Open Collaboration Framework centric to Federated Cloud for Smart Earth ~ on Case of Disaster Mitigation and Environment Technology

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Abstract

Smart Earth becomes the most important issue of the world under the umbrella of Sustainable development. Among others, Disaster Mitigation Competence Centre (DMCC) and Environment Computing stands for the top first vision of EU and UN. The vision of DMCC+ is pursuing humanity sustainable development in Asia by reducing the impacts of natural disasters. Centred on the primary barrier of disaster mitigation, DMCC+ aims to build up capacity of disaster risk analysis by deeper understanding and innovative simulation services. DMCC+ aims to conduct case studies on tsunami, storm surge, flood, forest fire monitoring and dust transportation and demonstrating the use of deeper understanding and advanced numerical simulation approaches. Besides environmental aspect, we also bring economic aspect into the framework, viz. Open API and Platform Economy, which may leads to the digital transformation of DMCC and Environment Computing System.

A knowledge-oriented hazard risk assessment approach based on deeper understanding of the root cause and drivers of a hazard is developed and verified in this study. The open collaboration framework consists of case study, simulation facility and knowledge base to carry out the hazard assessment by this approach has been initiated. Several case studies of different types in different countries were implemented. Simulation facility is built from the requirements of the target case study. Design of the knowledge base for disaster assessment by compiling all the materials and resources from case studies in an organized way is also proposed. A positive feedback loop is formed by the case study, simulation facility and knowledge base. Both the knowledge to the hazard physical processes and the simulation facility will progressively reinforced by the growing of case studies. Through integration and share of data, simulation facility and innovative applications, workflow, and details of computational environment that generate published findings in open trusted repositories from the open collaboration platform, an open science platform for disaster mitigation would be realized.

Keywords: Sustainable Development, Disaster Mitigation and Environment Technology, Federated Cloud, Open Collaboration Framework, Open API and Platform Economy, Digital Transformation.

I. INTRODUCTION

The economic drive has shifted form managing of scarcity to producing abundance [1]. The result is the waste of resources and environment damages. Sustainable development becomes the most important goal of the world under the umbrella of Smart Earth. Among others, Disaster Mitigation Competence Centre (DMCC) and Environment Computing stands for the top first vision of EU and UN. The vision of DMCC+ is pursuing humanity sustainable development in Asia by reducing the impacts of natural disasters. Centred on the primary barrier of disaster mitigation, DMCC+ aims to build up capacity of disaster risk analysis by deeper understanding and innovative simulation services. DMCC+ aims to conduct case studies on tsunami, storm surge, flood, forest fire monitoring and dust transportation and demonstrating the use of deeper understanding and advanced numerical simulation approaches.

Disaster mitigation has been a persistent challenge since the dawn of civilization. No place on earth is risk-free. According to researches [2], if the climate change trends could not be reversed or mitigated, the frequency or cost of natural disasters will keep increasing in the future. In order to coexist with the natural disasters, capability of risk estimation becomes essential. Hazard assessment is the core of disaster risk assessment. Worst- case scenario of natural disaster is not the most optimized approach in most of the cases. Insufficient knowledge to the root causes and physical characteristics of disasters leads to invalid and inefficient hazard estimation [3].

The primary challenge of hazard assessment is to determine the hazardous processes, especially its magnitude, location and time, in its entire lifespan. Natural hazards are dominated by two types of factors - the earth physical characteristics and the triggers. For example, crustal movements result in an earthquake. Sea temperature, humidity, wind shear and disturbed weather might lead to a tropical cyclone. Different combination of the two factors can induce different hazards. One single trigger might give rise to multiple various coupled disasters. One hazard is also possibly triggered by another hazard in series. For example, a strong typhoon might induce devastated storm surge such as the typhoon Haiyan caused huge damages to the Philippines in 2013. Earth physical environment could be changed by a disaster. Climate change would alter the trigger factors essentially. Consequently, the root cause of each disaster has to be detailed investigated to advance the knowledge of trigger mechanism, geophysical facts and their interactions during the process [1].

Based on scientific knowledge, numerical simulations could produce increasingly accurate estimations of hazard processes and be used in reducing society’s exposure to disasters [4]. "Physical science research is necessary to advance the understanding of the many complex interactions at play within the Earth system and to overcome the technical hurdles associated with translating knowledge into improved numerical simulation systems” [5].

Knowledge of Earth system and physical processes are expected to have tremendous advancement than the past two decades. Numerical simulation has benefits from both the scientific advancement and computational technologies. In spite of that, it is still not easy to access to accurate simulation facility for better hazard analysis. Cross-discipline integration, translation of up-to-date knowledge into the simulation, incapability of re-producing the hazard numerically as well as the regionality of disasters are the main challenges, especially for Southeast Asia and Southern Asia countries.

