出國報告 (European Geosciences Union General Assembly 2013)

出席「2013歐洲地質聯合會議」

服務機關：經濟部中央地質調查所

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報告日期：102年5月22日

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摘要

本出國計畫係執行核定之 102年出國計畫，出席「2013歐洲地質聯合會議」及發表水文地質調查及地下水資源評估研究成果1篇，我所參加的session為HS2.14：Measuring and modelling surface water – groundwater interactions。另同行之國內水文地質調查及地下水源評估團隊參加的sesstion為hydrological sciences - water, climate and health，共發表4篇調查研究成果。3篇為口頭報告，2篇為海報報告，其題目分別為：

「Applying Model Simulation to Identify The Importance of Protecting Groundwater Recharge Area - A Case Study of Choshuihsi Alluvial Fan,Taiwan」、「The Definition of Groundwater Recharge Area Using GIS Approach –A Case Study of Choshuihsi Alluvial Fan, Taiwan」、「Integrating Water Table Fluctuation Method and Groundwater Numerical Modeling on the Estimation of Regional Recharge Quantity of Pingtung Plain」、「Estimation of hydraulic conductivity using one dimensional electrical resistivity survey」與「The Flood Effects on Infiltration Rates in a Disconnected Stream」。

「Applying Model Simulation to Identify The Importance of Protecting Groundwater Recharge Area - A Case Study of Choshuihsi Alluvial Fan,Taiwan」是以台灣濁水溪沖積扇地下水區為例，探討地下水保護區對水質與水量上之影響；「Integrating Water Table Fluctuation Method and Groundwater Numerical Modeling on the Estimation of Regional Recharge Quantity of Pingtung Plain」是同時應用地下水歷線法與數值模擬分析屏東平原地下水水平衡；「The Definition of Groundwater Recharge Area Using GIS Approach –A Case Study of Choshuihsi Alluvial Fan, Taiwan」則是展示濁水溪沖積扇主要補注區的劃設；「Estimation of hydraulic conductivity using one dimensional electrical resistivity survey」則著重於結合地電阻成果與水質資料於區域性水力傳導係數空間分布之推估；「The Flood Effects on Infiltration Rates in a Disconnected Stream」則是探討洪水事件對河川入滲率及地下水系統之影響。

2013歐洲地質聯合會議關於水文地質及地下水資源之研究主題方面，氣候變遷仍為一重大議題，本次會議亦為重點之一，其他在地下水與地面水交互作用，對於生態、氣候變遷影響飲水健康、未來地下水資源的管理與監測，皆有相當多的研究。台灣未來在全球暖化下，導致降雨分配不平均及供應不穩定的情況下，未來水資源該如何管理，及對於地下水與地面水交換有何影響，本團隊與其它研究相互交流亦有豐碩的收獲。

壹、目的

經濟部中央地質調查所自81年起至97年執行臺灣地下水觀測網的調查研究，以建立臺灣地區水文地質基本資料，建置完善之地下水分層監測系統，長期蒐集地下水水文資料，做為地下水資源開發保育規劃之依據。並於98年起至101執行臺灣地區地下水區水文地質調查及地下水資源評估計畫，進行水文地質補充調查及補注潛勢評估，劃定重要地下水區之地下水補注區範圍，做為劃定地下水補注地質敏區之依據。展望我國未來產業的發展，衡以政府與國人對於環境保育觀念的重視，全球氣候的極端化造成降雨分布的不平均，強化地下水補注地質敏感區的調查研究，並進行劃設保育，加強掌握地表水、地下水的互動調配，能強化因應面對全球氣候的變遷。本次出席此國際研討會議，除了發表國內水文地質及地下水資源的調查成果，和國際學者進行技術及經驗之交流，另外就是要了解國際上地下水之調查進展與方法，以及相關之探測技術與經驗，提供國內後續地下水資源調查研究之規劃參考。

歐洲地質聯合會議(European Geosciences Union, EGU)每年舉辦一次，各年度均在奧地利維也納舉行，每年皆有數萬人參加，它的規模在國際上僅次於美國地球物理聯合會議(American Geophsical Union, AGU)，是歐洲相當重要的地質科學研究之交流平台。本次會議共規劃約23個議題，研討的主題包括：水文地質、能源、資源和環境、地球物理、地球化學、自然災害、地層學、沉積學等相關領域。希望透過地球科學領域各項知識與應用技術大會將匯集來自世界各地的地球科學專家，提供一個論壇，可以發表他們的作品，討論彼此的想法，達到互相交流與互相學習的目的。

