出國報告（出國類別：國際研討會）

「**2018** 年亞洲大洋洲地球科學協會年會 **(Asia Oceania Geosciences Society 2018)**」國際研討會

服務機關：行政院環境保護署土壤及地下水污染整治基金管理會

姓名職稱：柯顯文 科長

派赴國家：美國夏威夷洲檀香山

出國期間：107 年 6 月 3 日至 11 日

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摘要

本次赴美國夏威夷洲檀香山參加「2018 年亞洲大洋洲地球科學協會年會 (Asia Oceania Geosciences Society 2018)」，本研討會辦理日期為民國（下同）107 年 6 月 3 日至 6 月 8 日，為期 6 天，係由亞洲大洋洲地球科學協會(Asia Oceania Geosciences Society)主辦，總計共有 2,316 篇口頭論文發表及 1,278 篇海報論文發表，以及逾 3,300 人以上產官學研各界專家學者、工程師、學生、政府代表、非政府組織代表等參與。

本次研討會議程主要可分為 8 個學門、逾 210 個子題（大氣科學、生物地球科學、水文科學、海洋科學、行星科學、太陽能與陸地科學、固態地球科學、跨學門地球科學），其中與本署土壤及地下水業務較為相關的學門為「水文科學」(Hydrological Sciences)，論文發表方式分為口頭報告及海報展示，故經評估後，本署投稿海報摘要於水文科學學門下並獲接受，現場發表 1 篇海報論文，題目為「臺灣地下水水質保護未來展望 (The Future of Groundwater Quality Protection in Taiwan)」，內容係介紹我國地下水污染防治管理歷程與各調查階段對象進展，並提出下一階段推動方向。

藉由本次研討會之參與，瞭解各國均持續地下水水質長期變化情形，並透過各式水文模式與資通訊技術，擴大調查資料的應用面向，從污染防治、災害預防、風險評估等，賦予水質監測結果更大應用價值，達到土壤及地下水資源永續利用之目的。此外，經由研討會參與及海報發表，也加強與國外學者之交流，增加我國於國際間之能見度，宣揚我國地下水水質保護策略、監測管理作為，以及前瞻性的目標與未來展望。

目錄

一、目的

近年來土壤與地下水污染議題逐漸備受世界各國關注，我國亦已於民國 89 年公布實施「土壤及地下水污染整治法」等相關法規，以維護土壤及地下水環境。然而，土壤與地下水污染來源除人為活動因素外，部分特殊地質環境亦會造成土壤及地下水一般項目自然背景值偏高，將嚴重影響地下水使用行為與產業發展狀況，因此，土壤與地下水背景濃度問題亟需政府積極面對並解決。臺灣土壤及地下水資源管理工作目前已累積豐碩成果，包括污染防治、調查、整治及管理等層面，本次以地下水水質保護為名，藉由國際研討會之參與及海報成果發表，除宣揚我國近年對於地下水水質保護持續監測並滾動式檢討調整外，與各國產官學界專業人士共同交流工作心得，吸取國際新知與評析流程，掌握各國水質監測項目與監測數據應用之發展狀況。

本次參加位於美國夏威夷洲檀香山夏威夷會議中心(Hawaii Convention Center)，由亞洲大洋洲地球科學協會(Asia Oceania Geosciences Society, AOGS)舉辦之「2018 年亞洲大洋洲地球科學協會年會」，本年會每年定期舉辦，近年來參與之專家學者人數逐年上升，相互發表、觀摩研究成果，逐漸成為亞洲大洋洲地區地球科學界發表研究成果及心得交流討論的重要會議，經此會議可瞭解國際間土壤及地下水資源管理、污染調查、永續利用、資通訊技術創新、大數據應用等新發展趨勢。

研討會議程主要可分為 8 個學門、逾 210 個子題（大氣科學、生物地球科學、水文科學、海洋科學、行星科學、太陽能與陸地科學、固態地球科學、跨學門地球科學），其中與本署土壤及地下水業務較為相關的學門為「水文科學」(Hydrological Sciences)，論文發表方式分為口頭報告及海報展示，相關議題詳列如表 1。研討會與會人員包括產官學研各界專家學者、工程師、學生、政府代表、非政府組織代表等逾 3,300 人以上，並來自於 49 個不同國家/地區。詳細議程請詳見附件 1。

地下水為我國極重要之水資源，主要做為民生、農業、工業的用水

來源，因此本署長期致力於維護地下水水質，以確保國人用水安全。地下水水質管理工作主要包括水質監測、污染調查、改善整治等面向，其涉及水化學、水文地質、水井水力、地球化學、地球物理、分子生物等專業領域，由於氣候變遷已嚴重威脅水資源供需平衡，世界先進國家皆已投入大量資源於地下水管理相關的學術理論與實務技術等發展，我國亦亟需掌握國際動態並持續滾動式檢討施政方向，以符合潮流趨勢與國人期待。

本署自民國（下同）84 年起，針對全國地下水分區共設置 453 口區域性（即背景調查）監測井，以檢測地下水背景水質。歷經 15 年採樣檢測，目前已累積超過 40 萬筆地下水水質檢測數據。另 90 年起啟動高污染潛勢事業及工業區品質管理工作，累計設置 1,977 口場置性（即污染調查）監測井。並為有效整合政府資源，99 年起進行地下水監測資訊整合作業，彙整相關單位監測數據，亦掌握高污染潛勢區域，有效達到污染保護措施。

本次結合上述執行成果發表 1 篇海報論文「臺灣地下水水質保護未來展望 (The Future of Groundwater Quality Protection in Taiwan)」，投稿於本研討會之「水文科學－地下水資源評估、調查與模擬」之子題中 (Hydrological Sciences 10: Near Surface Investigation and Modeling for Groundwater Resources Assessment)，內容係介紹我國地下水污染防治管理歷程與各調查階段對象進展，並提出下一階段推動方向，藉由參加本次研討會達到下列效益：

（一）藉由會議期間專題研討地下水水質保護與管理之契機，瞭解國際間地下水水質監測與政策管理發展之趨勢。

（二）掌握各國對於地下水水質保護與管理之經驗，提升巨量監測資料與整合管理能力，以精進我國地下水污染預防保護措施。

（三）汲取先進國家地下水環境資源管理與調查技術之最新概況，作為國內後續研擬地下水資源管理政策、健全完備法規制度、強化行政管理體系之參考。

表 1　　水文科學(Hydrological Sciences, HS)相關子議題

編號	子議題名稱
HS01	Interactions Between Water and Ecosystem - Catchment Dynamics
HS02	Interactions with Water and Ecosystem - Riparian Zone Processes
HS03	Challenges in Hydrologic Modeling
HS04	Hydroinformatics
HS05	Remote Sensing and Data Assimilation in Hydrology
HS06	Cascade Reservoir Operations and Its Impact on Hydrology and Ecology
HS07	Hydrometeorology
HS08	Hydrology in a Changing World: Challenges in Modeling
HS09	Water Resources Planning, Management and Decision-making Under Hydrological Uncertainty
HS10	Near Surface Investigation and Modeling for Groundwater Resources Assessment
HS11	Dealing with Hydrological Extremes: Theory, Simulation, and Practice
HS12	Risk Assessment Related to Hydrological, Climatic, and Environmental Changes
HS13	Urban Water-related Problems
HS14	Water Cycle Observational and Satellite Remote Sensing Data Products and Their Applications
HS15	Hydrologic Extremes in a Changing Climate
HS16	Water-related Hazards and Their Forecasting and Warning
HS17	Ecohydrological Processes and Modelling in a Changing Environment
HS18	Individual and Compound Extremes in Hydrology: Observations and Models
HS20	Hydrologic Prediction in Data-scarce Situations
HS21	Monthly to Seasonal Projection of Extreme Climatic/hydrological Events
HS22	Climate Change Risk Assessment and Adaptation on Water-related Disaster and Water Resources in Asia and the Pacific
HS23	Hydrological Processes in Agricultural Lands
HS24	The Third Pole Environment - Hydrometeorological Processes and Human Dimension
HS25	Hydrologic Prediction and Measures Considering Extreme Climate Conditions
HS26	Global Cryosphere and Its Challenges
HS27	Extreme Erosion Processes, Hydrological Drivers and Connectivity
HS28	Impacts of Climate Change on Floods, Droughts, and Water Availability in Asian Countries
HS30	Ecohydrological Responses to Environmental Changes and Efficient Water Resources Management in Dryland Regions

編號	子題名稱
HS31	At the Edge of Hydrology: Natural- and Human-induced Changes in Fluxes Across the Land-ocean and Land-atmosphere Interfaces with Impacts on Global and Regional Water Cycle
HS32	Hydrometeorological Analysis of Natural Hazards
HS33	Modeling and Analysis of Hydrologic Processes in the Context of Climate Change
HS34	Monitoring and Modelling SPAC Hydraulic Gradient to Improve Estimation of Plant Transpiration and Water Stress

