A. Major Achievements and Contributions (2020-present)

In the past 5 years my research activities can be summarized as four aspects: (1) climate model development; (2) climate simulations and projections; (3) development and utilization of FV3-based weather forecast model; (4) wind energy assessment. I implemented HiRAM (HIgh Resolution Atmospheric Model developed in GFDL) in ACCC and conducted climate projections that resolve future changes in tropical cyclone and severe weathers. Nevertheless, HiRAM is AGCM and lack of interactive air-sea interface. I further coupled HiRAM with a one-column ocean model SIT (Snow/Ice/Thermocline) that its refined upper layers help resolving diurnal warm layer and cool skin. HiRAM-SIT mimics CGCM but considers no ocean circulation. The lack of ocean circulation is remedied by nudging with observation or climatology. The coupling of HiRAM-SIT also shows improvement of MJO eastward propagation with benefits by consideration of air-sea interaction and diurnal SST variation.

Utilizing HiRAM for long-term high-resolution climate experiments is one of the major activities in ACCC. Three periods of time-slice experiments using HiRAM had been conducted for present time (1979~2015), near future (2038~2065), and end of century (2074~2100). These HiRAM simulations and projections had been also provided to Taiwan's research community for dynamical downscaling to understand future climate change and impact in Taiwan. Other than HiRAM simulations and projections under CMIP5 RCP scenarios, I further utilized HiRAM and HiRAM-SIT to participate CMIP6-HighResMIP. There are 3 tiers of HR (high resolution) and LR (low resolution) simulations in CMIP6-HighResMIP protocol.

From 2016 I started to work on the implementation of FV3-based weather forecast system (fv3GFS) and introduced the two-way nested method that model configuration in the nested domain is individual from its configuration in the global domain. The global C768 (~13km) coordinate with a Taiwan-centered refined resolution of 3km in the nested domain is designed for the application of fv3GFS in Taiwan. With my help ACCC now uses fv3GFS for mechanism diagnostic of weather extremes, like heavy precipitations and winter storms, by changing initial and boundary conditions. Also, ACCC uses fv3GFS with the coupling of slab or mixed layer ocean model for study of typhoon and typhoon genesis under different climate scenarios.

From 2017 I started to cooperate with wind energy scientists and my work was providing high-resolution atmospheric modelling information. Later in 2019 and 2020 I participated in two wind energy projects as sub-project PI to establish the semi-operational atmospheric modelling system for simulating wind field. I first used regional forecast model WRF with Fitch module for daily wind field simulations and central Taiwan wind farms power calculation. Fitch module is a wind turbine parameterization that imposes momentum sinks as wind turbines on the mean flow and transfers kinetic energy into electricity and turbulent kinetic energy. With the satisfied daily wind filed simulations and wind farms power calculation, I further coupled Fitch module with the two-way nested

fv3GFS to estimate wind energy generations in the nested domain. From 2021 I joined the CCRAB project and I am in charge of climate risks assessment for offshore wind industry. A series of dynamic downscaling experiments using WRF to simulate 34 historical typhoons that effecting central Taiwan wind farms had been conducted. The pseudo global warming (PGW) experiments for these 34 typhoons under +2-deg and +4-deg scenarios were also conducted to understand the impact of strong wind against wind turbines.

B. Future Plan

As an associate research specialist from 2019, my research activities focus on weather/climate model development and utilization. Recently ACCC proposed the development of TaiESM2 with major change of implementing FV3 dynamic core. This is the most important task for model development in ACCC. Since I am the experienced user and developer of FV3, the development of fv3-TaiESM2 is the top priority in my future work. Another future working item is the development of TaiESM2 coupling with SIT. The model structure of TaiESM2-SIT will be similar to HiRAM-SIT, and TaiESM2-SIT is expected to better resolve SST and air-sea interaction with the benefit of extra high vertical resolution near ocean surface. After TaiESM2-SIT, the coupling of TaiESM2, SIT and TIMCOM (TaIwan Multi-scale Community Ocean Model) will be another task for model coupling. With the coupling with the three-dimensional ocean model TIMCOM, the lack of ocean circulations in SIT can be overcome. The model coupling of TaiESM2-SIT-TIMCOM is expected to be one of the model frameworks for TaiESM2.

Other than the model development of TaiESM2 and the coupling works, I will also continue the utilization and development of fv3GFS. Currently in ACCC fv3GFS is used for numerical weather prediction with forecast times ranging from a few days to two weeks, while HiRAM is used for climate simulation and projections with time scales from years to decades. In the future I would like to use fv3GFS to explore its skill for sub-seasonal to seasonal (S2S) predictions, and try to enhance the performance. The goal is the development of a seamless unified FV3-based model family that can be used across a range of temporal and spatial scales for numerical weather prediction, seasonal forecasting and climate modelling.

C. Curriculum Vitae

Education

- **Nat'l Chung-Hisng University**, Department of Environmental Engineering, Taichung, Taiwan
  PhD (Sep. 1999 – Jan. 2006). Advisor: Ben-Jei Tsuang
- **Nat'l Chung-Hisng University**, Department of Environmental Engineering, Taichung, Taiwan
  Master (Sep. 1997 – Jun. 1999). Advisor: Ben-Jei Tsuang
- **Nat'l Taiwan University**, Department of Environmental Engineering, Taichung, Taiwan
  BSc (Sep. 1990 – Jun. 1994).

Appointments

- **Associate Research Specialist**, Academia Sinica, Research Center for Environmental Changes, Taipei, Taiwan (May 2019 – present)
- **Assistant Research Specialist**, Academia Sinica, Research Center for Environmental Changes, Taipei, Taiwan (Nov. 2012 – May 2019)
- **Postdoc Fellow**, Academia Sinica, Research Center for Environmental Changes, Taipei, Taiwan (Jan. 2012 – Nov. 2012)
- **Associate Researcher**, Taiwan Typhoon and Flood Research Institute, Taichung, Taiwan (Sep. 2006 – Dec. 2011)
- **Postdoc Fellow**, Nat'l Chung-Hisng University, Department of Environmental Engineering, Taichung, Taiwan (Feb. 2006 – Sep. 2006)

Publications

1. Chao-An Chen, Huang-Hsiung Hsu*, Hsin-Chien Liang, Yu-Luen Chen, Ping-Gin Chiu, ***Chia-Ying Tu*** (2024, Jul). Impacts of Local and Remote SST Warming on Summer Circulation Changes in the Western North Pacific. Journal of Climate. DOI: 10.1175/JCLI-D-23-0403.1

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3. Kuan-Chieh Chen, Chih-Hua Tsou, Chi-Cherng Hong, Huang-Hsiung Hsu, ***Chia-Ying Tu*** (2023). Effect of model resolution on simulation of tropical cyclone landfall in East Asia based on a comparison of 25-and 50-km HiRAMs. Climate Dynamics, 61: 2085-2101.

4. Wan-Ling Tseng, Huang-Hsiung Hsu, Yung-Yao Lan, ***Chia-Ying Tu***, Pei-Hsuan Kuo, Ben-Jei Tsuang, and Hsin-Chien Liang (2022) Improving Madden–Julian Oscillation Simulation in Atmospheric General Circulation Models by Coupling with Snow–Ice–Thermocline One-dimensional Ocean Model. Geoscientific Model Development, in review, DOI: 10.5194/gmd-2021-381

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