今年發表的口頭報告及海報報告共有2,891篇論文，其中包含4,684篇口頭簡報，8,207篇海報簡報，簡報者來自個不同的國家，共有11,167位研究者參與，以德國、法國及英國之研究者最多，來自台灣的論文約有112篇。

貳、行程

本出國計畫行為102年4月6日至4月15日，行程表如下表所示。

表 1 出國計畫行程表

日期	地點	行程內容	備註
4月6日(星期六)	桃園機場至奧地利維也納	去程	台北時間
4月7日(星期日)	桃園機場至奧地利維也納	去程及研討會議報到	維也納時間
4月8日(星期一)	維也納	研討會議	
4月9日(星期二)	維也納	研討會議	
4月10日(星期三)	維也納	研討會議	
4月11日(星期四)	維也納	研討會議	
4月12日(星期五)	維也納	研討會議	
4月13日(星期六)	維也納	待機	
4月14日(星期日)	奧地利維也納至桃園機場	回程	維也納時間
4月15日(星期一)	奧地利維也納至桃園機場	回程	台北時間

參、過程

本次參加「2013歐洲地質聯合會議」過程分為發表國內水文地質調查研究成果及參加研討會2部分，在參加研討會部份，藉由參與研討會的過程，了解國際間學術研究潮流，本人主要著重水文地質調查相關及地下水資源評估研究等研究主題。

3.1 發表國內水文地質調查研究

本人在研討會中以海報方式發表兩篇研究，一篇與交通大學張良正教授等人共同發表之「以台灣濁水溪沖積扇地下水區為例，探討地下水保護區對水質與水量上之影響」(Applying Model Simulation to Identify The Importance of Protecting Groundwater Recharge Area - A Case Study of Choshuihsi Alluvial Fan, Taiwan)」，另一篇則與嘉南藥理科技大學陳文福副教授共同發表「濁水溪扇頂河床入滲之初步研究」(The Flood Effects on Infiltration Rates in a Disconnected Stream)(摘要如附錄 1)。

在「以台灣濁水溪沖積扇地下水區為例，探討地下水保護區對水質與水量上之影響」論文中，應用MODFLOW地下水數值模式掌握濁水溪沖積扇之水流流況，可分析地下水保護區對於補注量之影響。進一步結合MODPATH模式與前述水流流況，可掌握地下水保護區若無妥善管理下，遭受污染物影響後之污染流徑。