二、過程

（一）研討會

本次「2018 年亞洲大洋洲地球科學協會年會 (Asia Oceania Geosciences Society 2018)」國際研討會係由亞洲大洋洲地球科學協會(Asia Oceania Geosciences Society, AOGS)主辦。本研討會自 2004 年起，每年 6~8 月間召開，本年度會議時間為 107 年 6 月 3 日至 8 日，研討會中論文發表形式可分為口頭報告及海報論文展示，口頭報告於不同會議室進行各項議題之成果發表，海報論文於每日下午安排不同展示主題，與會者與作者可於展示期間相互交流。依據議題類別及本署推動業務需求，本次參與行程如表 2 所示，研討會現場相關照片如圖 1 所示。以下綜合本次與會過程依照議題重點條列說明，詳細摘要及發表資料內容請詳見附件 2 所示。

1. 地下水資源研析及永續利用

本議題主要講述將地下水長期蒐集之大數據,應用於多元水文模型上提供更準確之水資源管理策略參考,並透過雲端平台架構模式元件，提升管理的即時性及數據應用價值，以達水資源永續利用、生生不息之長期願景，各研究重點摘錄如下。

(1) 參考聯合國環境規劃署(UNEP)將旱地定義為乾旱指數(年平均降雨量與潛在蒸散量之比)小於 0.65 的區域。利用此定義，中國進行乾旱地區生態水文變化觀測值與模擬值之系統評估研究，研究初步結果指出，水文流量模擬需同時參考蒸散量、土壤濕度、地下水觀測等,已達較好的模擬預測結果,並須利用不同的氣候模型、地表模型、統計分析軟體等，進行反復的推估模擬運算，如此詳細的評估過程是對乾旱地區水資源管理技術、方法和策略制定上的一個重要步驟，目前研究仍持續進行中。

(2) 過去韓國在管理水資訊上，存在著各部門組織相互間資料蒐集、

管理、分享、數據分析的障礙，但近年在資訊參與及技術共享下，應用雲端介面即時管理監控，公民營部門可相互合作創造價值，從而更有效率地找出解決方案和制定政策，並提供災害預警與水資源管理應變作業使用。

(3) 參考各國在氣象、水利等應用技術，應結合眾多單位地下水監測大數據資料，開發以網頁架構、線上運算之視覺化模式，應用雲端平台即時模擬評析，提供地下水管理決策與研究上更即時的輔助工具，在資料格式整合、網路介面設計等突破下，隨著資通訊技術快速發展，將為地下水大數據管理之未來世界趨勢。

2. 地下水水質指標管理

本議題主要講述利用地下水長期蒐集之大數據進行統計分析，找出各水質參數間關聯性及關鍵代表性項目進行定期監測，並針對不同使用目的，給予適當濃度標準與訂定危害警戒值，各研究重點摘錄如下。

(1) 韓國金泉市研究以 250 組地下水水質樣品分析結果，結合空間統計分析與地理資訊系統，發現大部分水質檢驗項目間有較強的空間依賴性，僅硫酸鹽、硝酸鹽與溫度屬中弱依賴性，研究亦發現部分高硝酸鹽濃度區域可能是受農業污染所造成之結果。

(2) 日本埼玉縣從 2010 起有地下水監測計畫，監測井數約為 804 口，定期監測溫度、pH、導電度、溶氧、氧化還原電位、陰陽離子、重金屬等，此研究目標為地下水於熱交換系統中的適用性，研究時發現地下水不適用於熱交換系統的區域，多受到水中硬度偏高與硝酸鹽高濃度有關，又該區域多與農業生產活動密集區重疊。

(3) 中國北京的飲用水資源很大一部分來自喀斯特地層中地下水，佔總供水量 70%，研究地點為位於北京西南部的房山地區，此區地下水主要為緊急供水時期使用，研究探討地下水水流系統與水文變化、地下水分布與化學成分特性等，研究結果顯示地質構造對

於水文流動、水質化學成分有重要的影響作用，然而，人為的活動(例如不斷的開採礦石)，也會對地下水水質化學成分產生顯著影響,此影響可能受到地下水在不同地質結構中停留的時間不同、以及與含水層中不同礦物接觸的時間不同，而有所變化，研究結果將可提供行政機關進一步有效的管理與保護地下水資源。

3. 地下水污染項目對環境之衝擊

本議題主要講述過高的硝酸鹽濃度會致使地下水不利於使用,研究濃度變化因子或利用模式推估評析,可使我們提前制定因應對策、降低對環境的衝擊,而對於污染物質在環境分布與濃度變化之狀況，係受人為污染或自然地質成因所致，透過調查與監測，可掌握污染影響程度並採取必要之作為，各研究重點摘錄如下。

(1) 韓國蒐集 2001~2013 年間的地下水監測井硝酸鹽濃度數據，比較農業活動、民生廢/污水量、自來水量等資料，研究推估近年來地下水硝酸鹽濃度減少，主要與農業耕地面積減少有關，但仍指出民生污水處理量的改善，將有助於降低環境中硝酸鹽累積與污染情形。

(2) 美國紐約市供水系統中有 90%來自 Croton & Catskill / Delaware 集水區內的水庫，研究者以 RHESSys 模式利用水、碳、氮循環和傳輸過程，推估自不同植被與山坡水文條件之集水區內，流出之溶解有機碳與硝酸鹽濃度變化，有助於行政機關提前制定行動方針，動態調整管理策略。

(3) 在韓國一個油品污染場址中，利用多變量統計分析與 Mann-Kendal 趨勢模擬與 CFM 模型,研究 BTEX 污染物長期在地下水中的變化，以及與現地其他觀測項目之間的關聯性，結果顯示 BTEX 的下降與硫酸鹽、硝酸鹽、錳離子等有較良好的相關性，模式預測下濃度也有良好的自然移除率。

(4) 墨西哥 Puebla 谷以 98 口井研究位於火山帶的民用地下水含水

層，發現硼濃度與斷層、地層裂隙有關；研究中有 19 口井硼濃度達 2.1~5.0 mg/L (國際建議值為<1 mg/L)，又從深層含水層中檢出高濃度之硫酸鹽與溶解固體物，顯示地下水深淺層間可能存在熱液混合過程，導致富含硼濃度之地下水往地表移動。

(5) 韓國江原 Haean 盆地位於海拔約 400m 高度，四周山地相對高度差達 600~800m，本研究測量地下水中氡(Rn)的濃度以了解氡在地下的分布情形，結果顯示深層井的氡濃度相對淺層井較高，推測原因是深層母岩(花崗岩)暴露於鈾的放射性衰變下，而釋放氡進入地下水中。

4. 地下水受全球氣候變遷之影響

本議題主要講述在全球氣候變遷下，使淡水資源不足的地區面臨更大挑戰，許多地區在地下水水質與水量均屬高風險的狀況下，提出利用更完善的監測系統與模式分析，來提升地下水資源利用效率，並監測預防水資源水質遭受污染帶來更嚴重的影響，各研究重點摘錄如下。

(1) 由於東加沒有足夠的集水區與淡水供給系統，水質與水量均屬於高風險的狀況，為提供東加政府正確制定策略應對，APCC 與東政府合作研究建立湯加地下水資訊系統(ToGWIS)，利用地下水監測系統及網路模型分析，來預測管理水資源，期許在東加面臨氣候變遷水質、水量均受影響下，能加強地下水資源的評析策略，朝向水資源永續利用邁進。

(2) 中國內蒙河套平原受全球溫度上升與區域都市發展影響，地下水中的鹽度以每年 0.071 kg/m^3 的速度累積增加，需即時調整土地利用方式避免土壤劣化。

(3) 模擬預測台灣濁水溪流域 30~50 年後氣候變遷，模擬結果指出受氣候變遷影響河水流量恐減少 20%、地下水位面亦將顯著降低，建議行政部門宜預先展開應變對策，開發水資源並搭配土

