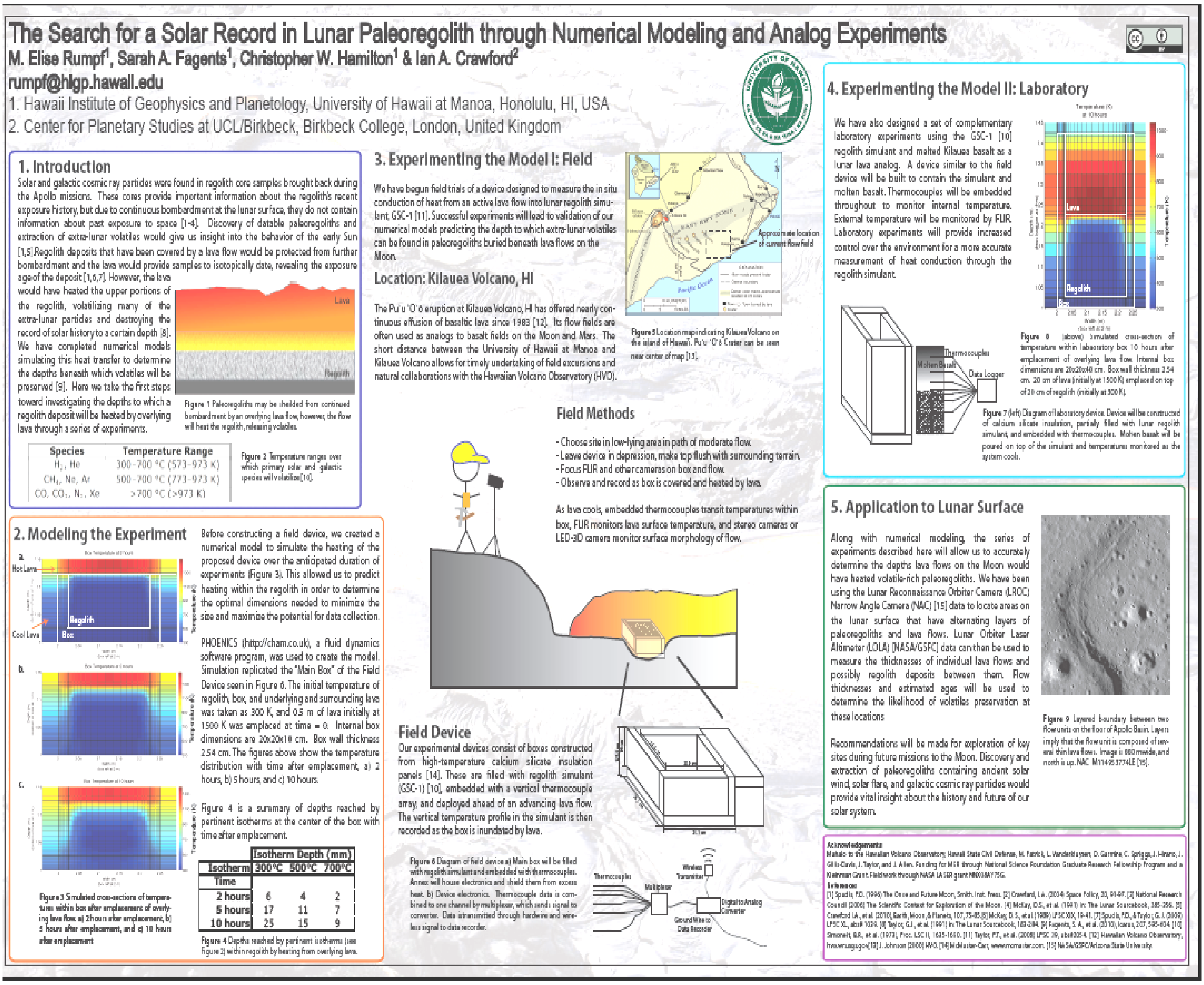
I am now writing engineering curricula for grades 6-12 at the Georgia Institute of Technology. While I am no longer directly in the classroom, I am still mentoring F1 teams. I also hope to incorporate CFD into some of the upper level curricula that I am developing. I look forward to continuing to introduce students to the concepts of CFD through the use of PHOENICS F1-VWT."