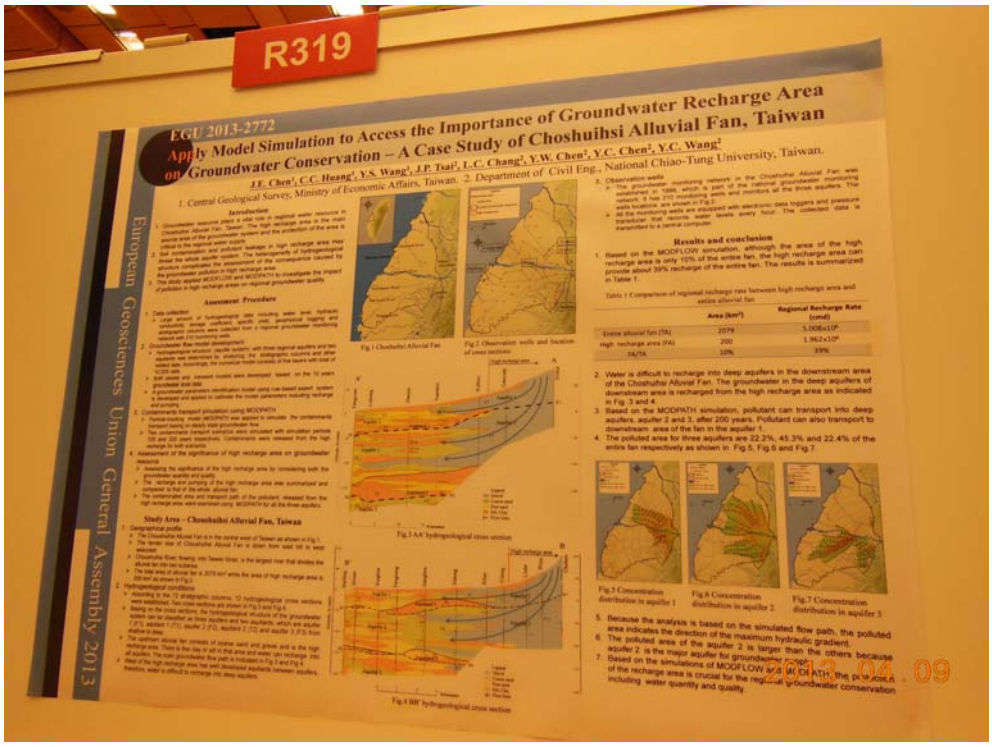

圖 1 Applying Model Simulation to Identify The Importance of Protecting Groundwater Recharge Area - A Case Study of Choshuihsi Alluvial Fan,Taiwan

在「探討洪水事件對河川入滲率及地下水系統之影響」論文中，屬於現地試驗的觀測，利用在濁水溪河床上埋設可量測溫度與張力之儀器，掌握河床間不同深度下溫度與張力間的變化，藉此間接掌握河床之入滲特性。作者實地量測濁水溪沖積扇扇頂之河床入滲率，記錄對降雨補注、河床入滲及側向補注，三項來源之比例有進一步的了解。原理是在河床面及垂直下方的河床下至少埋設兩處溫度記錄器，河床面的溫度向下傳遞時，因熱傳導及對流的影響，在河床下的溫度，其振幅及溫度序列會有所改變，利用其振幅差及溫度延遲可推算入滲流速。在EGU研討會中，也有類似的研究，例如捷克學者Pavel Ondr等人，發表「Changes in temperature of ground water during rainfall-runoff events」也是在監測降雨徑流地下水的溫度變化，來評估土壤剖面的降雨過程。

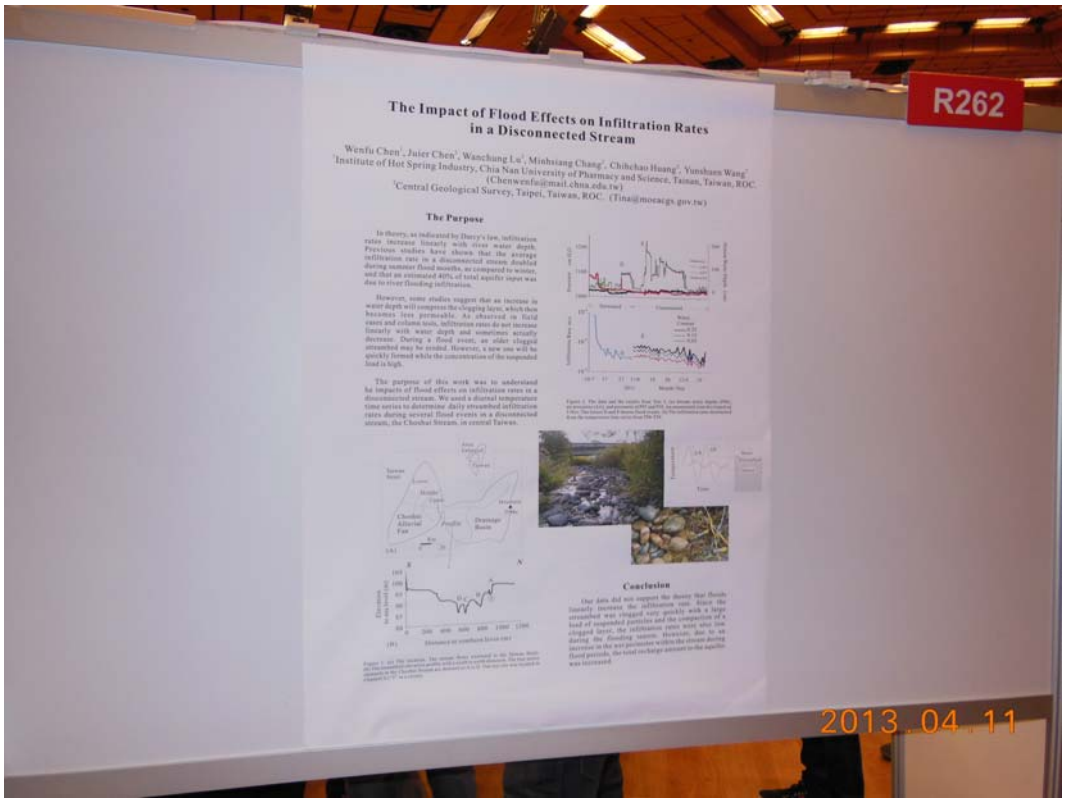

圖 2 The Flood Effects on Infiltration Rates in a Disconnected Stream

研討會中，相對於口頭報告僅能單方面傳遞資訊，海報發表可跟蒞會的各國學者進行雙向地意見交換，不僅能向國外學者報告國內在地下水方面的研究，本人亦在這個交流過程中獲益良多，從國外學者的意見中，給予不同的靈感與發想。