地利用政策妥善管理，降低民眾生命財產受到威脅之機會。

表 2　本次參與之研討會行程

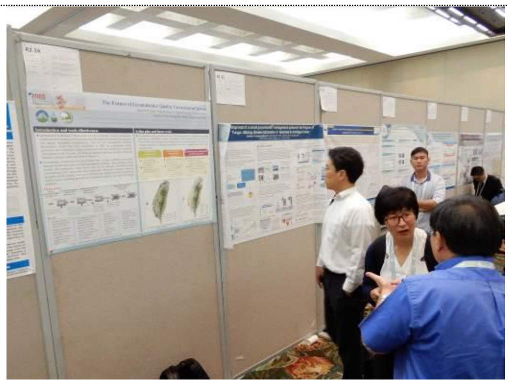
日期	工作內容概要
6 月 3 日	啟程臺北－檀香山
6 月 3 日	2018 年亞洲大洋洲地球科學協會年會註冊報到與場地確認
6 月 4 日	參加 2018 年亞洲大洋洲地球科學協會年會 一、開幕式 (Opening & General Assembly) 二、水文科學 (Hydrological Sciences) （1） 集水區的水與生態系統相互作用 (Interactions Between Water and Ecosystem - Catchment Dynamics) （2） 河岸間的水與生態系統相互作用 (Interactions with Water and Ecosystem - Riparian Zone Processes) （3） 水文模式建構的挑戰 (Challenges in Hydrologic Modeling)
6 月 5 日	參加 2018 年亞洲大洋洲地球科學協會年會 一、水文科學 (Hydrological Sciences) （1） 農地水文變化過程 (Hydrological Processes in Agricultural Lands) （2） 面對水文預報的不確定性(Confronting Uncertainties in Hydrological Forecasting) （3） **發表本署論文海報「臺灣地下水水質保護未來展望 (The Future of Groundwater Quality Protection in Taiwan)」**
6 月 6 日	參加 2018 年亞洲大洋洲地球科學協會年會 一、水文科學 (Hydrological Sciences) （1） 在水文不確定性情境下的水資源規劃、管理與決策制定 (Water Resources Planning, Management and Decision-making Under Hydrological Uncertainty) （2） 近地表之地下水資源評估調查與模式建構 (Near Surface Investigation and Modeling for Groundwater Resources Assessment)
6 月 7 日	參加 2018 年亞洲大洋洲地球科學協會年會 一、水文科學 (Hydrological Sciences) （1） 都市裡與水相關的問題(Urban Water-related Problems) （2） 在水文學邊緣：自然或人為致使的陸－海與陸－空通量變化，以及對全球與區域水循環的衝擊 (At the Edge of Hydrology: Natural- and Human-induced Changes in Fluxes Across the Land-ocean and Land-atmosphere Interfaces with Impacts on Global and Regional Water Cycle)
6 月 8 日	參加 2018 年亞洲大洋洲地球科學協會年會 一、水文科學 (Hydrological Sciences) （1） 亞洲大洋洲地區於水相關災害及水資源上的氣候變遷風險評估與適應 (Climate Change Risk Assessment and

日期	工作內容概要
	Adaptation on Water-related Disaster and Water Resources in Asia and the Pacific)」 二、跨學門地球科學 (Interdisciplinary Geosciences) （1） 利用水的穩定同位素追蹤水文氣象、生態水文及水文過程 (Tracing Hydrometeorological, Ecohydrological and Hydrological Processes Using Stable Water Isotopes) 三、閉幕式 (Closing & Awards)
6 月 9 日	檀香山參訪
6 月 10 日	返程檀香山－臺北
6 月 11 日	返程檀香山－臺北

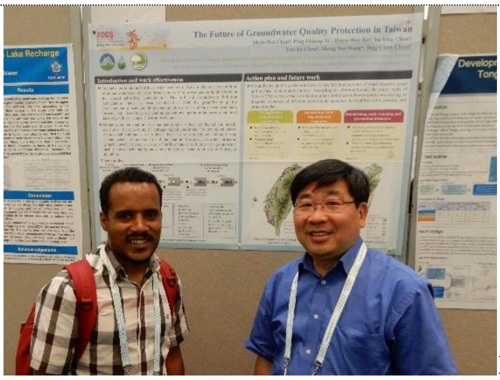
會場報到註冊

開幕式 AOGS 主席致詞

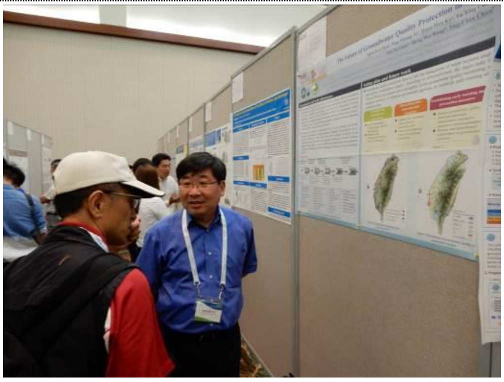
AOGS 主題專區演講



本署海報發表場地



本署海報解說現場



本署海報解說現場

觀摩參展廠商

觀摩參展廠商

圖 1 研討會相關照片

（二）本署海報發表

本次研討會中，本署發表 1 篇海報論文「臺灣地下水水質保護未來展望 (The Future of Groundwater Quality Protection in Taiwan)」內容係介紹我國地下水污染防治管理歷程與各調查階段對象進展，進一步提出完善井網密度、跨部會資源整合、研析趨勢並建立潛勢區分布等下階段目標，內容概述如下，海報如圖 2 所示。

1. 地下水為臺灣重要之水資源之一，過去十多年臺灣經濟蓬勃發展導致臺灣地下水資源大量耗損且造成地下水污染情形，爰此，行政院環境保護署(以下簡稱本署)於 2000 年公布實施「土壤及地下水污染整治法」，並成立土壤及地下水污染整治基金，以辦理土壤及地下水污染防治及整治工作。本署近十年來已陸續完成土壤及地下水高污染潛勢之調查工作。

   (1)於 1995~2002 年間設置區域性監測井，並自 2002 年起常態性辦理定期監測，透過長期數據建立背景水質參考建議值。

   (2)自 2001 年起陸續辦理調查工作，調查區域包括加油站、運作中工廠、廢棄工廠、軍事營區及民航站等。在污染調查的過程中，共計設置場置性監測井逾 1,900 口。

   (3)自 2010 年起整合土壤及地下水監測資料，共計蒐集逾 72,000 筆水質數據。並自 2011 年起推動目的事業主管機關檢測備查作業，各目的事業主管機關設置監測井逾 930 口，至今已累及達 9,200 筆備查水質數據。

2. 一般而言，地下水污染整治期程較土壤污染整治漫長，故建議應確實掌握區域水文地質條件及連續地下水水位等資料，以加速地下水污染整治進度。除了上述工業行為造成地下水污染之外，農業行為及自然地質條件等因素亦會影響地下水水質品質，包括海水入侵造成地下水鹽化狀況、地質條件造成砷從礦物釋出於地下水之中、過量農業施肥導致地下水硝酸鹽氮濃度偏高等現象。

3. 為提升臺灣地下水水質保護工作，本署將強化地下水污染監測，並整合跨部會資源，以建立地下水預警與保護措施，具體實施策略包括：(1) 完備地下水水質監測井井網密度，並搭配監測設備提升地下水水質時間與空間之掌握程度；(2) 整合經濟部水利署及中央地質調查所之環境資源，提升地下水污染調查及整治成效；(3) 研析地下水水質趨勢並建立污染潛勢分布，推動環保、農業、經濟等跨部會地下水污染預防保護措施。

