

LECTURE 9



Dr. Philip Li-Fan Liu

- Research Assistant, Department of Civil Engineering, MIT, 1969 - 1974.
- Assistant Professor, School of Civil and Environmental Engineering, Cornell, 1974 - 1979.
- Visiting Assistant Professor, Department of Civil Engineering, University of Delaware, July 1977 - December 1977.
- Associate Professor, School of Civil and Environmental Engineering, Cornell, 1979 - 1983.
- Guggenheim Fellow and Visiting Associate at W.M. Keck Laboratory, Caltech, 1980 - 1981.
- Professor, School of Civil and Environmental Engineering, Cornell, 1983 - now.
- Associate Director, School of Civil and Environmental

- Engineering, Cornell, 1985 - 1986.
- Associate Dean for Undergraduate Affairs, College of Engineering, Cornell, 1986 - 1987.
 - Visiting Scientist, Delft Hydraulics Laboratory, August 1987 - January 1988.
 - Visiting Professor, Institute of Hydrodynamics, Technical University of Denmark, January 1988 - June 1988.
 - Visiting Fellow, Osaka City University, Japan, January 1994.
 - Visiting Professor, Department of Civil Engineering, National Taiwan University, September 1994 - August 1995.
 - Visiting Professor, Department of Civil Engineering, National University of Singapore, January 2000.
 - Graduate Field Professor, College of Engineering, Oregon State University, September 2001 - August 2006.
 - Visiting Professor, Mediterranean Institute for Advanced Studies (IMEDEA), CSIC - Universidad de las Islas Baleares, Spain, February - May 2002.
 - Adjunct Professor, Tropical Marine Science Institute, National University of Singapore, July 2003 - July 2006.
 - Kwoh-Ting Li Professor, National Central University, Taiwan, 2007 - now.
 - National Science Council Chair Professor, National Central University, Taiwan, July - December 2008.
 - Guest Professor, Leichtweiß-Institut für Wasserbau, Technische Universität Braunschweig, Germany, January - June 2008.
 - Director, School of Civil and Environmental Engineering, Cornell, July 2009 - June 2015.

Date: 2019.5.6

淡江大學熊貓講座
Tamkang Clement and Carrie Chair

劉立方 院士
Philip Li-Fan Liu, ScD

新加坡國立大學副校長(研究與科技)
美國國家工程院院士
美國地球物理學會會士
中央研究院院士

講題 **2018 Sulawesi Earthquake and Palu Tsunami**

時間地點 2019 5/6 14:00-16:30
守謙國際會議中心有蓮國際廳

工學院 水資源及環境工程學系 敬邀

INTRODUCTION

- Philip L.-F. Liu is a Distinguished Professor in the Department of Civil and Environmental Engineering at NUS. He is also serving as the Vice President for Research and Technology. Currently he is on leave from Cornell University where he is the Class of 1912 Professor in Engineering. Liu is also the holder of Kwoh-Ting Lee Chair Professorship at the National Central University, Taiwan, where he is affiliated with the Institute of Hydrological and Oceanic Sciences.
- After graduating with a B.S. degree in Civil Engineering from National Taiwan University in 1968, Liu studied at Massachusetts Institute of Technology and received a S.M. degree in Civil Engineering in 1971 and a ScD degree in 1974. He joined Cornell faculty as an Assistant Professor in the School of CEE in 1974 and was promoted to Associate Professor in 1979 and Full Professor in 1983. He served as the Associate Director of the School in 1985-1986 and as the Associate Dean for Undergraduate Studies of Engineering College in 1986-1987. Liu was the Director of the School of CEE from July 1, 2009 to June 30, 2015.
- Liu is a member of the National Academy of Engineering (NAE), a fellow of the American Geophysical

Union (AGU), and a distinguished member of the American Society of Civil Engineers (ASCE). He has received many academic awards, including the prestigious ASCE Walter L. Huber Civil Engineering Research Prize (1978), the J. S. Guggenheim Fellowship (1980), the ASCE John G. Maffatt & Frank N. Nichol Harbor and Coastal Engineering Award (1997), the International Coastal Engineering Award ASCE (2004) and the Alexander von Humboldt Research Award (2009).