Focusing on reducing the hazard risks by innovative high-performance simulations based on deeper understandings of the natural phenomena, Disaster Mitigation Competence Centre (DMCC) coordinated by Academia Sinica Grid Computing Centre in Tai- wan, working together with Partners including Philippines, Malaysia, and Indonesia, has started to build up an open collaboration framework from 2015. Simulation portals is developed from thoroughly investigated case studies. The whole hazardous event is able to be reproducible from the collaboration framework. The simulation facility will be continuously enhanced from more case studies. Regional distributed cloud infrastructure is used to support the workflow of simulations, data management and sharing, and col-laborations. Through the open collaboration framework, partners are able to access seamlessly to the knowledge from case studies, to conduct new case studies by making use of the simulation facilities, and to reuse or repurposing all resources.

Numerical simulations become a norm today for hazard analysis, disaster management and scientific research [6]. However, for a case study, reproducible simulations, accessible observation data, sharable simulation facility as well as discoverable work- flow and simulation know-how are all not easily attainable. The open collaboration framework in this study is designed to integrate all these requirements from case studies and collaborations with user groups of various roles in the hazard impact assessment to enhance the disaster mitigation capability.

The research methodology and open collaboration framework and Open API and Platform Economy are explained in section 2. Case studies as verified examples are described in section 3. Design of the knowledge base is followed in section 4. Lessons learned and future perspectives are highlighted in section 5 before the summary in the last section.

II. THE OPEN COLLABORATION FRAMEWORK

Combining deeper understandings and advanced numerical simulations to achieve more accurate hazard impact analysis involves complex processes [4]. Not just multidisciplinary expertise is required but also the necessary resources are highly possible come from numerous institutes of various countries, in view of efficiency. The open collaboration [7, 9] platform is to support such regional federation of resources and to provide access to managed services covering data, tools, case studies, expertise and visualization, etc. Research collaboration usually demands sharing of resources and knowledge to address specific challenges related to discovery, modeling, simulation, validation or risk/benefit assessment of innovations [1, 8, 10]. For regional collaborations in Asia, the open collaboration platform also supports rapid spread of knowledge, access to high performance and validated simulation facility, workflow to conduct case studies, as well as reuse and repurposing of all resources in the platform.

Leveraging fast-growing observation data and computing technologies, scientists today are able to uncover patterns in historical data and merge those with current observations to predict what might happen in the future by numerical simulations. Aiming at deeper understanding of natural hazards, the Disaster Mitigation Competence Centre of the EGI-Engage project built up a collaboration network and online tools to simulate the whole life cycle of hazardous events according to the abstract open collaboration framework as depicted in Fig.1. The framework was verified by historical cases of different types and locations using the Asia-Pacific regional e-Infrastructure.

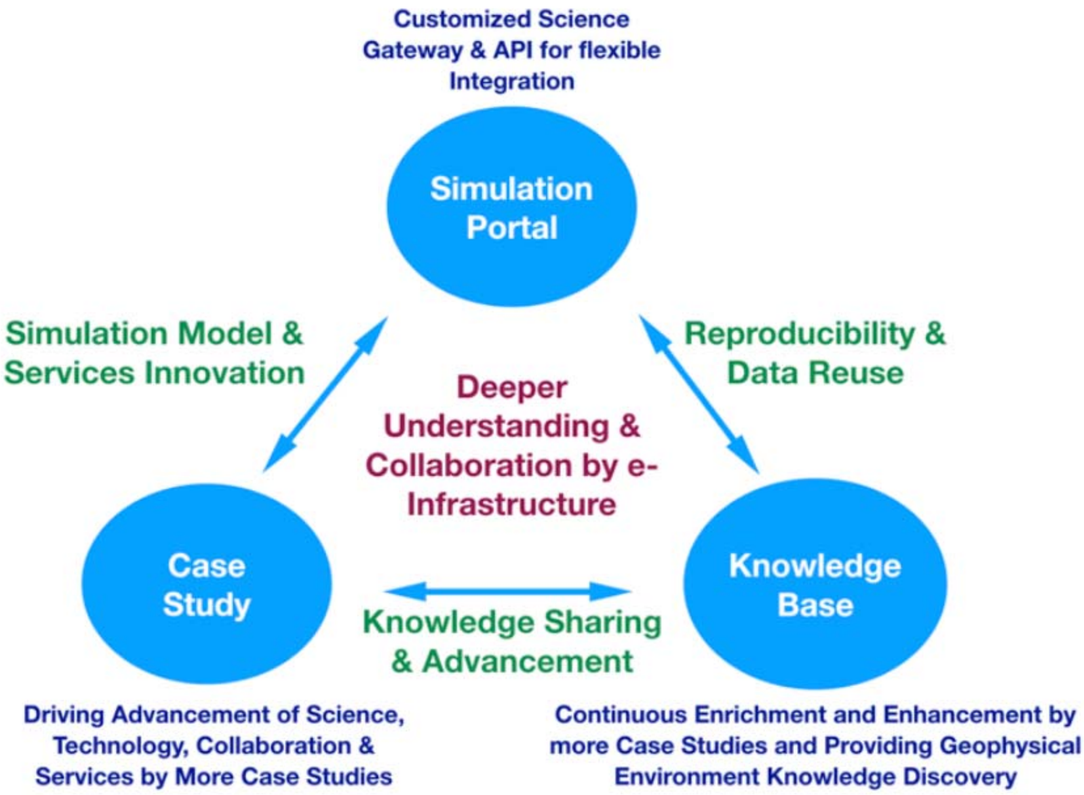

Fig. 1. Open Collaboration Framework for Disaster Mitigation Based on Deeper Understanding & Moving Towards Open Science