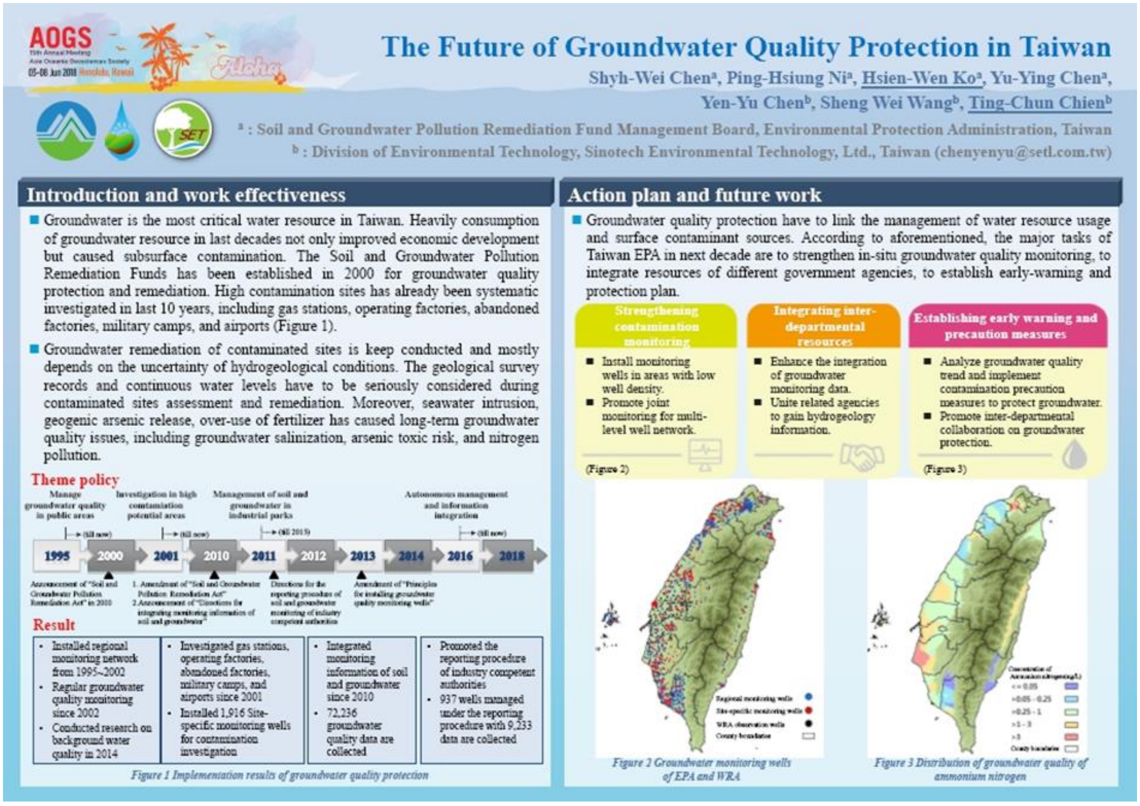


圖 2 本署發表之電子海報

三、心得與建議

（一） 心得

1. 亞洲大洋洲地球科學協會(AOGS)成立於 2003 年，旨在促進地球科學發展及其在人類福祉上之應用，由於亞洲大洋洲地區多為易受自然災害影響區域，透過科學、社會與技術等方式，來加強吾人對於自然災害發生的認知，並深入參與並解決這些議題；每年定期召開年會，2018 年吸引亞洲大洋洲地區及其他區域逾 51 個不同地方的專家學者與會、觀摩與發表研究成果，為亞洲大洋洲地區地球科學界發表研究成果及心得交流討論的重要會議。透過會議中各研究地發表，了解國際間地下水資源規劃管理與決策制定、水文模式建構、水循環及水域與生態系統之相互作用等議題之最新發展趨勢等。尤其近年來全球氣候變遷、乾旱等因素，引發地下水水質鹽化、降雨預測不確定性、洪氾頻率增加等，使得地下水資源管理預測更為艱鉅，本次會議中看到多篇研究蒐集地下水定期監測成果，利用水質數據來進行水資源評析、模擬與預測，本署亦整合歷年監測數據與地下水管理作為，發表相關主題論文海報 1 篇（如附件），並進一步提出完善井網密度、跨部會資源整合、研析趨勢並建立潛勢區分布等下階段目標，顯示我國在地下水管理方面已屬十分先進。

2. 在資通訊技術快速發展的帶動下，近年水文模式快速擴大應用於水文科學中的各個領域，作為提供吾人模擬、追溯與預測之工具，進而可推衍出各種極端情境提前制定因應策略；本次會議中對於水文模式建構中的挑戰，探討多個面向議題如：(1)不同尺度下的水文模式建構與預測(Hydrologic Modeling and Forecasting)及其不確定性(Uncertainties)之探討，包含臺灣、美國、韓國、澳洲、印度等；(2)流域逕流預測(Runoff Predictions)與洪氾災害(Flood Hazard)之研究，包含英國、日本、韓國、香港、新加坡等；(3)近地表之地下水資源評估調查(Near Surface Investigation)，包含臺灣(本署論文海報發表)、美國、香港、中國等；(4)地下水補注與傳輸，包含臺灣、澳洲、中

國等。

3. 本次會議發表多篇地下水污染物調查研究和管理相關主題論文,主要內容及研究國家或地區包含:(1)地下水鹽化問題,包含中國內陸黃河河套盆地因人為活動快速增加導致淺層地下水鹽分累積之研究、日本東京新島預測未來重大海嘯侵襲時地下水鹽化與回復之研究等;(2)地下水中硝酸鹽濃度研究與評估,包含美國紐約水庫中上游森林集水區溶解有機物與硝酸鹽流入濃度之模擬與研究、日本長崎縣島原市研究地下水化學特性與硝酸鹽污染的污染來源相關性、韓國慶尚北道金泉市研究地下水中陰陽離子的空間變異性與特徵等;(3)地下水中微量元素污染濃度探討,包含墨西哥中部火山帶 Puebla 谷中含水層中硼濃度受火山活動影響之研究等。

（二） 建議

1. 本次會議許多研究指出在全球氣候變遷、乾旱、劇烈降雨、洪氾災害等不利因素下,應加強重視地下水資源保育與管理;我國透過 453 口區域性地下水監測井網,推動地下水水質監測與管理計畫,觀念及作法尚屬先進,惟未來針對上游流域集水區、山區地下水水質水量等,仍應進一步推動跨部會資源整合,提升預警保護成效,資料整併後,可使水文地質模式資料庫更趨完整,建構完善模式提供評估建議;針對歷年蒐集之大數據,可結合資通訊與網路平台,加強數據的可視化(visualization)與應用產出,必能提升整體地下水管理與決策過程之效率。

2. 本次會議針對地下水污染問題之調查與因應作為之研究,包含硝酸鹽濃度研究、內陸或沿海地區地下水鹽化、微量元素污染等,可與國內地下水區域性監測井監測結果進行參照比對,提供我國持續針對地下水污染監測標準及管制標準進行滾動式檢討時,評估納管或修正標準。

3. 本次會議本署發表海報論文一篇,經由海報展示與說明介紹,與國外學者相互交流,宣揚我國地下水管理歷程與階段推動作法,獲得國外

學者專家肯定。於會議中，亦看到韓國、中國、日本等，亦有許多區域地下水質探討研究案例，亦值得我們參考借鑒。

四、附件

附件一 研討會議程

Sun-03 Jun	Mon-4 Jun	Tue-5 Jun	Wed-6 Jun
Build-up 8:30am to 2pm Volunteer Training 11am to 2pm Room 327	Conference Registration 7:30am to 6pm	Conference Registration 7:30am to 6pm	Conference Registration 7:30am to 6pm
	AM1 Oral 8:30 to 10:30am	**AM1 Oral** 8:30 to 10:30am	**AM1 Oral** 8:30 to 10:30am
	AM Coffee/Tea 10:30 to 11am, Ballroom B	AM Coffee/Tea **Innovation Theatre** 10:30 to 11am, Ballroom B	AM Coffee/Tea **Innovation Theatre** 10:30 to 11am, Ballroom B
	AM2 Oral 11am to 12:30pm IG**: **Kamide Lect** & **Section DL** PS: **Kamide Lect** & **Section DL** 11:30 am to 12:30pm	**AM2 Oral** 11am to 12:30pm HS: **Kamide Lect** & **Section DL** ST: **Kamide Lect** & **Section DL** 11:30 am to 12:30pm	**AM2 Oral/Workshop*** 11am to 12:30pm AS: **Kamide Lect** & **Section DL** BG: **Kamide Lect** & **Section DL** 11:30 am to 12:30pm
	Section Meetings* 12:30 to 1:30pm (Includes Packed Meals)	Lunch Break 12:30 to 1:30pm Regional Advisory Committee Meeting 12:30 to 1:30pm Room 327 (By Invitation Only)	Lunch Break 12:30 to 1:30pm Publication Committee/Editorial Board Meeting 12:30 to 1:30pm Room 327 (By Invitation Only)
Conference Registration 2 to 6pm Council Meeting 4 to 6pm Room 328 AOGS-LAC Meeting 18:30 Ala Moana Hotel (By Invitation Only)	**PM1 Oral** 1:30 to 3:30pm	**Poster Session** HS, ST 1:30 to 3:30pm Ballroom B **PM1 Oral/Special** 1:30 to 3:30pm	**Poster Session** AS2, BG 1:30 to 3:30pm Ballroom B **PM1 Oral/Special** 1:30 to 3:30pm
	Booth Dressing 3 to 6pm PM Coffee/Tea 3:30 to 4pm Ballroom B	PM Coffee/Tea **Innovation Theatre** 3:30 to 4pm, Ballroom B	PM Coffee/Tea **Innovation Theatre** 3:30 to 4pm, Ballroom B
	AOGS2018 Opening **Axford Lectures** General Assembly 4 to 6:30pm	**PM2 Oral*** 4 to 6pm	**PM2 Oral*** 4 to 6pm
		Field Trip **Pacific Tsunami Warning Centre** 8:15 to 11:45am Ticketed Event: Book/Pay in Advance	**Field Trip** **Hawaii Institute for Marine Biology** 9am to 1:45pm Ticketed Event: Book/Pay in Advance
	Welcome Reception (Exhibition Opens) **Poster Session** AS1, IG, PS 6:30 to 8:30pm Ballroom B **Innovation Theatre** 6:45 to 7:15pm & 7:30 to 8pm Ballroom B		AOGS-NASA Advance Planning Meeting 6 to 7pm, Room 327 (By Invitation Only)
		All Day Exhibition - 9:30am to 6pm, Level 4 - Ballroom B	**All Day Exhibition - 9:30am to 6pm, Level 4 - Ballroom B**

附圖 1 大會議程(1/2)