- University Scholarship for outstanding undergraduate students, National Taiwan University (1966-1969)
- Justice Foundation Faculty Fellowship, College of Engineering, Cornell University (1978-1979)
- Walter L. Huber Civil Engineering Research Prize, American Society of Civil Engineers (ASCE) (1978)
- Engineering Foundation Fellowship (1980)
- J.S. Guggenheim Foundation Fellowship (1980)
- Tau Beta Pi Excellence in Teaching Award (1982)
- Osaka City University Fellowship, Japan (1993)
- National Science Council Fellowship, Taiwan (1994)
- John G. Maffatt & Frank E. Nichol Harbor and Coastal Engineering Award, ASCE (1997)
- Best paper award from the Division of the Ocean, Offshore and Arctic Engineering, the American Society of Mechanical Engineers (ASME), "A Multi-layer Approach to Modeling Water Waves from Very Deep Water to Shoreline" (P. J. Lynett and P. L.-F. Liu) (2002)
- Best paper award from Journal of Mechanics, "Oscillatory Flows over a Permeable Wavy Boundary" (S-C, Hsiao and P. L.-F. Liu) (2004)
- International Coastal Engineering Award, ASCE (2004)
- Fellow, American Geophysical Union (AGU) (2006)
- Kwoh-Ting Li Chair Professorship, National Central University, Taiwan (2007-now)
- Alexander von Humboldt Research Award (2009-2010).
- National Science Council Chair Professorship, Taiwan (2008-2009)
- Endowed Chair Professorship (Class of 1912 Professor of Engineering), Cornell (2008 - now).
- Distinguished Member, ASCE (2013 - now)
- Outstanding alumnus, Department of Civil Engineering, National Taiwan University (2014)
- Member, Chi Epsilon Honor Society (2014)
- Outstanding paper award from the Journal of Waterway, Port, Coastal and Ocean Engineering, ASCE, "Advective Diffusion of Contaminants in the Surf Zone."

(Winckler, P., Liu, P. L.-F., and Mei, C. C.) (2014)

- Member, National Academy of Engineering (2015 - now)
- Hamaguchi Award (2017)

ABSTRACT

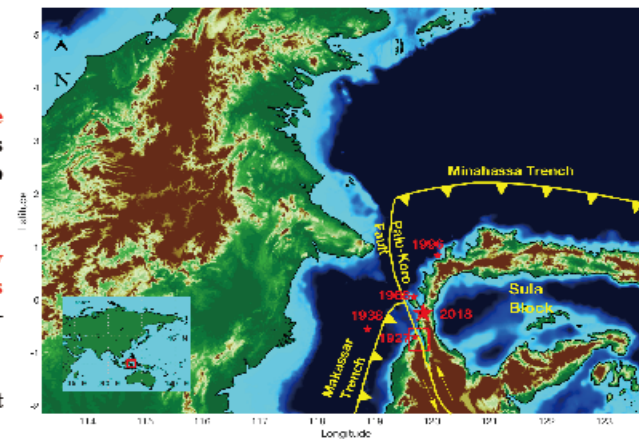


THE EARTHQUAKE

On September 28th at 10:02:43 UTC time, a Mw **7.5 strike-slip** earthquake struck in Sulawesi Island. A significant damage was reported in Palu bay, located at the earthquake location.