Deeper understanding approach is to have systematic hazard analysis and profiling on underlying causes, drivers of the target events. Simulation is conducted with optimal initial conditions, boundary conditions and parameterization with best knowledge to the physical processes based on the observation data. As exemplified by numerical weather prediction, the substantial improvement in the past two decades is realized through advances of fundamental sciences, numerical models and high-performance computing. Observation data provides necessary descriptions of the current status of the dominant earth system (such as atmosphere, ocean, hydrology, land surface, etc.) so that the numerical simulations can start with the best estimation of initial conditions. The models capture the key atmospheric dynamics and use right physical parameterization so that samples of prediction can be generated accordingly. The whole process has to be carried out efficiently by scalable parallel computing schemes.

Being advantageous from results of case studies, simulation model could be applied to similar disaster events of the same type at different location with customization. By deeper understandings of the hazards, the simulation models would be more accurate. Growing by the case studies, the simulation facilities would be more useful and robust for complicated or compound disasters.

Case studies are valuable both in gaining in-depth understanding of the features, drivers and their interactions of the disaster and in improving the simulation process and modeling. The approach of case study also provides an alternative design for retrospective learning, evaluation and hazard risk strategy planning. The basic principle of case selection is based on the frequency of occurrence and the scale of damage or intensity.

In addition to demonstrate the practices of numerical simulations based on deeper understanding approach, case studies also verify the design of shared knowledge base through the open collaboration platform. From case studies, we can collect information for such as explaining what was happened, illustrating a hypothesis, reproducing optimized event simulation process, etc. The information will be further used to organize the knowledge base as an educational tool demonstrating best practices and raising awareness about disaster risk analysis. Such case studies showed that discoveries can be driven by the need to address the adverse effects of disasters on lives and societies.

A Knowledge Base is used to share all the materials and resources of DMCC case studies in an organized way. It is implemented over the DMCC Open Collaboration Platform to support hazard risk analysis by making use of DMCC services and resources. The knowledge base will also provide the collective intelligence environment for partners to conduct new case studies or reproduce and reinvestigate existing cases.

The open collaboration framework consists of the core multi-disciplinary taskforce and the technical platform. The technical platform contains online services for simulation, data and information management in collaboration with both EGI and Asia partners. The taskforce covers scientific group, technical group, e-Infrastructure group and user support group. The primary functions of taskforce are to identify case studies; collect observation data and supporting materials; develop simulation models; validate the models based on historical observation scenarios; integrate the model and data with e-infrastructures; conduct performance tuning; deploy the scenarios and tools into online portals.

Since the Sustainable Development has to consider the environmental aspect and economic aspect, Besides scientific aspect, we also bring economic aspect into the framework, viz. Open API and Platform Economy [1], which may leads to the digital transformation of DMCC and Environment Computing System.

In the Platform Economy, a platform is a economic service model that creates value by facilitating exchanges between two or more interdependent groups, usually users and providers. This term is used by analysts to describe the competitive nature of digital innovation. In order to make these exchanges happen, platforms harness and create large, scalable networks of users and resources that can be accessed on demand.

Platform economy is the tendency for computing to increasingly move towards and favor digital platform service models. Platforms are underlying computer systems that can host services that allow users, entrepreneurs, institutions and the general public to connect, share resources or promote their services in terms of collaboration. And, it results in so-called digital transformation.

Sharing Economy is the idea that users would prefer to share resources/services, esp. Open Data, and services become common wealth. The platform economy facilitates this as an institution can develop a digital economic platform that users can log onto to gain access to resources/services through a subscription. The platform service providers earn profits from externality of economics.