Sun-03 Jun	Thu-7 Jun		Fri-8 Jun		Sat-9 Jun
Build-up 8:30am to 2pm Volunteer Training 11am to 2pm Room 327	Conference Registration 7:30am to 6pm		Conference Registration 7:30am to 4pm		Council Meeting 09:00 to 12:30 Room 328 (By Invitation Only)
	AM1 Oral 8:30 to 10:30am	**All Day Exhibition - 9:30am to 6pm, Level 4 - Ballroom B**	**AM1 Oral** 8:30 to 10:30am	**All Day Exhibition - 9:30am to 4pm, Level 4 - Ballroom B & Tear Down / Ship-Out - By 5pm**	
	AM Coffee/Tea **Innovation Theatre** 10:30 to 11am, Ballroom B		AM Coffee/Tea **Innovation Theatre** 10:30 to 11am, Ballroom B		
	AM2 Oral 11am to 12:30pm OS: **Kamide Lect & Section DL** SE: **Kamide Lect & Section DL** 11:30 am to 12:30pm		**AM2 Oral** 11am to 12:30pm		
	Lunch Break 12:30 to 1:30pm AOGS2020 Advance Planning Meeting 12:30 to 1:30pm Room 327 (By Invitation Only)		Lunch Break 12:30 to 1:30pm Council Lounge 12:30 to 1:30pm Room 328		
Conference Registration 2 to 6pm Council Meeting 4 to 6pm Room 328 AOGS-LAC Meeting 18:30 Ala Moana Hotel (By Invitation Only)	**Poster Session** OS, SE 1:30 to 3:30pm **PM1 Oral/Special** 1:30 to 3:30pm Ballroom B		AOGS2018 Closing **Special Lectures** Awards & Recognition AOGS2019 Presentation 1:30 to 4pm, Ballroom A **Innovation Theatre** 3:30 to 4pm, Ballroom B Farewell Reception 4 to 5pm, Ballroom A		
	PM Coffee/Tea **Innovation Theatre** 3:30 to 4pm, Ballroom B				
	PM2 Oral/Workshop* Meet-the-Experts 4 to 6pm, Ballroom B Foyer				
	Field Trip **Coastal Geology of Oahu** 9am to 4pm Ticketed Event: Book/Pay in Advance		Convener's Dinner "Fri-Night Fireworks Cruise" Depart for Harbour: 4:30pm Cruise Ends: 8:15pm Ticketed Event: Book/Pay in Advance		
	Student Volunteer Night Hiking Hawaii Café 7 to 9pm		**Field Trip** **Waikiki Beach Coastal Management** 12:30 to 2:30/4:30pm Ticketed Event: Book/Pay in Advance		

附圖 1 大會議程(2/2)

Day 1 - 04 Jun 2018, Monday
Program Overview

04 Jun 2018, Monday				
Time / Room	AM1	AM2	PM1	PM2
	08:30 - 10:30	11:00 - 12:30	13:30 - 15:30	16:00 - 18:00
MR301	HS03 (p50)	HS03 (p50)	HS03 (p51)	
MR302A	SE19 (p66)	SE19 (p66)	SE19 (p66)	
MR302B	AS12 (p37)	AS12 (p37)	AS36 (p43)	
MR303A	AS55 (p47)	AS55 (p48)	AS54 (p46)	
MR303B	AS19 (p39)	AS36 (p43)	AS19 (p40)	
MR304A	ST11 (p74)	ST11 (p74)	ST06 (p72)	
MR304B	BG01 (p48)	BG01 (p49)	PS01 (p60)	
MR314	SE22-35 (p69)	SE22-35 (p69)	SE22-35 (p70)	
MR315	AS31 (p41)	AS31 (p42)	AS31 (p42)	
MR317A	ST20 (p75)	ST20 (p75)	ST10-21 (p73)	
MR317B	OS06 (p57)	OS06 (p58)	OS20 (p58)	
MR318A	HS01 (p49)	HS02 (p50)	HS16 (p53)	
MR318B	HS30 (p53)	HS30 (p54)	HS06 (p52)	
MR319A	AS09 (p34)	AS09 (p34)	AS09 (p35)	
MR319B	SE20 (p67)	SE20 (p68)	SE20 (p68)	
MR321A	SE18-34-37 (p64)	SE18-34-37 (p64)	SE18-34-37 (p65)	
MR321B	SE10 (p63)	SE10 (p63)	SE04 (p62)	
MR322A	OS02-AS (p56)	OS02-AS (p56)	OS02-AS (p56)	
MR322B	HS07 (p52)	HS04 (p51)	IG07 (p54)	
MR323A	IG24 (p54)	KL-IG (p11), DL-IG (p7)	IG24 (p55)	
MR323B	PS10 (p61)	KL-PS (p12), DL-PS (p8)	PS16 (p61)	
MR323C	ST03 (p71)	ST03 (p71)	ST03 (p72)	
MR324	OS23 (p59)	OS23 (p59)	OS01 (p55)	
MR325A	AS10 (p35)	AS10 (p36)	AS11 (p36)	
MR325B	AS17 (p38)	AS17 (p38)	AS17 (p39)	
MR326A	AS28 (p40)	AS28 (p41)	AS39 (p44)	
MR326B	AS46 (p44)	AS46 (p45)	AS48 (p46)	
Ballroom B				AS1 Posters (p77) PS Posters (p99) IG Posters (p92)

附圖 2 各日參與議程(1/5)

Day 2 - 05 Jun 2018, Tuesday
Program Overview

05 Jun 2018, Tuesday				
Time / Room	AM1	AM2	PM1	PM2
	08:30 - 10:30	11:00 - 12:30	13:30 - 15:30	16:00 - 18:00
MR301	HS23 (p138)	KL-HS (p10), DL-HS (p6)		HS32 (p138)
MR302A	PS09-04 (p149)	PS05 (p149)	PS09-04 (p150)	PS09-04 (p151)
MR302B	AS08 (p118)	AS08 (p118)	AS08 (p118)	AS35 (p131)
MR303A	AS16-53 (p122)	AS16-53 (p122)	AS54 (p133)	AS54 (p133)
MR303B	AS34 (p129)	AS34 (p130)	AS34 (p130)	AS37 (p131)
MR304A	PS14 (p153)	PS14 (p154)	PS22 (p155)	PS22 (p156)
MR304B	BG05-SE (p134)	BG06-AS (p135)	BG06-AS (p135)	BG06-AS (p136)
MR314	SE11-13 (p159)	SE11-13 (p160)	SE22-35 (p162)	SE22-35 (p163)
MR315	AS31 (p127)	AS31 (p128)	AS31 (p128)	AS31 (p129)
MR317A	ST17 (p168)		SS03 (p165)	ST17 (p168)
MR317B	OS12 (p144)	OS12 (p144)	OS25-BG (p147)	OS25-BG (p147)
MR318A	HS34 (p139)			HS05 (p136)
MR318B	HS18 (p137)			HS11 (p137)
MR319A	AS20 (p123)	AS20 (p123)	AS20 (p124)	AS29 (p127)
MR319B	SE31-07 (p163)	SE31-07 (p164)	SE31-07 (p164)	SE31-07 (p165)
MR321A	SE21 (p161)	SE21 (p162)	SE02 (p156)	SE02 (p157)
MR321B	SE04 (p158)	SE03 (p157)	SE03 (p158)	SE16 (p160)
MR322A	OS18 (p145)	OS16 (p145)	OS18 (p146)	OS18 (p146)
MR322B	IG06 (p141)	IG22 (p142)	IG12 (p141)	IG12 (p142)
MR323A	IG01 (p139)		IG04 (p140)	IG04 (p140)
MR323B	PS18 (p154)	PS11 (p151)	PS11 (p152)	PS11 (p152)
MR323C	ST13 (p166)	KL-ST (p12), DL-ST (p8)	SS09 (p166)	ST13 (p167)
MR324	OS04 (p143)	OS05 (p143)	OS27 (p148)	OS27 (p148)
MR325A	AS11 (p119)	AS11 (p119)	AS11 (p120)	AS11 (p120)
MR325B	AS03 (p116)	AS03 (p116)	AS03 (p117)	AS03 (p117)
MR326A	AS13 (p121)	AS13 (p121)	AS49 (p132)	AS49 (p132)
MR326B	AS27 (p126)	AS27 (p126)	AS22 (p124)	AS22 (p125)
Ballroom B			**OPENING**	

附圖 2 各日參與議程(2/5)

Day 3 - 06 Jun 2018, Wednesday
Program Overview

06 Jun 2018, Wednesday				
Time / Room	AM1 08:30 - 10:30	AM2 11:00 - 12:30	PM1 13:30 - 15:30	PM2 16:00 - 18:00
MR301	HS21 (p215)	HS28 (p218)	HS17 (p214)	HS17 (p215)
MR302A	PS06 (p229)		PS06 (p230)	PS02 (p229)
MR302B	AS35 (p208)		IG13 (p222)	SE09 (p240)
MR303A	AS33 (p206)			AS33 (p207)
MR303B	AS37 (p208)			AS37 (p209)
MR304A	PS17 (p231)	PS17 (p232)	PS17 (p233)	PS17 (p234)
MR304B	BG07 (p211)	KL-BG (p9), DL-BG (p6)		BG10-IG (p211)
MR314	SE26 (p243)	SE26 (p243)	SE25-40 (p242)	SE25-40 (p243)
MR315	AS26-BG (p204)	KL-AS (p9), DL-AS (p5)		
MR317A	ST22 (p250)	ST22 (p250)	ST22 (p251)	ST14 (p247)
MR317B	OS14 (p225)	OS19 (p226)	OS24 (p228)	OS24 (p228)
MR318A	HS09 (p212)	HS09 (p212)	HS26 (p216)	HS26 (p217)
MR318B	HS12 (p214)	HS25 (p216)	HS10 (p213)	HS10 (p213)
MR319A	AS29 (p205)		SS08 (p244)	AS29 (p206)
MR319B	SE08 (p239)	SE08 (p240)	SE06-30-39 (p238)	SE06-30-39 (p239)
MR321A	SE02 (p238)	SE01 (p236)	SE01 (p237)	SE01 (p237)
MR321B	SE15 (p240)	SE15 (p241)	SE23 (p241)	
MR322A	OS03 (p223)	OS03 (p223)	OS17 (p226)	
MR322B	IG09 (p221)	IG22 (p222)	IG08 (p220)	IG08 (p221)
MR323A	IG03 (p218)		IG03 (p219)	IG03 (p219)
MR323B	PS12 (p231)	PS21 (p236)	PS20 (p234)	PS20 (p235)
MR323C	ST15 (p247)	ST08 (p245)	ST08 (p245)	ST08 (p246)
MR324	OS21 (p227)		OS13 (p224)	OS13 (p224)
MR325A	AS06 (p202)	SS12 (p245)		AS06 (p203)
MR325B	AS03 (p202)	ST19 (p249)	ST19 (p249)	ST16 (p248)
MR326A	AS07 (p203)			AS07 (p204)
MR326B	AS40 (p209)			AS40 (p210)
Ballroom B			BG Posters (p269) AS2 Posters (p252)	