圖 3 國外學者閱讀論文內容

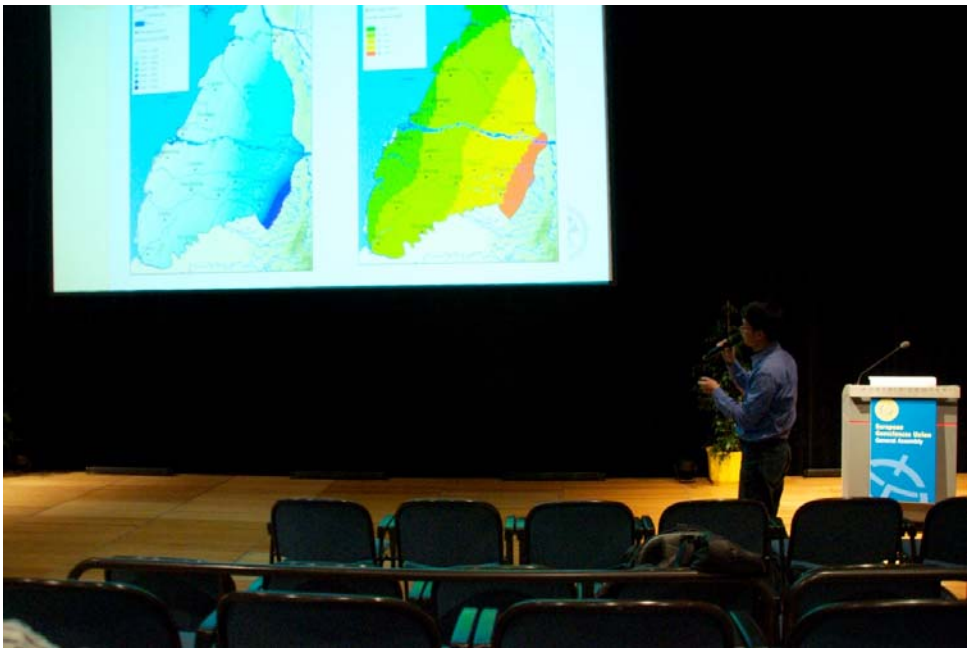

圖 4　濁水溪沖積扇地下水補注區研究成果發表

3.2 國際地下水調查研究現況與成果

EGU的發表共有海報發表與口頭報告兩種，可選擇有興趣的相關議題進行聆聽或閱讀，在與許多國家交換及分享調查成果與經驗中，了解到目前的國際學術潮流。以下區分為三大部分，分別為水文地質的現地監測與調查、地下水文地質架構與地下水資源等，以下將進一步說明：

A.　水文地質的現地監測與調查

除了傳統的地質鑽探等侵入式調查方式外，重力場量測屬於一種新的非侵入式的地球物理調查方法，重力場的變化除了可以給予地球結構上的組成，也可以作為地質動態過程變化的依據，例如用於火山岩漿庫的移動之應用。部分研究也將重力應用於集水區或地下水區之水文變化之研究。

另外，地下水文監測方面，傳統上多著重於飽和含水層之水位監測，國內亦廣泛建立地下水觀測網，廣泛觀測國內九大地下水區之分層地下水位變化。由於氣候變遷的影響，目前氣象水文條件急遽變化，歐洲地區常有酷寒或酷熱的情事發生，台灣地區則極旱與極澇之頻率亦大幅增加，地表逕流之排水能力受到未飽和含水層入滲機制之影響，而飽和含水層之補注量更是與

入滲機制息息相關。

本人在這次研討會發現，許多歐洲研究者應用長時期監測之lysimeter 設備，取得未飽和土壤中時序變化之入滲量與土壤張力剖面、含水量剖面、溫度剖面與水質水樣等研究有多方交流，進一步了解有部分案例已有長達30 年以上之監測資訊。在這樣的設備中，可藉由張力計、TDR、溫度計與重量計等不同感應器，建立不同之量測議題。歐洲研究者以這類的作法探討各式各樣的議題，包含相同土壤於不同氣候條件下，如寒帶或熱帶之入滲差異；探討土壤之各項土壤滲透特性；探討植被對於地表逕流流與土壤入滲能力之差異等。對於我們目前正進行之地下水補注區補注量評估研究目的相關。