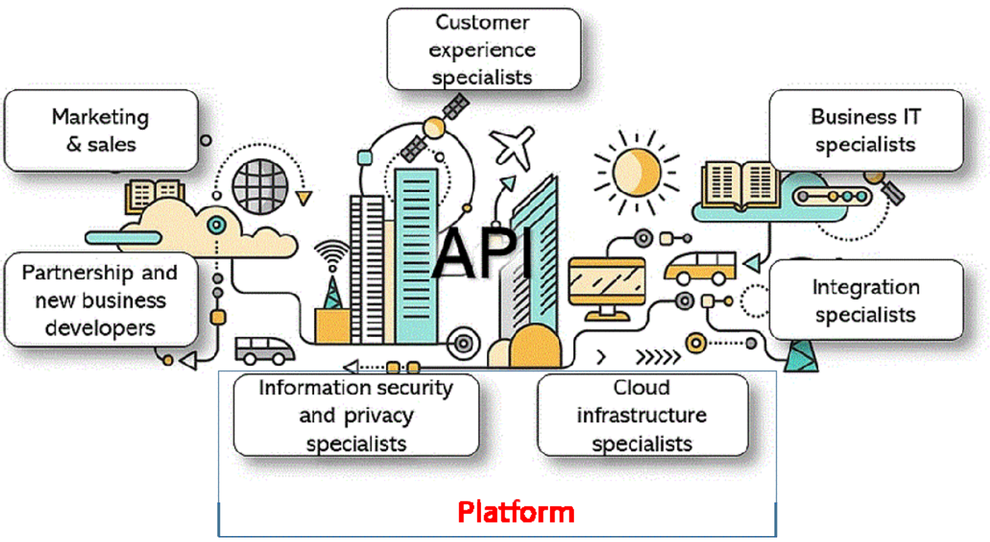

Fig. 2.Synergy of API and P latform Economy

In API Economy as shown in Fig 2, institution utilizes resources efficiently and quickly to create added value for own users. These resources can be for example data or function provided by other organizations. Building blocks utilized are own APIs and open APIs provided by other organizations (free or commercial) in addition to developer communities. These enable quicker adaptability to unpredictable and faster changing user needs. Defining characteristics of API Economy are competing for popularity among application developers and considering them as primary users. In brief, services are offered from organizations to developers.

APIs enable interaction with platform economy operators. One's service model may encounter a "forced opening" of APIs at any time – see it as an opportunity. The API economy is not just part of platform economy, but APIs can be used for increasing internal productivity or for offering different service models [1].

III. CASE STUDY

3.1 Storm Surge

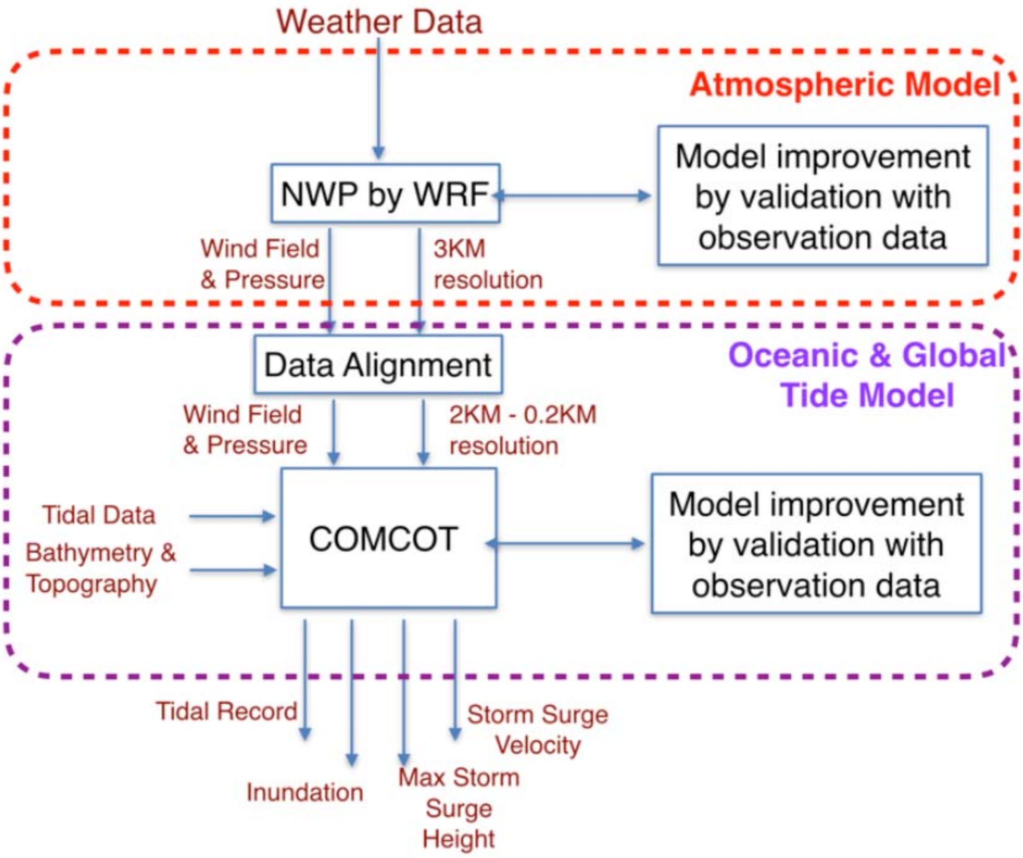

Fig. 3. A New Storm Surge Simulation Model for Typhoon Haiyan by Coupling Atmospheric and Oceanic Models Leveraging

Storm surge induced by super typhoon Haiyan is the typical case study of DMCC. Itis one of the most intense typhoon devastated the Philippines and caused 6,340 confirmed fatality and 1,061 missing people, $2.86 billion USD damage in November 2013. Based on the weather simulation and tsunami simulation facility, DMCC demonstrated how the innovative storm surge science gateway is developed by combining atmospheric model and ocean model to estimate the impacts of storm surge as shown in Fig. 3.