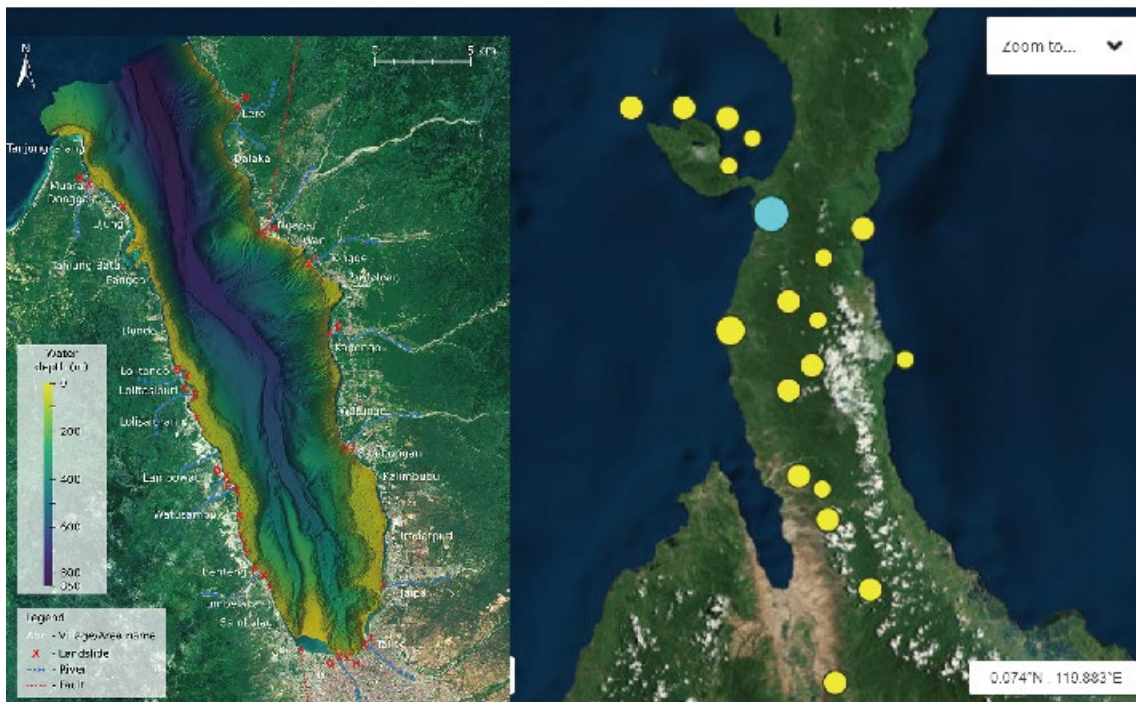
Many highlights of the earthquake:

- Very shallow slip (within 10 km).
- Despite the earthquake was mainly **strike slip**, the mapped fault trace contains abrupt bends which are capable to generate dip-slip components.
- Earthquake crossed Palu bay. **Geometry of the rupture beneath the bay remains unknown** (are bends, with significant dip-slip, a possibility?).
- Fast rupture (super-shear). Bends do not modify high rupture speeds.