圖 5 維持土壤不變形，針對未飽和層以 lysimeter 進行長時期之地表入滲監測與調查

圖 6 廠商展示以 lysimeter 進行地表入滲監測情形

B. 地下水文地質架構

地層的不均質性是水文地質一大特點，因此不論含水層怎麼劃分，始終都存在地下水流場及傳輸過程的不確定性。有學者利用數值模擬的方式、穩定和放射性同位素以及其他自然和人工示踪劑作為示踪劑，探討地下水的來源，追踪地下水的流動途徑、評估地下水補注量，或是用來研究地表水/地下水相互作用，都與我們目前所進行的研究方向和內容相關。Alexandra Gemitzi 等學者在「Use of stable isotopes in order to clarify complex interactions among various water bodies in a coastal aquifer system」利用氫氧穩定同位素，探討沿海的地下水含水層中，地表水、地下水及海水之間的交互作用，成果顯示在冬季除海水外的所有水體與天水線非常接近，說明降雨是地表水和地下水的主要來源，而在夏季，則低於天水線，說明發生海水入侵的行為。此外，海水和地下水的同位素組成有很大不同，所以直接進入含水層的海水入侵的可能性似乎非常低。目前國內也是以同位素的方法來了解地下水的補注來源。

德國及日本Klaus Hebig等學者於日本北海道所作的研究「Are single-well "push-pull" tests suitable tracer methods for aquifer characterization?」。push-pull test是一種先透過人工注入示蹤劑，再藉由回抽過程取回的試驗，其僅需要單井即可施測。比較注入濃度與回收濃度之貫穿曲線(breaking curve)，去了解地下之水質環境。例如：回收量少，可能土壤吸附能力強，或受到化學反應分解等。作者於大型的沖積扇未固結的含水層中，阻水層間夾出現，如何利用單井在100公尺深的地下水觀測井中，加入示踪劑以注入及抽取的方式，觀測污染物的傳輸過程並進一步了解側向水的交互作用及了解區域性地下含水層的水力特性；目前還屬於研發階段，結果還算不錯，如果可行，相較於雙井抽水試驗所需費用較高且會有場地的限制，值得國內於地下水區進行水力參數試驗者的注意。

冰河地層通常可以形成極佳的含水層，挪威地質調查局Oliver Kracht等人，在「Experiences and issues with the implementation of microscreen multilevel groundwater samplers in glaciofluvial aquifers in Southern Norway」設計每2公尺的多層次觀測井，採集水樣作地球化學分析，探討沉積環境及人類活動，也引起我的興趣。

抽水試驗與Theim公式常用於現地透水係數檢定，但是對於天然含水層之高度異質性與非等向性，Theim公式則有其侷限。德國學者Zech等人(2012)於Water Resource Research期刊上提出Effective Well Flow Method，可應用於異質非等向性地層抽水試驗之參數推估。也應用於Horkheimer Insel場址，驗證結果證明方法可行。

過去研究最多的是海洋岩心及花粉，由於儀器解析度變高 ， 例如珊瑚年輪，湖泊沉積物及洞穴鐘孔石的研究， 都可解析更頻繁的氣候變化時間序列，。法國學者Edauord bard利用質譜儀發現自末次最監冰期(18000年)以來還出現了三次的暖期，過去所出現的極端氣候都是超過我們的想像， 相較現今的氣候變化都是小事件。

在集水區的水文地質研究中，裂隙含水層中的流動和運輸過程的分析，除了必須考慮當地的非均質性外，怎樣掌握系統的裂隙分布，並可持續監測

這些地下水傳輸的管道，對於上游集水區的水文地質調查仍然是一個挑戰。有些學者利用模式的建置及地質鑽探方式，探討裂隙含水層及地下水流場的建置，這跟國內目前對於山區地下水資源的調查方向一致。此外，大會的另一個討論主題則是地下水流系統對環境所造成的影響。由於地下水過渡的抽用造成地層下陷，流場的改變引發污染物的傳輸等現象，對於地下水補注區的調查也提供了一些想法。