Storm surge is produced by a strong typhoon and is a very complex phenomenon because it is sensitive to the slightest changes in storm intensity, forward speed, radius of maximum winds, angle of approach to the coast, central pressure, and the shape and characteristics of coastal features. This rise in water level can cause extreme flooding in coastal areas particularly when storm surge coincides with normal high tide.

When a certain scale typhoon is predicted to hit, the storm surge simulation will be initiated to estimate the wave height and its inundation depth to the target area by the input of meteorological force from the weather simulation and the tidal boundary conditions. All figures and tables should be numbered consecutively and captioned, and be placed in text as close to the reference as possible.

Leveraging the parallelized and optimized nonlinear tsunami model, pressure gradient and wind shear stress calculations are included. Furthermore, non-linear interactions among tide, topography and surface friction are also analyzed to attain inundation and run-up height. Validated by tidal gauge data, the bias is smaller than 0.1m and root mean square is smaller than 0.6m of storm surge simulations on Typhoon Haiyan by the devised storm surge model. High resolution and high accuracy storm surge propagation simulations on Typhoon Haiyan in offshore regions and in nearshore regions are depicted in Fig. 4.

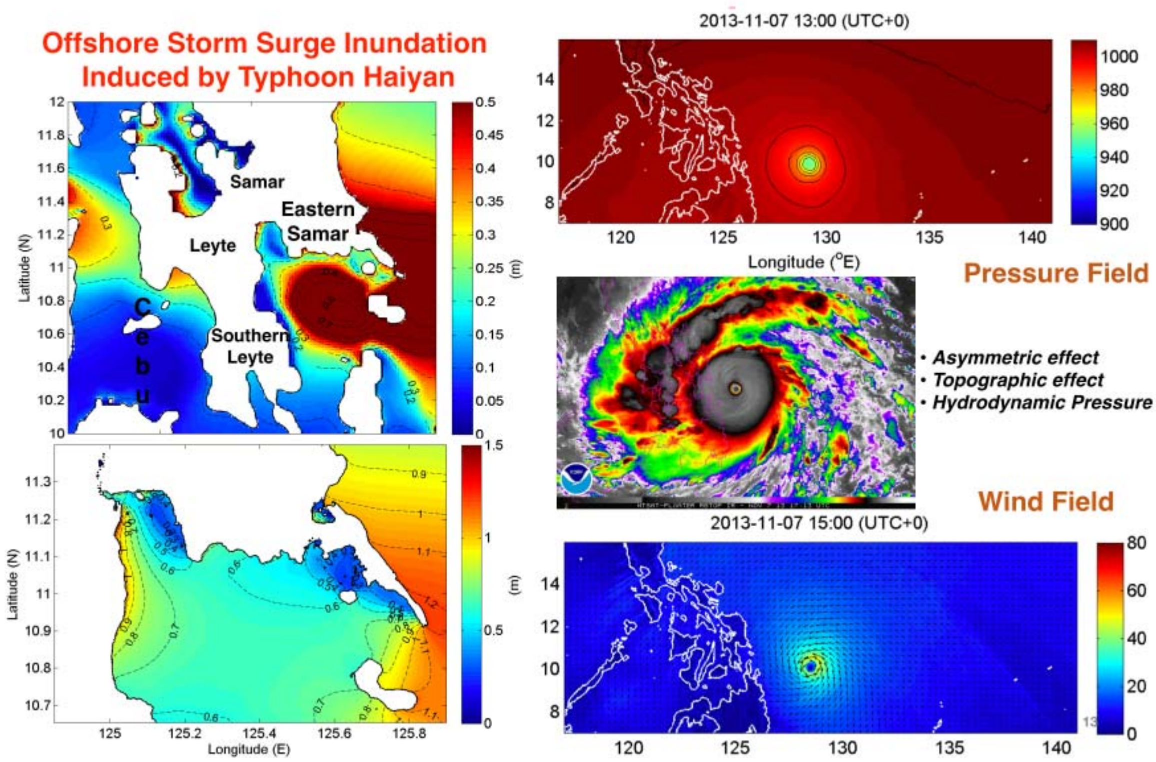

Fig. 4. Storm Surge Simulation on 2013 Typhoon Haiyan by Coupling Ocean and Atmospheric Model

Understanding the interfaces among atmosphere, ocean and land surface is a key to the physical features of a hazard. From this case study, the storm surge impact analysis could be carried out directly benefited from the breakthroughs of weather prediction instead of relying on theoretical assumptions. On the other hand, the scientist group also overcame the simulation limits of a strong typhoon especially on the lowest pressure and strongest windspeed from the case study.

3.2 Tsunami

By integrating with real-time earthquake reporting system, DMCC tsunami simulation facility is able to provide the tsunami simulation and generates an inundation map within 5 minutes with an inundation resolution finer than 40 meters, which is sufficient for hazard assessment. As verified by the case study on the 2011 Tohoku earthquake, a full tsunami life cycle simulation conducted with 4 arc-minute resolution at single layer spherical coordinate could be finished in less than 3 minutes, with quite well accuracy in comparison with observation data of gauges in Russia, Japan and Taiwan.