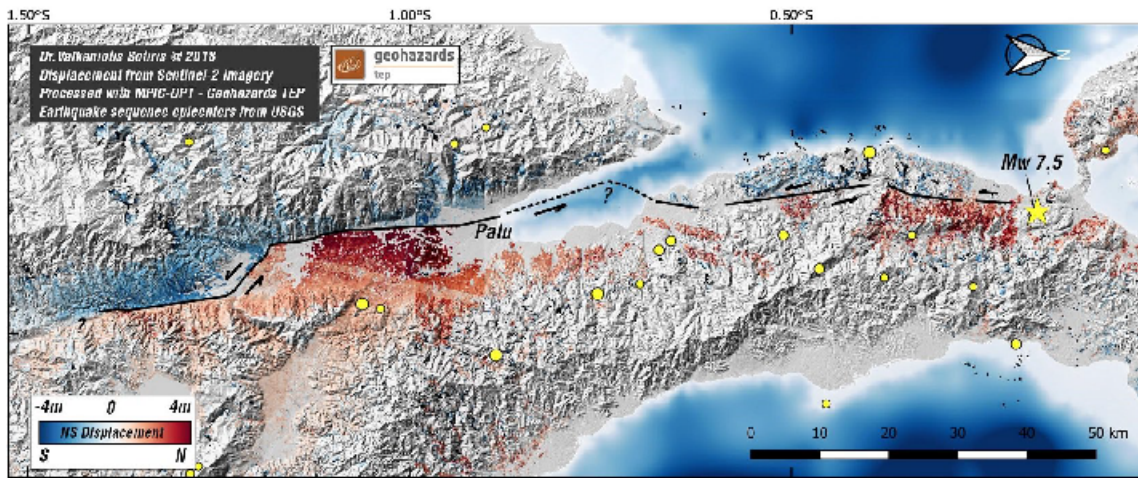


Source: Sepulveda et al. (2019) ² (in prep.)