附圖 2 各日參與議程(3/5)

Day 4 - 07 Jun 2018, Thursday
Program Overview

07 Jun 2018, Thursday				
Time / Room	AM1	AM2	PM1	PM2
	08:30 - 10:30	11:00 - 12:30	13:30 - 15:30	16:00 - 18:00
MR301	HS22 (p301)	HS22 (p301)	HS22 (p302)	HS22 (p302)
MR302A	ST04 (p324)	ST04 (p325)	ST04 (p325)	ST12-23 (p328)
MR302B	AS41 (p286)	AS41 (p287)	AS41 (p287)	AS01 (p278)
MR303A	AS42 (p288)	AS42 (p289)	AS50 (p291)	AS50 (p292)
MR303B	AS43-44 (p289)	AS43-44 (p290)	AS23 (p284)	AS23 (p285)
MR304A	PS03 (p312)	PS03 (p312)	PS03 (p313)	PS08 (p316)
MR304B	BG04 (p295)	BG04 (p296)	BG04 (p296)	SS10 (p323)
MR314	SE25-40 (p319)	KL-SE (p13), DL-SE (p8)		SE32 (p319)
MR317A	ST-PS15 (p328)	ST09 (p327)	ST-PS15 (p329)	ST-PS15 (p330)
MR317B	OS24 (p311)	HS08 (p297)	HS20 (p300)	OS08 (p309)
MR318A	HS33 (p304)	HS27 (p303)	HS14 (p299)	HS14 (p300)
MR318B	HS13 (p298)	HS13 (p298)	HS13 (p299)	HS31 (p303)
MR319A	AS30 (p285)	AS30 (p286)	AS45 (p290)	AS45 (p291)
MR319B			SS07 (p322)	SE05 (p318)
MR321A	SE41-33 (p321)			SE41-33 (p322)
MR321B	SE38 (p320)			SE38 (p320)
MR322A	OS10 (p310)		BG03-IG (p294)	BG08-IG (p297)
MR322B	IG20 (p307)	IG21 (p308)	IG16-BG (p306)	IG16-BG (p307)
MR323A	IG02 (p305)	IG25 (p308)	IG02 (p305)	IG02 (p306)
MR323B	PS07 (p314)	PS13 (p317)	PS07 (p314)	PS07 (p315)
MR323C	ST07 (p326)	ST07 (p327)	ST02 (p323)	ST02 (p323)
MR324	OS09 (p309)	KL-OS (p11), DL-OS (p7)		OS09 (p310)
MR325A	AS05 (p280)	AS05 (p281)	AS05 (p281)	AS05 (p282)
MR325B	AS03 (p278)	AS04 (p279)	AS04 (p279)	AS04 (p280)
MR326A	AS07 (p282)	AS21 (p283)	AS21 (p284)	AS18-02-OS (p283)
MR326B	AS56 (p293)	AS56 (p293)	AS56 (p294)	AS51 (p292)
Ballroom B			SE Posters (p341) OS Posters (p331)	

附圖 2　各日參與議程(4/5)

Day 5 - 08 Jun 2018, Friday
Program Overview

08 Jun 2018, Friday				
Time / Room	AM1	AM2	PM1	PM2
	08:30 - 10:30	11:00 - 12:30	13:30 - 15:30	16:00 - 18:00
MR301	HS22 (p379)	HS22 (p380)		
MR302A	ST05 (p390)	ST05 (p391)		
MR302B	AS38 (p373)	AS38 (p373)		
MR303A	AS32 (p371)	AS32 (p372)		
MR303B	AS47 (p375)	AS47 (p375)		
MR304A	PS19 (p384)	PS19 (p384)		
MR304B	BG09-OS (p378)	BG09-OS (p378)		
MR314	SE36 (p388)	SE36 (p389)		
MR317A	ST01 (p389)	ST01 (p390)		
MR317B	OS09 (p382)	OS09 (p383)		
MR318A	HS24 (p380)	HS24 (p381)		
MR318B	HS15 (p378)	HS15 (p379)		
MR319A	AS45 (p374)	AS45 (p374)		
MR319B	SE24-29 (p386)	SE24-29 (p386)		
MR321A	SE12-17 (p385)	SE12-17 (p385)		
MR321B	SE27 (p387)	SE27 (p388)		
MR322A	BG02-IG (p377)	BG02-IG (p377)		
MR322B	IG17 (p382)	IG15 (p381)		
MR323A	IG11 (p381)	IG25 (p382)		
MR325A	AS05 (p369)	AS05 (p370)		
MR325B	AS04 (p369)	AS04 (p369)		
MR326A	AS52 (p376)	AS52 (p376)		
MR326B	AS24-25 (p370)	AS24-25 (p371)		
Ballroom B			CLOSING	

附圖 2 各日參與議程(5/5)

附件二 關切議題摘要與發表資料

附表 **1** 地下水資源研析及永續利用**(1/3)**

HS30-D1-AM1-318B-001 (HS30-A033)

Assessing Advances and Challenges in Observing and Modeling Ecohydrological Processes over Drylands Across Different Continents

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The United Nations Environment Program (UNEP) defines drylands as a region with an aridity index (the ratio of the average annual precipitation to the potential evapotranspiration) of less than 0.65. With this definition, this study provides a systematic assessment of available observations and simulations of ecohydrological variables over dryland areas. The observed datasets include gauge measurements and satellite-derived estimates (e.g., from MODIS, SMAP, GRACE), while the numerical simulations are from climate model outputs (e.g. CMIP5, and 6) and land surface model outputs (e.g., CLM, Noah-MP). In addition to various reanalysis products (e.g., ERA-Interim/Land, MERRA-2), we will use outputs from our recently developed multisensor multivariate global land data assimilation system. While a substantial amount of analysis work is being carried out, our initial results show the offline Noah-MP land surface model performance for evapotranspiration (ET) and runoff is aridity-dependent over Texas in the United States. ET is better modeled in wet than in dry years, whereas streamflow is most poorly simulated in dry regions with a large positive bias. Modeled ET bias is more strongly correlated with the base flow bias than surface runoff bias. These early results help identify potential processes for future model improvements. For example, improving the dry region streamflow simulation would require synergistic enhancements of ET, soil moisture and groundwater observation and modeling. Detailed assessments are important steps towards developing efficient dryland water resources management technologies, methods and strategies.

HS04-D2-PM1-P-006 (HS04-A001)

Water Management Innovative Platform Using Big Data and Cloud Computing

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Water resources are valuable assets without alternative reserves, which can cause conflicts between regional districts. It is the core element of national economic activity, and a necessary part in all production industries. There is need to prepare for the increasing demand of water resources, and to develop new strategies to manage large volumes of data. In Korea, there is a gap between technology and system in collecting, managing, sharing, and analyzing data for each organization which manages water information. Recent huge amount of water information encourages to participate in various organizations such as technology sharing, public institutions and citizens, and to create value through mutual cooperation. Thus, it is effective to forecast and respond to disaster and water resources management by utilizing big data and cloud computing effectively. Using big data can identify the source of the problem, and allow for predictions and responses. Big data can be used as an important tool for realistic problem recognition, efficient solution, and optimized policy formulation. In addition, it is necessary to construct a distributed computing foundation by interconnecting various devices by combining distributed processing, which is a main technology of cloud computing. We proposed a water management innovative masterplan that utilizes big data and cloud computing. We investigated the distribution flow of water data in Korea. It builds a database that integrates information systems such as water, city, ecology, and water data to perform big data analysis. It is then send to the national government, and suggested a plan to build disaster and water resource management system, using big data and cloud computing.

Acknowledgement: This work is supported by the Korea Agency for Infrastructure Technology Advancement (KAIA) grant funded by the Ministry of Land, Infrastructure and Transport (Grant 17AWMP-B083066-04).