DMCC tsunami simulation portal (iCOMCOT [11]) provides the easiest web interface to simulate a tsunami event. The system provides a geographical user interface to easily identify the earthquake epicenter, observation stations, and simulation areas by making use of a web mapping services, such as Google Maps. User only needs those parameters together with simulation name, simulation time, time period to save output data, focal mechanism, and nested-grid arrangement, then the simulation could be carried out. Among them, fault model, nested-grid and tide station settings will be kept in the system for future reuse. iCOMCOT is a real-time tsunami simulation system which is fast, accurate, reliable, and user friendly.

In addition to regenerate several devastating tsunami events such as 2011 Tohoku earthquake and 2004 Indian Ocean tsunami, the COMCOT-based tsunami model was also used for potential tsunami impact analysis in Taiwan [12, 13]. The applications of iCOMCOT for the potential tsunami impact analysis for South China Sea and Indian Ocean have been included in the future plan of DMCC.

IV. KNOWLEDGE BASE FOR DISASTER MITIGATION

Knowledge Base is used to share all the materials and resources from case studies in an organized way. It is implemented over the designed Open Collaboration Platform to support the utilization of services and resources and provide the collective intelligence environment for partners to conduct new case studies or reproduce and reinvestigate existing cases.

Although, for basic disaster information we could always benefit from well-organized global or regional centers, such as the Pacific Tsunami Warning Centre [14] for tsunami events and the International Best Track Archive for Climate Stewardship (IBTrACS)[14] for tropical cyclones, and the Global Fire Monitoring Centre[16] for forest fires. With case studies directly contributed by the severely affected country, we have much better opportunity to be able to acquire detailed data about the target hazards. The Open Collaboration Platform maintains the data federation that provides flexibility to check up the basic information of events from those reliable regional and global information centres (or related national resource centres). On the other hand, the Platform also collects detailed information from case studies and for future applications.

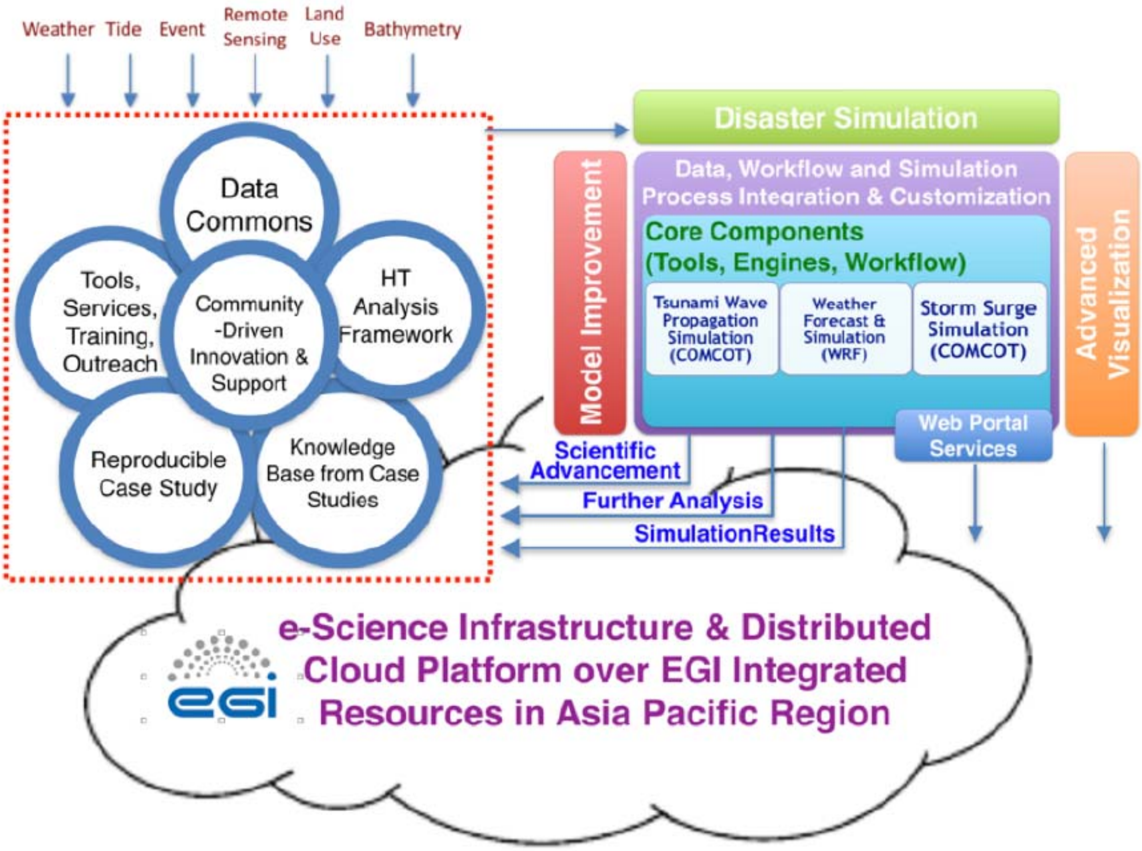

Fig. 5. Moving Towards Open Science Platform from DMCC Collaboration Framework — Integrating Data, Simulation Portal & Innovative Modelling, and Knowledge base from case studies