Fred C Stillwell, Program Director - Robotics
Center for Education Integrating Science, Mathematics, and Computing (CEISMC)
Georgia Institute of Technology, Atlanta, GA 30332-0282
http://www.ceismc.gatech.edu/

4.2 The Search for a Solar Record in Lunar Paleoregolith through Numerical Modelling and Analog Experiments

by M E Rumpf[1], S A Fagents[1], C W Hamilton[1] & I A Crawford[2]

1 Hawaii Institute of Geophysics & Planetology, University of Hawaii at Manoa, Honolulu, Hawaii, USA
2 Centre for Planetary Studies at UCL Birkbeck, London, UK



The Search for a Solar Record in Lunar Paleoregolith through Numerical Modeling and Analog Experiments

M. Elise Rumpf[1], Sarah A. Fagents[1], Christopher W. Hamilton[1] & Ian A. Crawford[2]
rumpf@higp.hawaii.edu
1. Hawaii Institute of Geophysics and Planetology, University of Hawaii at Manoa, Honolulu, HI, USA
2. Center for Planetary Studies at UCL/Birkbeck, Birkbeck College, London, United Kingdom

1. Introduction

Solar and galactic cosmic ray particles were found in regolith core samples brought back during the Apollo missions. These cores provide important information about the regolith's recent exposure history, but due to continuous bombardment at the lunar surface, they do not contain information about past exposure to space [1-4]. Discovery of datable paleoregoliths and extraction of extra-lunar volatiles would give us insight into the behavior of the early Sun [1,5].Regolith deposits that have been covered by a lava flow would be protected from further bombardment and the lava would provide samples to isotopically date, revealing the exposure age of the deposit [1,6,7]. However, the lava would have heated the upper portions of the regolith, volatilizing many of the extra-lunar particles and destroying the record of solar history to a certain depth [8]. We have completed numerical models simulating this heat transfer to determine the depths beneath which volatiles will be preserved [9]. Here we take the first steps toward investigating the depths to which a regolith deposit will be heated by overlying lava through a series of experiments.

Figure 1 Paleoregoliths may be shielded from continued bombardment by an overlying lava flow, however, the flow will heat the regolith, releasing volatiles.

Species	Temperature Range
H_2, He	300–700 °C (573–973 K)
CH_4, Ne, Ar	500–700 °C (773–973 K)
CO, CO_2, N_2, Xe	>700 °C (>973 K)

Figure 2 Temperature ranges over which primary solar and galactic species will volatilize [10].

2. Modeling the Experiment

Before constructing a field device, we created a numerical model to simulate the heating of the proposed device over the anticipated duration of experiments (Figure 3). This allowed us to predict heating within the regolith in order to determine the optimal dimensions needed to minimize the size and maximize the potential for data collection.

PHOENICS (http://cham.co.uk), a fluid dynamics software program, was used to create the model. Simulation replicated the "Main Box" of the Field Device seen in Figure 6. The initial temperature of regolith, box, and underlying and surrounding lava was taken as 300 K, and 0.5 m of lava initially at 1500 K was emplaced at time = 0. Internal box dimensions are 20x20x10 cm. Box wall thickness 2.54 cm. The figures above show the temperature distribution with time after emplacement, a) 2 hours, b) 5 hours, and c) 10 hours.

Figure 3 Simulated cross-sections of temperatures within box after emplacement of overlying lava flow. a) 2 hours after emplacement, b) 5 hours after emplacement, and c) 10 hours after emplacement

Figure 4 is a summary of depths reached by pertinent isotherms at the center of the box with time after emplacement.

	Isotherm Depth (mm)		
Isotherm	300°C	500°C	700°C
Time			
2 hours	6	4	2
5 hours	17	11	7
10 hours	25	15	9

Figure 4 Depths reached by pertinent isotherms (see Figure 2) within regolith by heating from overlying lava.