C. 地下水資源

在地下水資源這個議題方面，在EGU研討會可分為許多面相。以大尺度水文(Large scale hydrology)這個面相來說，以全球的觀點來討論需求對地表水與地下水資源之關連，Graaf等學者在「Dynamic Attribution of Global Water Demand to Surface Water and Groundwater Resources: Effects of Abstractions and Return Flows on River Discharge」研究中，以全球性的水文模型來模擬1960至2010間，河川出滲與灌溉入滲之變化，提供全球性的水資源與水文變化的特徵。

在EGU研討會中，亦有許多學者著重於氣候變遷與地下水資源間的關係，Critto等學者於「Assessment of climate change impacts on groundwater resources: the case study of Veneto and Friuli plain in Italy」、Antonellini等學者於「Effects of a Changing Climate on Seasonal Variation in Natural Recharge of Unconfined Coastal Aquifers」與Olioso等學者於「Modeling of drainage and hay production over the Crau aquifer for analyzing the impact of global change on aquifer recharge」等，均探討氣候變遷下地下水資源的影響，許多研究均以GCM模式搭配不同之CO^2排放情境，藉此了解地下水資源的變化。以Critto等學者之研究為例，他們以MIKE SHE/MIKE 11地下水與地表之交互機制，藉由GCM模擬模擬2021至2050年間地下水資源之變化，在他們的研究中，未來水文條件朝向越趨豐澇，因此地下水位與水資源亦隨之增加。

在模擬方面，Saada與Martin兩位學者於「Estimation of Groundwater Recharge of the Western Aquifer Basin Using Water Level Fluctuation

Approach」，以地下水歷線法來推估以色列的補注量，從1970年至2006年間年補注量約3.85億噸。在他們的研究中，也建立降雨量與補注量之關係，因此如藉由GCM模式模擬與合成氣候變遷後之降雨量，即可推估在此降雨條件下的補注量。

肆、心得與建議

本次赴奧地利維也納參加 2013 歐洲地質聯合會議行程總計十天，正式研討會共有七天，除了進行本所研究成果發表外，並觀摩與本計畫主題相關之地下水、地球物理、地球化學及地下水資源評估調查技術外，並找適當時機與國際學者進行討論與交流，不僅可以學習對方之經驗，也提供本身未來對於計畫規劃的方向提供更多不同角度的思惟。

此次參加研討會行程，認識到國際學者在基礎科學數理部分紮根很深，十分重視利用基礎調查資料進行學理上之驗證，資料展示也相當完整，讓我對於國際地下水研究領域有更寬廣的認識；而對於我們發表的論文內容則不僅符順學理且能與國際研究趨勢接軌，最大的特色是針對實地研究成果內容進行發表，此亦引起不少國際學者的興趣。

臺灣地區之地下水資源頗為豐富，惟近年來隨著社會結構的改變，致各標的需水量激增，水庫的興建又受到自然及社經條件的限制，地下水於未來勢必將持續扮演不容忽視的角色。各種目的用水競相開發結果，導致地下水過度開發利用，雖促成各項產業之發展，卻衍生許多國土資源損害及其他的環境保育問題，例如地層下陷、地下水鹽化與污染等問題。有鑑於地下水資源之高度重要性，而地下水補注區為地下水之水源地，土地或水體若受污染或不當使用，更將嚴重影響各地下水區之水質與水量。因此需精確掌握地下水資源量及地下水補注區的範圍，利用地下水流模式建置可以大尺度的評估地下水資源並作為水資源管理的依據。目前國際間皆發展非常先進的建模工具，可以減少對於預測的不確定性，值得引用；但對於模擬所需要的基本資料調查則扮演關鍵的角色，因此國內地下水及水文地質基本資料的調查及監測應持續的建立，畢竟全面且持續的記錄是所有研究的基礎。

在不斷變化的土地利用和氣候條件，國土和社會面臨自然災害與日

俱增，問題變得複雜許多，地球科學界進行跨領域研討成果及進行互相交流變成一種趨勢，國內目前於地下水補注地質敏感區的調查研究，即嘗試結合地質、土木水利、地球物理、地球化學、重力測量及水文專家共同合作，資料互相交疊分析，雖然已有不錯的成果及進展，但仍需加強和國際技術交流，吸取經驗，無論是理論或是現地調查，都能有效的解決我們在地質敏感區想要了解的資訊。

地下水是世界上最重要的且受最好的保護的資源,但也是最受剝削的淡水資源，而土壤扮演水文循環中的至關重要的角色，精確估算區域的土壤入滲量，以及掌握未飽和層的動態機制，是未來在評估地下水補注地質敏感區補注範圍及補注量一個重要的調查項目,我在 EGU 研討會中，對於這方面的調查與監測也得到了一些想法。