There are still many technological challenges in gathering event data and information from case studies and analysis. First, how to transform domain knowledge in a machine usable form while retaining the semantic relationship between various fragments of information. Second, how to extract semantic information from heterogeneous sources including unstructured texts. Last, the design and structure of such federated knowledge base to support applications for case studies and analysis. In our design, the Knowledge Base for disaster mitigation (DMKB) is a compiled collection of data, information, tools and services around an event or a theme to support scientific researches. Metadata and data format for the DMKB has to be defined first based on the schemes of primary local, regional, and global data sources. APIs or Web Services to access those sources are needed to enhance the automation and flexible workflow. Similarly, APIs and data services should be delivered to user communities. Data harvesting services as well as data analysis services based on requirements from case studies and user communities should be developed. In the beginning, DMKB is built on architecture of linked practices. A catalogue of DMCC case studies by event/time/location/hazard type/etc. will be constructed and provides a list of actual data files with links for access. In addition to DMKB and the simulation services, open access and digital archives of all materials about the selected cases based on standard metadata schemes and access protocols are all maintained.

As a result, integration of data, simulation portals & innovative simulation applications, and knowledge base from case studies over the common distributed infrastructure could pave solid ground for open collaboration and open science according to the experiences of DMCC. Design of the whole logical architecture is described in the Fig. 5.

As learned from case studies, the information architecture for the knowledge base for disaster mitigation should consist of the basic contents as follows. In the future, formal content analysis has to be conducted to achieve a referenced content architecture or metadata design. In addition, data source and related knowledge bases worth to be federated should be also considered. The data format description, metadata and APIs have to be well documented in the reference architecture.

Case description: covers synopsis history, hazard overview, description of the disaster event and disaster specific attributes (which includes the header for each disaster (for example, the international number ID for a typhoon/tropical cyclone) and best tracks of a typhoon, news report and academic publications.

Scientific investigation on mechanisms of the disaster: This should be categorized by disaster types and models used. Physical characteristics, triggers and their interactions have to be described according to the domain ontology. Three dimensions of simulation and analysis outcomes needs to be covered: 1) spatial dimension (path and impactful region of the hazard); 2) temporal dimension (when); 3) magnitude dimension (what are the degree of the most important scale indicators).

Data sets: Observation data from national, regional and/or global weather or monitoring agencies such as the National Weather Services of US, Central Weather Bureau of Taiwan, etc. used for the case studies have to be retained. Model input data, satellite and in-situ observations, verification data, geographic data all should be incorporated if they are available.

Simulation workflow and programs or services used: The procedures to reproduce the case study simulations including the required parameters and the model integration time (including start time and end time) have to be included. The workflow could be using the simulation web portals (with URLs), container (with reference to repositories such as DockerHub, GitHub, etc.) or Jupyter (Jupyter Hub will be provided in the future).

- Analysis: Outcomes of simulations, the inspection between simulations and observation data as well as the gap analysis for this discrepancy. Solution or recommendation for future works should be also provided.
- References: document and publications in multimedia or any form which is related to the disaster event, analysis, and studies should be organized as a list of references with citations or access points.

V. LESSONS LEARNED AND FUTURE PERSPECTIVES

Building complex computer models of natural systems that can forecast impeding disasters has been one of the grand challenges for earth and environmental sciences in the early twenty-first century. e-Science is the unification of empirical, theoretical and computational approaches [17]. In this study, we have demonstrated the effective approaches to develop innovative and accurate simulation models on multi-hazards events such as the storm surge caused by a strong typhoon. Through the open collaboration framework, we will keep extending the e-Science technologies for primary barriers in software, data management, visualization, and the coordination of diverse communities to develop advanced analysis and algorithms from case studies of various types of disasters.

Deeper qualitative understandings such as possible weather and disaster patterns are crucial for effective disaster mitigation. Multi-hazard scenarios are not negligible at all for a production hazard assessment facility. In our work, work, the numerical simulation services are coping with the practical workflows and could cover the whole lifecycle of a disaster. In addition, through systematic classification of related hazards according to the geophysical environment facts and triggers, multi-hazard risk estimation could be also implemented in combination of individual hazard modules.

Extension of simulation capability for more complicated and combined hazard events is essential. For instance, by combining meteorological and hydrological modelling, the extreme weather event and its scouring or landslides impacts could be estimated. Combining seismic wave propagation and tsunami wave propagation processes, impacts of the high potential tsunami-causing faults in western pacific and Indian oceans could be investigated in details. By considering tracer advection and model chemistry parameterizations, new ways to evaluate atmospheric evolution with compositions such as aerosols and trace gases could be enhanced.