After shocks a Palu bay



Ground displacements and fault lines

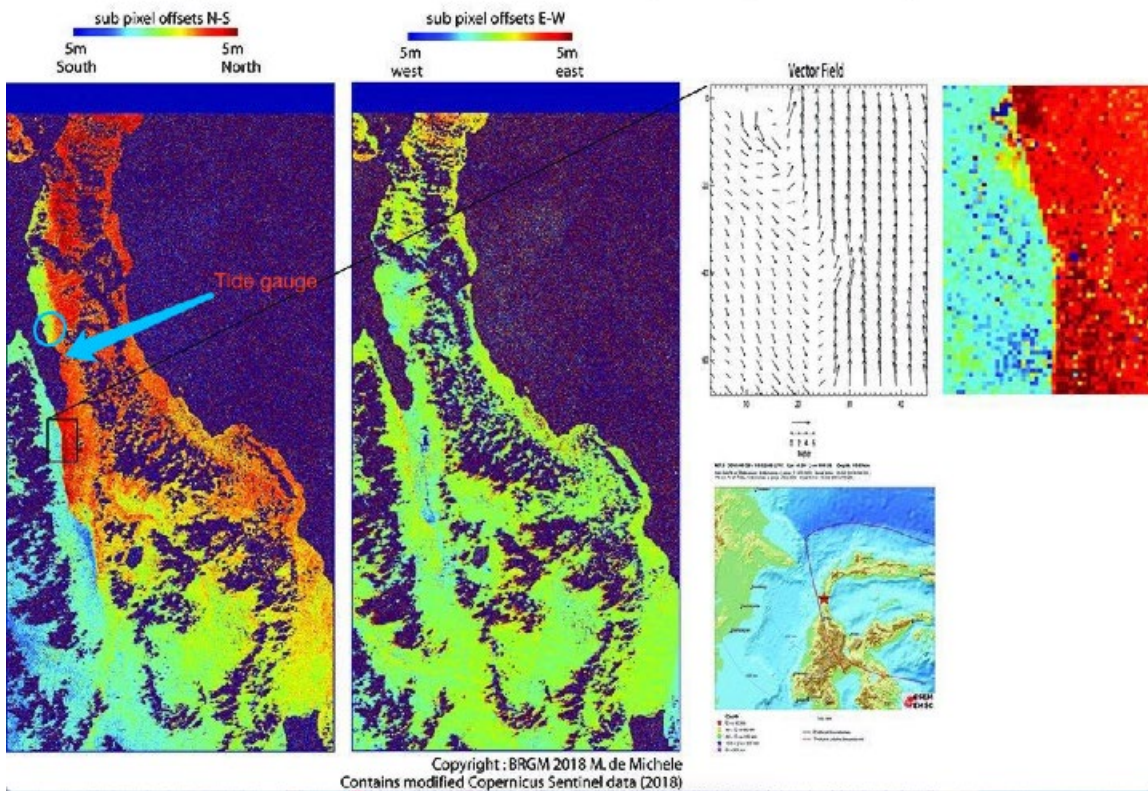


Challenge #1

The geological information of the fault plane underneath the bay is incomplete

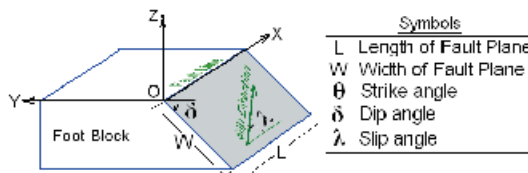
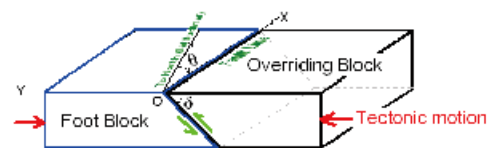
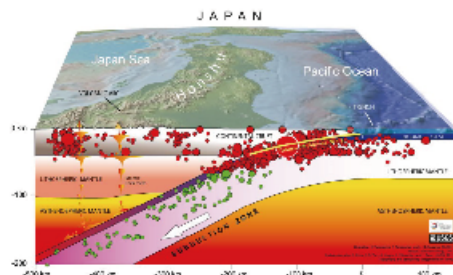
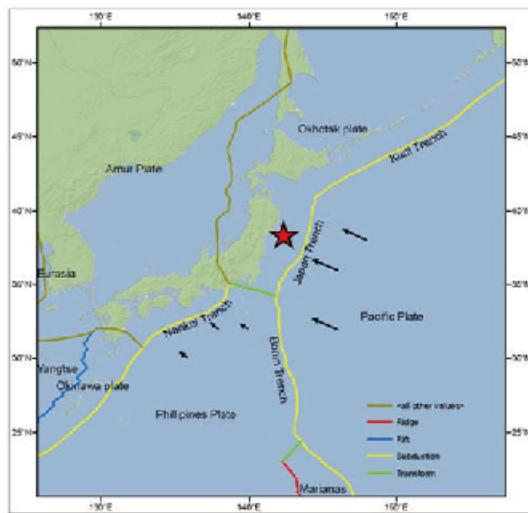
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Sentinel-2 derived displacement field of the 2018-09-28 Mw 7.5 MINAHASA, SULAWESI, INDONESIA earthquake



Tsunami Generation Mechanism – Earthquake

Tectonic plates and subduction zone



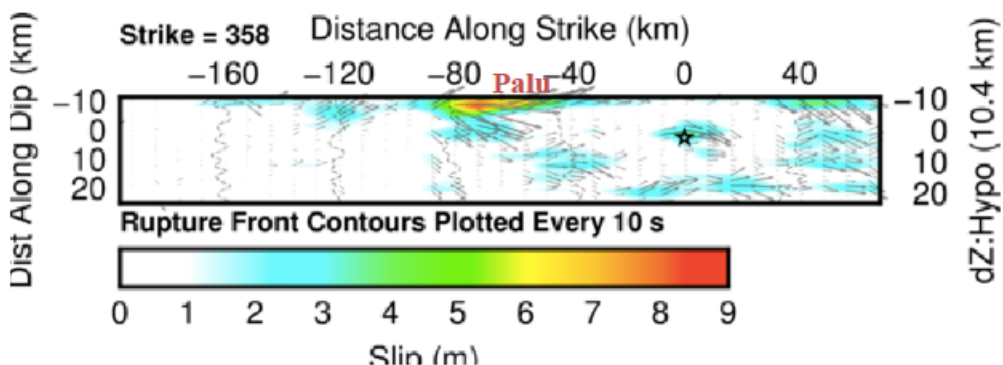
XOY parallel to the horizontal earth surface; OZ pointing upward;
 θ is the azimuth of OX measuring clockwise from the latitudinal.