3. Experimenting the Model I: Field

We have begun field trials of a device designed to measure the in situ conduction of heat from an active lava flow into lunar regolith simulant, GSC-1 [11]. Successful experiments will lead to validation of our numerical models predicting the depth to which extra-lunar volatiles can be found in paleoregoliths buried beneath lava flows on the Moon.

Location: Kilauea Volcano, HI

The Pu'u 'O'ō eruption at Kilauea Volcano, HI has offered nearly continuous effusion of basaltic lava since 1983 [12]. Its flow fields are often used as analogs to basalt fields on the Moon and Mars. The short distance between the University of Hawaii at Manoa and Kilauea Volcano allows for timely undertaking of field excursions and natural collaborations with the Hawaiian Volcano Observatory (HVO).

Figure 5 Location map indicating Kilauea Volcano on the island of Hawai'i. Pu'u 'O'ō Crater can be seen near center of map [13].

Field Methods

- Choose site in low-lying area in path of moderate flow.
- Leave device in depression, make top flush with surrounding terrain.
- Focus FLIR and other cameras on box and flow.
- Observe and record as box is covered and heated by lava.

As lava cools, embedded thermocouples transit temperatures within box, FLIR monitors lava surface temperature, and stereo cameras or LED-3D camera monitor surface morphology of flow.

Field Device

Our experimental devices consist of boxes constructed from high-temperature calcium silicate insulation panels [14]. These are filled with regolith simulant (GSC-1) [10], embedded with a vertical thermocouple array, and deployed ahead of an advancing lava flow. The vertical temperature profile in the simulant is then recorded as the box is inundated by lava.

Figure 6 Diagram of field device a) Main box will be filled with regolith simulant and embedded with thermocouples. Annex will house electronics and shield them from excess heat. b) Device electronics. Thermocouple data is combined to one channel by multiplexer, which sends signal to converter. Data is transmitted through hardwire and wireless signal to data recorder.

4. Experimenting the Model II: Laboratory

We have also designed a set of complementary laboratory experiments using the GSC-1 [10] regolith simulant and melted Kilauea basalt as a lunar lava analog. A device similar to the field device will be built to contain the simulant and molten basalt. Thermocouples will be embedded throughout to monitor internal temperature. External temperature will be monitored by FLIR. Laboratory experiments will provide increased control over the environment for a more accurate measurement of heat conduction through the regolith simulant.

Figure 8 (above) Simulated cross-section of temperature within laboratory box 10 hours after emplacement of overlying lava flow. Internal box dimensions are 20x20x40 cm. Box wall thickness 2.54 cm. 20 cm of lava (initially at 1500 K) emplaced on top of 20 cm of regolith (initially at 300 K).

Figure 7 (left) Diagram of laboratory device. Device will be constructed of calcium silicate insulation, partially filled with lunar regolith simulant, and embedded with thermocouples. Molten basalt will be poured on top of the simulant and temperatures monitored as the system cools.

5. Application to Lunar Surface

Along with numerical modeling, the series of experiments described here will allow us to accurately determine the depths lava flows on the Moon would have heated volatile-rich paleoregoliths. We have been using the Lunar Reconnaissance Orbiter Camera (LROC) Narrow Angle Camera (NAC) [15] data to locate areas on the lunar surface that have alternating layers of paleoregoliths and lava flows. Lunar Orbiter Laser Altimeter (LOLA) [NASA/GSFC] data can then be used to measure the thicknesses of individual lava flows and possibly regolith deposits between them. Flow thicknesses and estimated ages will be used to determine the likelihood of volatiles preservation at these locations

Recommendations will be made for exploration of key sites during future missions to the Moon. Discovery and extraction of paleoregoliths containing ancient solar wind, solar flare, and galactic cosmic ray particles would provide vital insight about the history and future of our solar system.

Figure 9 Layered boundary between two flow units on the floor of Apollo Basin. Layers imply that the flow unit is composed of several thin lava flows. Image is 880 m wide, and north is up. NAC M114953774LE [15].

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We look forward to hearing from you.