附錄 1發表研究成果摘要

陳瑞娥等人。

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Applying Model Simulation to Identify The Importance of Protecting Groundwater Recharge Area - A Case Study of Choshuihsi Alluvial Fan, Taiwan

Jui-Er Chen (1), Chih-Chao Huang (2), Yun-Shuen Wang (3), Jui-Pin Tsai (4), Liang-Cheng Chang (5), Yu-Wen Chen (6), You-Cheng Chen (7), and Yun-Chih Wang (8)

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Groundwater is an important source of water supply, especially for areas lacking in surface water. Many countries have delineated recharge areas to protect groundwater resources. If the areas were not protected, the groundwater quantity and quality would be affected because of human activities. To understand the importance of recharge areas, this study applied MODFLOW and MODPATH to qualify the effects after a recharge area was polluted.

This study developed a steady state groundwater simulation model consisting of three aquifers to simulate the groundwater flow of Choshuihsi Alluvial Fan. The simulation heads from MODFLOW were used as input into MODPATH to estimate concentration field. The initial condition of MODPATH was that the contamination particles were distributed on the surface of the shallow aquifer inside the recharge area and the simulation period was set as 200 years. Results shows that parts of the particles flow into the deep aquifers and parts of them flow into the distal-fan of the shallow aquifer 200 years. The result also shows that 22.2%, 45.3% and 22.4% of the three aquifers were polluted, respectively.

The second aquifer was polluted widest, this is because the confining bed at mid-fan and distal-fan between first aquifer and second aquifer were well developed. This caused the recharge of second aquifer to rely on the lateral recharge from recharge area and so does third aquifer. Furthermore, the large amount of pumpage at distal-fan of second aquifer caused groundwater level to lower. This situation makes a higher head difference between top-fan and distal-fan of second aquifer. Therefore, the contamination from recharge area has more opportunity to be transported to distal-fan.

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The Definition of Groundwater Recharge Area Using GIS Approach –A Case Study of Choshuihsi Alluvial Fan, Taiwan

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Groundwater recharge areas are regions with high permeability that accept surface water more readily than other regions. If the land use/cover were changed, it would affect the groundwater recharge. Also, if this area were polluted, the contamination easily infiltrates into the groundwater system. Therefore, the goal of this study is to delineate the recharge area of Choshuihsi Alluvial Fan.

This study applies 6 recharge potential scale factors, including land use/land cover, soil, drainage density, annual average rainfall, hydraulic conductivity and aquifer thickness to estimate the infiltration ability and storage capacity of study area. The fundamental data of these factors were digitized using GIS (Geographic Information System) technology and their GIS maps were created. Then each of these maps was translated to a score map ranged from 1 to 100. Moreover, these score maps are integrated as a recharge potential map using arithmetic average, and this map shows recharge potential in 5 levels, such as very poor, poor, moderate, good and excellent. The result shows that majority of “good” and “excellent” areas is located at the top of the fan. This is because the land use of top-fan is agricultural and its surface soil type is gravel and coarse. The top-fan, which is close to mountain areas, has a higher average annual rainfall than other areas. Also, the aquifer thickness of top-fan is much thicker than other areas. The percentage of the areas ranged as “good” and above is 9.63% of total area, and most areas located at top-fan. As a result, we suggest that the top-fan of study area should be protected and more field surveys are required to accurately delineate the recharge area boundary.

陳宇文等人

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Integrating Water Table Fluctuation Method and Groundwater Numerical Modeling on the Estimation of Regional Recharge Quantity of Pingtung Plain