Need to convert the Focal Mechanisms to vertical seafloor displacement to generate tsunamis

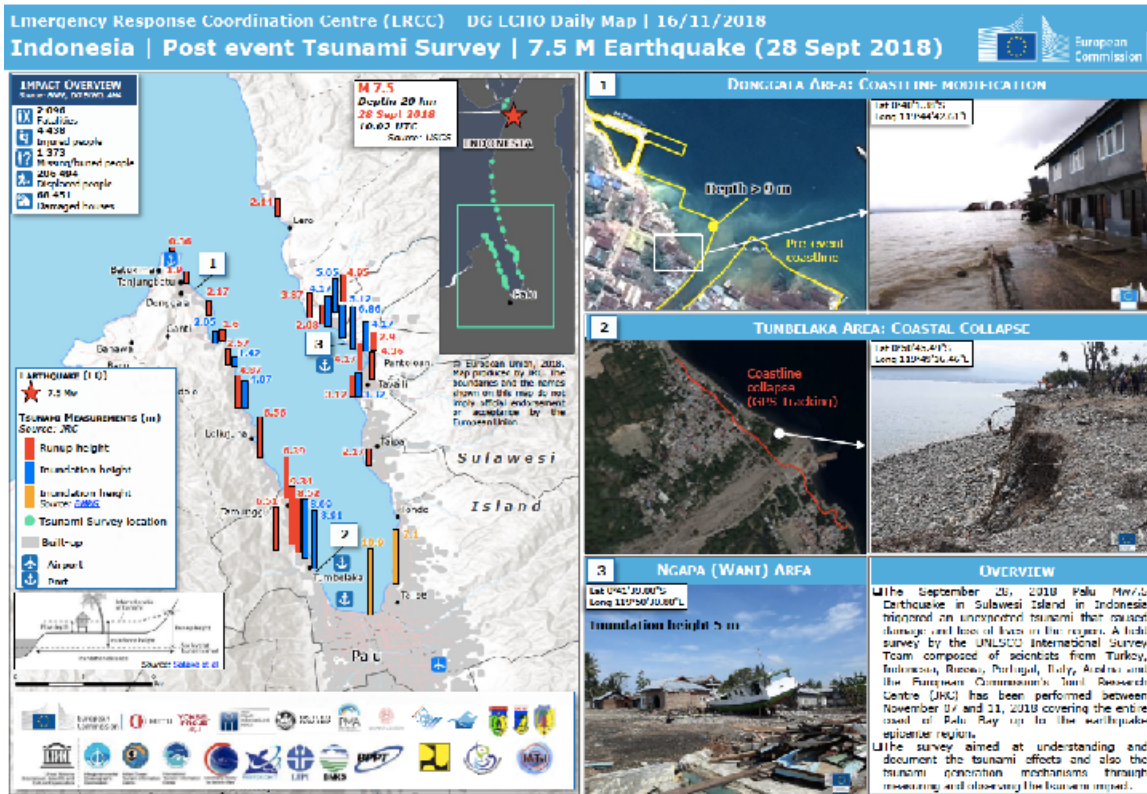
U.S. Geological Survey - Earthquake Hazards Program
M 7.5 – 78km N of Palu, Indonesia
 2018-09-28 10:02:43 (UTC) | 0.178°S 119.840°E | 10.0 km depth

After comparing waveform fits based on the two planes of the input moment tensor, we find that the nodal plane (strike = 358.0°, dip = 66.0°) fits the data better. The seismic moment release based upon this plane is 2.5e+20 dyne-cm (Mw = 7.5) using a 1D crustal model interpolated from CRUST2.0 (Bassin et al., 2000).