HS10-D3-PM2-318B-011 (HS10-A006)

Let's Play Groundwater Models Online

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Groundwater is one of relatively stable water resources in most countries as compared with surface water resources. With the increasing variability of climate conditions, the sustainable management of groundwater resources has become a challenging task. Accurate assessment of groundwater resources relies on sufficient measurements and efficient analysis tools. The integrated technologies and multidisciplinary knowledge for groundwater have enhance the understanding of dynamics in groundwater systems. Taking advantages of widely developments in computer sciences and web service, the web platform provides an excellent open environment for groundwater investigations. However, most groundwater relevant web platforms are mainly focusing on the data visualization. The data (points, polylines, and polygons) and pre-analysis results (i.e., the figures) overlap a street map to indicate the location of interests and quantify the influenced regions of groundwater hazards. Such one-way interaction framework has significantly limited the implementations of measurement data and groundwater relevant applications. The study aims to develop an online web-based platform for groundwater data visualization, temporal and spatial data analysis, mesh generation and flow modeling. The study integrates multiple program languages such as Java, C, Python, and FORTRAN to bridge the data flow and online visualization. The interactive real-time web environment enables users to screen temporal and spatial measurements on the web map, conduct online data analyses, and develop numerical groundwater models. With well-designed database and numerous modules for data analyses and modeling, the platform allows users to share data and develop collaborative activities. The built-in analysis tools can also improve the efficiency of groundwater management and decision-making processes.

HS10-D3-PM1-318B-007 (HS10-A025)

Evaluation of Groundwater Quality Spatial Variability in Gimcheon Region, South Korea

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In Gimcheon region of South Korea 250 groundwater samples were chemically analyzed for major ions, pH, and electrical conductivity following standard methods. AquaChem 2014.2 model linked with PHREEQC was used for the analysis and characterization of the hydrochemistry, and the GIS based geostatistical methods were used for evaluation of its spatial variability and mapping. In most of the samples Ca-HCO3 is the leading water constituents in the area. The dominance of major cations and anions are in the order of (Ca > Na > Mg > K), and (HCO3 > NO3 > SO4 > Cl) respectively. The saturation indices (SI) analysis shows under saturation in almost all samples with respect to anhydrite, aragonite, calcite, dolomite, fluorite, gypsum and halite. The semivariogram/ covariance analysis reveals a strong spatial interdependence of most of the parameters considered except SO4, NO3 and temperature which shows weak to moderate spatial dependence. The suitability analysis of the groundwater quality for irrigation and domestic uses based on the commonly used evaluation criteria indicates that the groundwater in the area can be used for agricultural use without causing significant impact on soil as well as crops. The drinking water suitability analysis made based on the WHO guidelines for major parameters indicates the groundwater in the area is suitable for drinking except in some samples where high nitrate (NO3) concentrations observed, which could be an indicator of agricultural pollution.

Acknowledgments: This work was supported by a grant (18RDRP-B076272-05) from Infrastructure and transportation technology promotion research Program funded by the Ministry of Land, Infrastructure and Transport of Korean government.

HS10-D2-PM1-P-023 (HS10-A016)

Creation of a Detailed Groundwater Quality Map and its Application to a Water-Adequacy Evaluation for an Open-Loop Ground Source Heat Exchange System

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A ground source heat exchange system (GHEs), which uses heat energy of groundwater and subsurface geology for air conditioning and heating of water, is an economically and environmentally friendly technology. This technology is widely used in Europe and North America, but it is rarely used in Japan. In order to become a widely used technology in Japan, publication of detailed information on expected regional GHE efficiency and on economic advantages is essential.

GHEs can be classified into two types: “closed loop” and “open loop” systems. The open loop system uses pumped groundwater directly in the heat exchanger and then discharges it to the surrounding water environment. During this heat exchange process, the generation of scale, such as Ca, Mg, Fe, Mn, and Si originally dissolved in groundwater, on the inner wall of the pipes of the heat exchange system and the degradation of metal piping can affect the heat exchange efficiency and life cycle cost of GHEs. Therefore, evaluation of the groundwater quality in terms of efficient and stable system operation is important. The objectives in this study are to evaluate the potential of scale generation and of metal pipe degradation based on groundwater quality.

A groundwater quality monitoring program has been conducted since 2010. The number of surveyed sites is approximately one thousand, and water temperature, pH, electrical conductivity, oxidation-reduction potential, cations, anions, and metal ions have been monitored at each site. We compared these data to the Water Quality Guidelines for Refrigerating and Air Conditioning Equipment, and evaluated the water’s suitability. We also displayed a large amount of data on the map using a Geographic Information System (GIS). The characteristics of groundwater quality were discussed in terms of regional geology and depth of aquifer.

HS13-D2-PM1-P-032 (HS13-A022)

Hydrochemical Features of Karst Groundwater System in Fangshan, Beijing, North China

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Karst groundwater is an important water resource for drinking in Beijing, which account for as much as 70 % of water supply. This paper, took Fangshan in the southwest of Beijing, as the research area,where new emergency water source was built. In order to explor the regultaion of groundwater flow system and hydrogeochemical evolution, the groundwater distribution and hydrochemical composition were investigated in the Xiayunling-Longmentai synclinorium hydrogeological unit. The results showed that: The geological structure play an important role in controlling karst groundwater flow and geochemistry condition. Groundwater migrates from northwest recharge area to southeast discharge area, accompanying TDS rises with runoff distance as a whole. Hydrochemical types is mainly HCO_3-Ca·Mg. Primary chemical components of groundwater are predominated by Ca^{2+}, Mg^{2+}, HCO_3^- and SO_4^{2-} and the origin of which is associated with dissolution and precipitation of aquifer minerals, including calcium carbonate, dolomite, and gypsum. Additionally, anthropogenic activities such as rising exploitation also have striking effects on hydrochemical components. This could be the result of groundwater flow at the different geological structure, causing various residence time and interactions between groundwater and aquifer minerals. This research could provide significant insights into the local governments that can make effective management and protection of karst groundwater in Beijing.

Keywords: Karst groundwater; Hydrochemical characteristics; Geochemical evolution; Fangshan in Beijing

HS12-D2-PM1-P-015 (HS12-A015)

Evaluation of Nitrate Concentration in Groundwater of Korea for 2001–2013

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Nitrate contamination is a main factor affecting human health and the environment. Especially in groundwater, nitrate contamination arise from primarily use of nitrogen fertilizer. The purpose of this study is to analyze and examine the trend of nitrate concentration in groundwater of Korea. Also, to consider its effects on groundwater quality and agricultural practices. We analyzed the nitrate concentrations of Korean groundwater based on data of groundwater quality monitoring wells observed twice a year over the period of 2001–2013. The maximum nitrate concentration decreased from 168.91 to 48.11 mg/L more than three times in 10 years and the mean value gradually decreased. Statistical analysis of nitrate data also show a significant declining trend. Generally, the nitrate values of groundwater wells ranged between 1.78–5.62 mg/L and meet the Korean potable water standards. As a result of comparing nitrate concentrations based on the use of groundwater (agriculture, domestic, drinking, and other), the linear gradient of agricultural groundwater is most prominent with value of -0.46 mg/L per year. The analysis show that the nitrate in groundwater got decreased in Korea, especially in cropland areas. Therefore, this study conclude that the groundwater nitrate declines due to reduction in use of nitrate fertilizer derived by reduced cropland area, more sustainable agricultural practices, and progressive improvement of sewage disposal services. However, recent self-sufficiency rate of domestic crops is only 24% as of 2014, and the country is heavily dependent on foreign crops, so it is expected that level of nitrate in groundwater could rise again if the Korean government promotes domestic crop production. This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIT) (No. NRF-2015R1A4A1041105).

HS01-D1-AM1-318A-005 (HS01-A009)

Modeling Dissolved Organic Carbon and Nitrate Export for a New York Water Supply Watershed

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The Catskill/Delaware reservoirs, a part of the New York City (NYC) water supply system, normally supply 90% of the drinking water to NYC. This water supply is the largest unfiltered water supply system in the United States; maintaining the high quality of water collected in these watersheds is critical for clean and sustainable water supply. In this study, we evaluate predictions from RHESSys, an ecohydrologic process-based model, of streamflow, dissolved organic carbon (DOC), and nitrate in Biscuit Brook, a forested headwater catchment of the Neversink Reservoir. RHESSys includes spatially distributed and coupled water, carbon and nitrogen cycling and transport processes, allowing simulation of the spatial-temporal distribution of DOC/nitrate in the watershed. DOC/nitrate simulations depend on hydrological flowpath structure and connectivity, ecosystem composition and distribution, and including the impact of inter-annual weather conditions and disturbance. Three different alternative RHESSys model structures, with varying vegetation phenology pattern and hillslope hydrologic connectivity, were tested to find an appropriate model structure, with reasonable estimates of streamflow and DOC/nitrate exports to streams. Model comparison showed that incorporating dynamic phenology (model-2; climate-condition-varying vegetation phenology) improved model agreement with streamflow and DOC in the fall and nitrate in the spring, compared with a static phenology model (model-1). Incorporating the connectivity of riparian zone and deep groundwater storage with dynamic phenology (model-3) improves summer flow/DOC and fall stream nitrate, compared with model-2. The marginal improvement for DOC prediction between model-2 and model-3 is smaller than the model parameter uncertainty, while the improvement in nitrate prediction is larger than the model parameter uncertainty. This study demonstrates the effects of inter-annual vegetation phenology and hillslope hydrologic connectivity are important for simulating the hydrology, stream DOC/nitrate dynamics in a NYC water supply watershed.