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EGU 2013

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Abstract

Pingtung Plain is one of the most important groundwater areas in Taiwan. Because of the over usage of groundwater resource, several kinds of environmental impacts and natural hazards such as land subsidences and seawater intrusions have happened near the coast area of Pingtung Plain. To avoid the environmental impacts, an accurate quantification estimation of groundwater recharge is crucial for the planning of sustainable management for groundwater resources. Traditionally, groundwater numerical modeling is the most popular approach to estimate the quantity of regional recharge. Based on the assignment of different boundary conditions in numerical modeling, the spatial distribution of pumping can be accurately determined. However, because the construction process and the calculation of groundwater numerical modeling is more complex and the computational burden of numerical modeling is large, the length of the time step of numerical modeling for regional groundwater system traditionally is a month or a season which is much longer than the lengths of precipitation events. Because the low sampling frequency is like a kind of low pass filter might ignore the impact of precipitation events, a monthly numerical model is difficult to simulate the increasing quantity of groundwater storage during or after a precipitation event. Besides, because the increasing quantity of groundwater storage is the combined effect of pumping and recharge, also called net recharge, the recharge and pumping quantities are very difficult to be separated only using a numerical model. To overcome the disadvantage of numerical modeling for separating the recharge and pumping, a Water-Table Fluctuation (WTF) method can determine these two terms based on the fluctuations of groundwater levels or storage from different periods, such as draught period and flooding period. For example, because the quantity of recharge during draught period is rare enough to be ignored, the fluctuation of system information can be used to determine the potential decline quantity include pumping quantity and loss quantity. In this study, daily groundwater levels are also used in WTF to avoid the impact of low sampling frequency mentioned above. Therefore, this study propose a hybrid architecture which integrates the water balance results of

WTF and numerical modeling to estimate the the annual quantities of recharge, pumping and loss for Pingtung plain.

In this study, the integrated result demonstrate the groundwater balance analysis of Pingtung plain from 1999 to 2010. The averages of annual pumping for F1, F2 and F3-1 respectively are 133, 440 and 412 million tons and the average pumpage for the entire system is 985 million tons. The loss quantity of entire system is about 825 to 1393 million tons. The recharge quantity is about 1270 to 2124 million tons, the average quantity of recharge is 1765 million tons and the relationship between the accumulated quantities of recharge and precipitation for each precipitation event is positive based on a linear regression analysis. The linear regression model demonstrates that if every 100 (mm) of precipitation may cause 62 million tons recharge. The proposed hybrid architecture have the ability to demonstrate the status of water balance before, during and after precipitation events. The loss quantity is about the 63% of the quantity of vertical recharge and, therefore, the quantity of effective recharge is about the 37% of the quantity of vertical recharge.

Water-Table Fluctuation, Groundwater Numerical Modeling, MODFLOW, Pingtung Plain and Groundwater Recharge

陳祐誠等人

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Estimation of hydraulic conductivity using one dimensional electrical resistivity survey

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Groundwater is an important source of water supply. Understanding hydrogeological parameters is necessary before estimating groundwater resource. However, high uncertainty is expected for hydrogeological parameters such as hydraulic conductivity and storage coefficient. Traditionally, these parameters are obtained using pumping tests. Nevertheless, due to high cast, limited data can be collected. The 1D electrical resistivity survey, a relatively low cost method, provides an alternative for estimating hydrogeological parameters. Most studies that use 1D electrical resistivity survey for parameter estimation incorporate Ariche's Law. This law is used to obtain (1) the formation factor and (2) the relationship between the formation factor and field data using a regression equation. Generally, Ariche's Law is used for sandy soil and the effects resulted from clay are usually neglected and a regression equation is usually applied to the entire studied area. This study uses Ariche's Law to develop multiple regression equations for different hydrogeological conditions and takes clay into consideration for parameter estimation. The developed algorithm is applied to estimate hydraulic conductivity of alluvial fan of Chou-Shui River Basin in Taiwan. The fan top is sandy soil. The fan center and fantail have a considerable portion of mud in aquifers. Two regression equations are developed for the parameter estimation of study area.

陳文福等人

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The Flood Effects on Infiltration Rates in a Disconnected Stream

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In theory, infiltration rates increase linearly with river water depth, as indicated by Darcy's law. Previous studies show average infiltration rate in a disconnected stream was doubled during the summer flood months than the winter and estimate 40% of the total aquifer input was from river flooding infiltration. However, some studies suggest an increase in water depth will compress the clogging layer, which then becomes less permeable. Infiltration rates did not increase linearly with water depth and sometimes actually decrease, as had been observed in field cases and column tests. In a flood event, an older clogged streambed may be eroded but a new one will be forming quickly while the concentration of suspended load is very high. Our purpose is to understand the flood effects on infiltration rates in a disconnected stream. We use diurnal temperature time series to determine the daily streambed infiltration rates during several flood events in a disconnected stream, the Chohsui stream, in Central Taiwan. Our data do not support the flood dramatic increasing infiltration rate theory. The infiltration rates were also low in the flooding season because of the streambed was clogged very quickly with large load of suspended particle. However, the total recharge amount to aquifer would be increase because the increase of wet perimeter in the stream during a flood period.