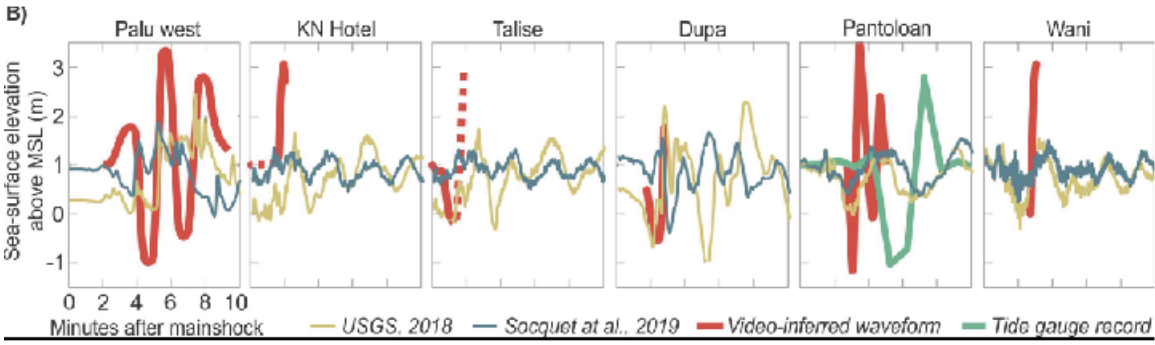
Cross-section of Slip Distribution USGS Finite Fault Model



Direct Evidence of Tsunamis — Post-tsunami surveys



Flow Chart for simulating tsunami generation and propagation



MINUTE



Met with President, Dr. Huan-Chao Keh and TKU colleagues



Met with Chairman of the Board, Dr. Flora Chia-I Chang and TKU colleagues

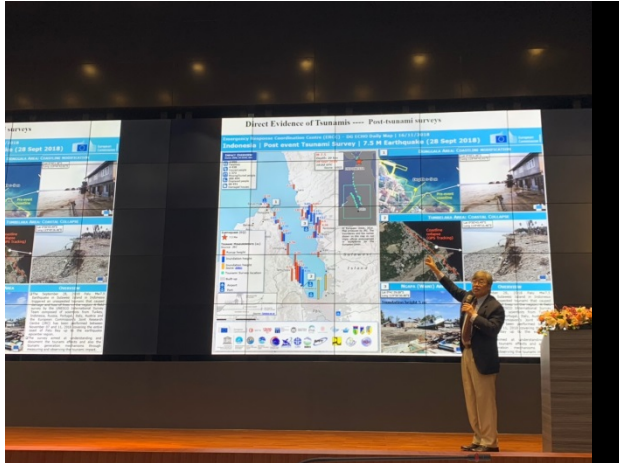
- For the 9th lecture of the Tamkang Clement and Carrie Chair Lecture Series, TKU invited Dr. Philip Li-Fan Liu, the Vice President (Research and Technology) of the National University of Singapore, an academician at the US National Academy of Engineering, and an academician at Academia Sinica, Taiwan. Dr. Liu is an internationally renowned scholar in the field of tsunami science and fluid mechanics (theory, calculation, and experimentation). He is also widely known in the fields of marine engineering and hydraulic engineering.
- Before the Chair Lecture at TKU, Dr. Philip Li-Fan Liu visited President, Dr. Huan-Chao Keh and Chairman of the Board, Dr. Flora Chia-I Chang.
- Dr. Liu's lecture was held at 2:00 pm on May 6, 2019, at the Hsu Shou-Chlien International Conference Hall, Tamsui

Campus. The event commenced with a joint opening address by the Dean of the TKU College of Engineering, Dr. Tzung-Hang Lee, and the Chair of the Department of Water Resources and Environmental Engineering, Dr. Po-ching Lee. This was followed by an introduction of Dr. Liu's numerous accomplishments by Yun-Ta Wu, an assistant professor from the same department.



- The topic of Dr. Liu's speech was the 2018 Sulawesi Earthquake and Palu Tsunami. Dr. Liu told attendees about the response mechanism in place when Indonesian

tsunamis occur and the new generation of tsunami alert systems that was later developed. He also described his research at Sulawesi Island in 2018, when he led a team to survey the area and test the local bay landscapes.



- In addition to Dr. Liu's lecture, a series of discussions were also arranged in which the visiting speaker addressed the possibility of future collaboration on Ministry of Science and Technology (MOST) research projects, while also discussing possible directions for future research and cooperation with both Tamkang students and faculty.