Deployment of data-oriented machine learning technology to understand the transformation process and its correlations with target event characteristics should be conducted. Developing processes of a disaster in its complete lifecycle is able to be captured in required resolution of time, location and magnitude, such as the precipitation, wind intensity and low pressure. Organization of the data has to characterize the hazards, their structures and their temporal changes. For example, the data organization has to contain the segmented precipitation objects and their associated attributes. Machine learning algorithms then could be applied for learning the patterns and features of specific events from the data. Again, sufficient data is the key to this task.

Integrating and sharing data, simulation facility and innovative applications, workflow, and details of computational environment that generate published findings in open trusted repositories are the first step towards an open science platform for disaster mitigation. As more scientific disciplines are relying on computational methods and data-intensive exploration, it has become essential to develop software tools that help document dependencies on data products, methodologies and computational environments. To document, archive and share all data and the methodologies used makes scientists reproduce and verify scientific results and students learn how they were derived. Ability to rerun the same computational steps on the same data would be a dissemination standard, which includes workflow information that explains what raw data and intermediate results are input to which computations.

VI. SUMMARY

Hazard assessment and prediction by numerical simulation is crucial to the disaster mitigation studies and applications. Similar to weather forecast today which has been playing a vital role in people's daily lives, many critical decisions must be made in advance of potentially disruptive environmental conditions. The primary challenge lies on our knowledge to the earth system and how to achieve reliable and accurate simulations as early as possible.

By means of case studies and root cause investigation of the disaster events, we have achieved high-performance and accurate simulation facility to estimate the risks during the whole hazard lifecycle over the distributed e-infrastructure. In DMCC, we also demonstrated the effective collaboration model to incorporate end users, scientific groups, technical groups, infrastructure support group, user support groups and simulation

facility in partner countries to accomplish the planned case studies by investigating the underlying causes. DMCC open collaboration framework has established a practical environment to estimate disaster risks of similar events while continuously improve the simulation facility and services from user experiences by engagement of all necessary expert groups based on deeper understanding approaches.

Regional and multidisciplinary collaborations are of essential importance to disaster mitigation development in Asia Pacific countries. The DMCC collaboration framework is extending these collaborations in disaster types, the associated impact activities, cooperation groups and countries as well as the understandings to the sciences. More importantly, the collaboration framework would be extended and distributed in any type of collaborations in different areas supported by the common e-Infrastructure. The direct benefits of all partners are the rapid spread of knowledge from case studies, seamless access to high performance simulation facility, and the capability to reuse or conduct case studies, etc. Through open science and open service paradigm, the DMCC collaborations would be sustainable and much valuable if the momentum and case studies could be maintained and moving forward.

All these case studies would be compiled into knowledge base of the DMCC collaboration framework and the simulation could be reproduced for education, training and further studies. Besides the simulation facilities, users could also access the observation data, archive of historical events, case studies, and knowledge base. The DMCC collaboration framework is thus a primitive online collaborative platform as defined by OECD [10] which supports efficient scientific processes by combining common research tools and data repositories for disaster mitigation.

Acknowledgements

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以智慧地球聯盟雲為核心之開放式協作框架~

以災難舒緩與環境科學為例

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摘要

自從 1990 年代中期起，經濟之動力已由管理稀有性轉向製造浪費，其後果是資源浪費與環境破壞。永續發展成為全球之目標，其中最重要目標是智慧地球。災難舒緩科技中心，環境運算與農業是歐盟最優先發展之計畫。歐盟之計畫係追求在亞洲之人道永續發展，以降低自然環境災害之影響。以主要之深度理解與創新性之模擬服務為核心，DMCC+ 計畫首先以海嘯，暴風巨浪，洪水，森林火災監控，粉塵傳輸為個案研究標的，以建立深度知識及進階數值模擬方法。除了自然環境考量，我們也將經濟學觀點加入生態系框架，即開放式 API 及平台經濟。如此得以進行災難舒緩科技中心與環境生態系之數位轉型。

本研究提出一套以對根源原因及災害原因之深度理解為基礎的知識導向災害風險評估方法並驗證之。許多不同國家的不同型態之個案在本研究中將被實現，並依目標個案需求建立模擬機制。.在此基礎上，本研究進而提出以個案之材料與資源彙編為基礎之組織性災害評估知識庫設計。個案研究，模擬機制與知識庫形成了一個正向回饋的迴路。災害物理過程之知識及模擬機制將隨個案之增加而逐步更堅實化。經由整合與分享資料，模擬機制，創新服務，工作流程以及精緻的運算環境，足以藉由開放式協同作業平台之可信任大數據庫及時發佈最新發現，本研究實現了一個開放式災害防範科技服務平台。 以此為基礎，可以進一步進行環境科技服務中心之數位轉型。

關鍵詞：永續發展、智慧地球、聯盟雲、災害舒緩與環境科技、開放式協作平台、開放式 API 及平台經濟、數位轉型。