HS13-D2-PM1-P-033 (HS13-A031)

Statistical Analysis for Long-Term Groundwater Quality Data from Oil-Contaminated Area

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Data mining using statistical techniques was performed on long - term groundwater quality data in oil-contaminated area. In this study, the spatial distribution of the groundwater pollution and the dispersion of the pollutants were evaluated through the spatial analysis. The correlation between pollutant factors and other observation items was analyzed through principal component analysis. In addition, the trend of groundwater pollution change was identified using time series analysis method, and a time series model was constructed to predict the purification period of the groundwater system.

In this polluted area, the concentration of BTEX in the groundwater and the amount of free phase oil collected as the main pollution index were selected and representative pollution directions were selected. Simultaneous visualization of the spatial distribution and temporal changes of groundwater pollution, benzene was divided into two sections. The geostatistics were used to observe spatial changes of pollutants and electron acceptors and to quantitatively and qualitatively evaluate the effects of natural abatement. As a result of multivariate analysis, it was confirmed that sulfate, nitrate, and manganese ions were reduced by BTEX and TPH, which are indicators of oil pollution. Especially, It was found that redox zoning was formed depending on the distance. In the Mann-Kendal Trend test, it was confirmed that most of the major pollutants were decreasing. The reaching times to the sub-baseline concentration predicted by the ARIMA model and the combined prediction model (CFM) are predicted to be from the second half of 2027 (Toluene) to the second half of 2067 (Benzene) and the free phase oil until the first half of 2035.

HS10-D3-PM2-318B-009 (HS10-A029)

Presence of Boron in the Puebla Valley Aquifer System, Mexico North America

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The hydrogeochemistry of 98 wells was studied in the Puebla Valley aquifer system that provides water to the City of Puebla (> 1.4 million people), central Mexico; the aquifer system is located in an active inter-volcanic zone, which coexists with volcanic rock and facies of intruded and non-intruded carbonates. The studied aquifer system is constituted by 3 aquifers: shallow (detritus of volcanic origin), middle (Andesitic rocks and pyroclastic deposit) and deep (marine carbonate rocks), presenting hydrothermal and possibly geothermal processes. Results of the present investigation allow us to report an anomalous distribution of dissolved Boron concentrations in groundwater in the central area of the study area. The anomalous concentrations of Boron found are related to the crossing of a fault and a fracture. Creating the confluence of the groundwater of the deep and shallow aquifers of the Puebla Valley Aquifer system studied in the Alto Atoyac sub-basin, Puebla, Mexico. The concentration of Boron in 19 wells surpassed the permissible limits of international regulation, greater than 1 mg / L, presenting concentrations between the ranges of 2.1 to 5.0 mg / L, which represents an increase to the previously published concentrations of 1 to 3 mg / L. The discussion of the present investigation regarding the presence of Boron is based on the relationship with the possible influence of volcanic activity that occurs in the area. Results of the present investigation also allow us to elucidate about the hydrothermal processes that are carried out by the mixture of groundwater between the deep and shallow aquifers; since we have detected an increase in the concentration of dissolved sulfates finding concentrations of 2800 mg / L and associated dissolved solids.

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Evaluation of Radon Concentrations in Groundwater of the Haean Basin, Korea

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This study was conducted to identify the distribution of Radon (Rn) in groundwater which can accumulate in basin due to geological factors, to high concentrations. Rn is one of the radioactive materials and, is harmful to the human health and exposed environment. Haean basin was formed as a result of differential erosion of circular outer boundary metasedimentary rocks and circular inner boundary granitic rocks. In this study, we measured groundwater level, Rn concentrations and field parameters (pH, DO, ORP, EC, and water temperature) in well of five sites (HA1–HA5). Groundwater level was ranged from 2.45–4.12 m below the ground surface. The results of Rn concentrations, measured from the shallow wells (HA1 and HA2) have low Rn concentration as 520 and 1,510 pCi/L, and from the bedrock wells (HA3, HA4, and HA5) have high Rn concentration as 1,990, 2,500, and 1,810 pCi/L. Cause for the high Rn concentration in the bedrock wells is that base rock (granite) exposed more to radioactive decay heat of uranium. The results of field parameters (pH, DO, ORP, EC, and water temperature) were 6.1–7.6, 3.54–5.95 mg/L, 72–285 mV, 79.7–497 μS/cm, and 9.3–13.1℃, respectively. This study concludes that research is required to generate a big data set of Rn concentration in groundwater of Haean basin for detailed investigation of its source and effects. This work was supported by National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIT) (No. NRF-2015R1A4A1041105).

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Development of Smart Groundwater Management System in the Kingdom of Tonga: Utilizing Climate Information in Response to Shortage of Water

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Securing water resources and safe drinking water is of utmost importance in the Pacific Islands under the changing climate. In Tonga, there is no large catchment area combined with poor fresh water supply systems, making it one of the top priorities to identify available water resources and their storage. The supply and demand of water resources in Tonga is regionally biased and the quantity and quality are at high risk due to seawater intrusion and surface water pollution and depletion. All of these issues place Tonga in a very vulnerable state in obtaining sustainable water resources. Therefore, APEC Climate Center (APCC) and the Tonga Ministry of Lands, Survey and Natural Resources (MLSNR) are conducting a joint research project to develop a smart groundwater management system for utilizing climate information in Tonga's water sector. The project aims to support Tonga water sector decision-makers to sustainably secure water resources by providing optimal alternatives. As one of three components to be implemented by 2018, APCC analyzed Tonga's climatology, climate change impact, and water recharge for Tongatapu Island. APCC also installed a real-time groundwater monitoring system and developed a web-based model to analyze and predict sustainable use of underground water resources by collaborating with HydroNet and Dong-A University. Through this project, Tonga Groundwater Information System (ToGWIS, http://210.125.181.22/), the integrated groundwater information system was developed.

This will enable the government of Tonga to better advise the public on water usage for daily, agricultural, and industrial use during El Nino, extreme drought, and other events. Moreover, through the project outcomes, they will be able to establish a strategic plan for sustainable water resource security in response to climate change. In addition, the quality of life and water security of local communities are ultimately expected to improve through this smart groundwater information system.

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Addressing Salinity Accumulation in the Hetao Basin, Yellow River, Inner Mongolia

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The Hetao Irrigation District on the Yellow River in arid, cold Inner Mongolia is one of China's three largest irrigation areas and home to one million farmers. Hetao has experienced significant increasing temperatures over the past 60 years although Basin-wide precipitation and pan evaporation have not significantly changed over this period. Since 1961, annual water extractions from the Yellow River have averaged 4.7 km^3 per year. Increasing upstream diversions and rapidly growing downstream water demands as well as environmental flow requirements have resulted in the phasing-in of a mandated 15% reduction in supply to Hetao. Over 30% of annual irrigation supply is used to flush accumulated salt from top soils into shallow groundwater. A whole-of-basin mass balance approach, assuming a closed basin, shows that on average 3 million tonnes of salt annually have been accumulating since 1967 in the unconfined groundwater and soils of the Basin, mostly from evaporated irrigation supply. Deposition of salt is spatially varied but it is shown to have increased the area-weighted average salinity of Hetao's unconfined aquifer by 0.43 kg m^{-3} per decade over the last 30 years. It is proposed that density-driven convection transports accumulated salt from the surface layers of groundwater to lower regions in the unconfined aquifer. At the current mean rate of salinity accumulation and even under mandated reductions in supply, including local climate trends, groundwater salinity in Hetao may severely limit crop production over a wide area within 100 years. To address this accumulation of salt, increased drainage from targeted areas with more saline groundwater is required. Without this, additional volumes of Yellow River water may be required for salt flushing. Further research is required on optimal drainage and salinity disposal systems and their location.

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Study of Climate Change Impact on Water Resources in Central Taiwan

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We propose an integrated procedure for evaluating the impact of climate change on water resources, with the Zhuoshui River Basin and its supply area, Changhua and Yunlin, in the Central Taiwan selected for the assessment.

This study adopted five downscaled general circulation models in 2046–2065 for assessing the climate change impact on: first, the downstream irrigation water requirements; second, the upstream river flow; and final, the water resources uses regarding both the supply and demand sides.

The irrigation water requirements will increase by 10% due to the rising temperature, and the river flow will likely reduce by 20% because of the decrease of precipitation. Thus, the shortage of irrigation water may become more severe in the future. As a facility for the adaptation, the Hushan Reservoir, which has operated in 2016, can assist in offsetting domestic and industrial demands. For holding the irrigation deficit at its present level, conveyance losses should be reduced to 30% and the farming area in the second paddy growth season should be decreased by 10%.