

AI機器學習降尺度

Shih-Hao Su (蘇世顥)

CCU (中國文化大學)
@TCCIP第四期成果發表



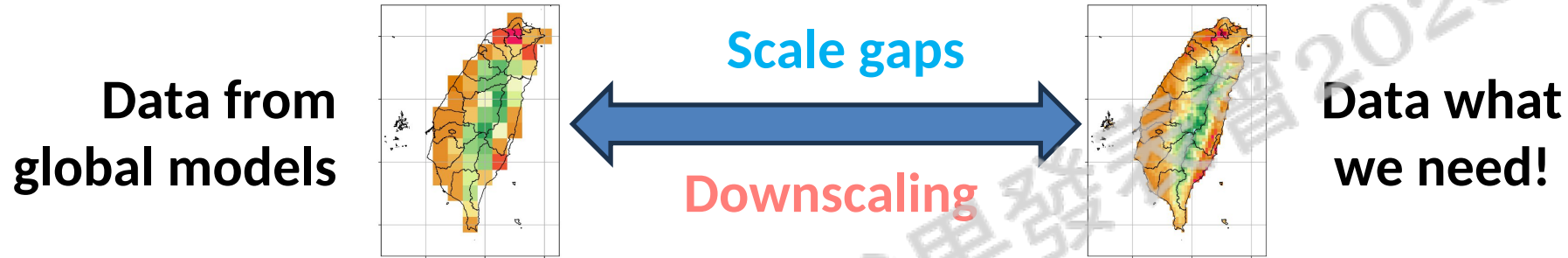
What you will get today

- Why Do We Need AI Downscaling?(為什麼需要 AI 降尺度 ?)
 - AI Downscaling for Climate Analysis
- How Can We Help AI Truly Learn Meteorological Signals?(如何讓AI 真的學到氣象訊號 ?)
 - Signal Matters — STAR-N (時空自適應標準化)
- An AI Downscaling Model Designed for Taiwan (為台灣而設計的 AI 降尺度模型)
 - Physics Matters — MISR (多變數整合超解析度)
- How Can We Use AI Downscaling Tools in the Future?(接下來, 我們可以怎麼使用AI降尺度工具 ?)
 - From “Data” to “Applications”

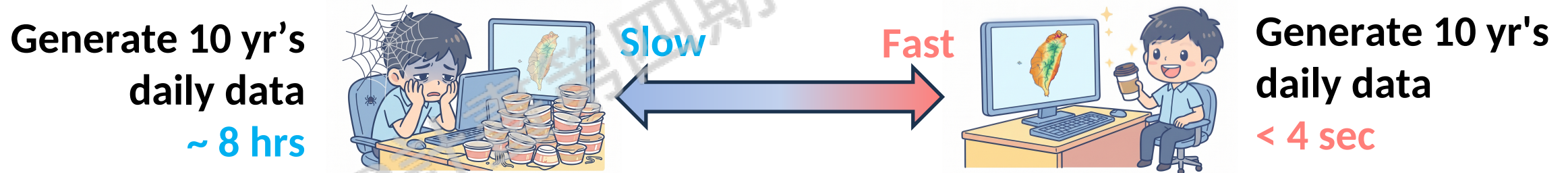


Why Do We Need “AI Downscaling”? (為什麼需要“AI降尺度”?)

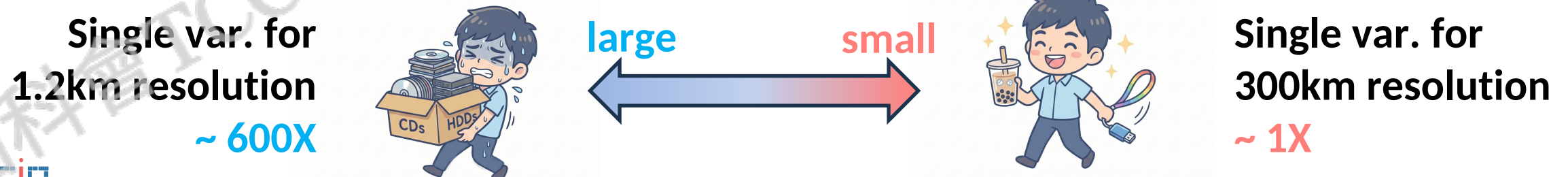
1. Scale gap of Climate data issue



2. The challenge of computational efficiency

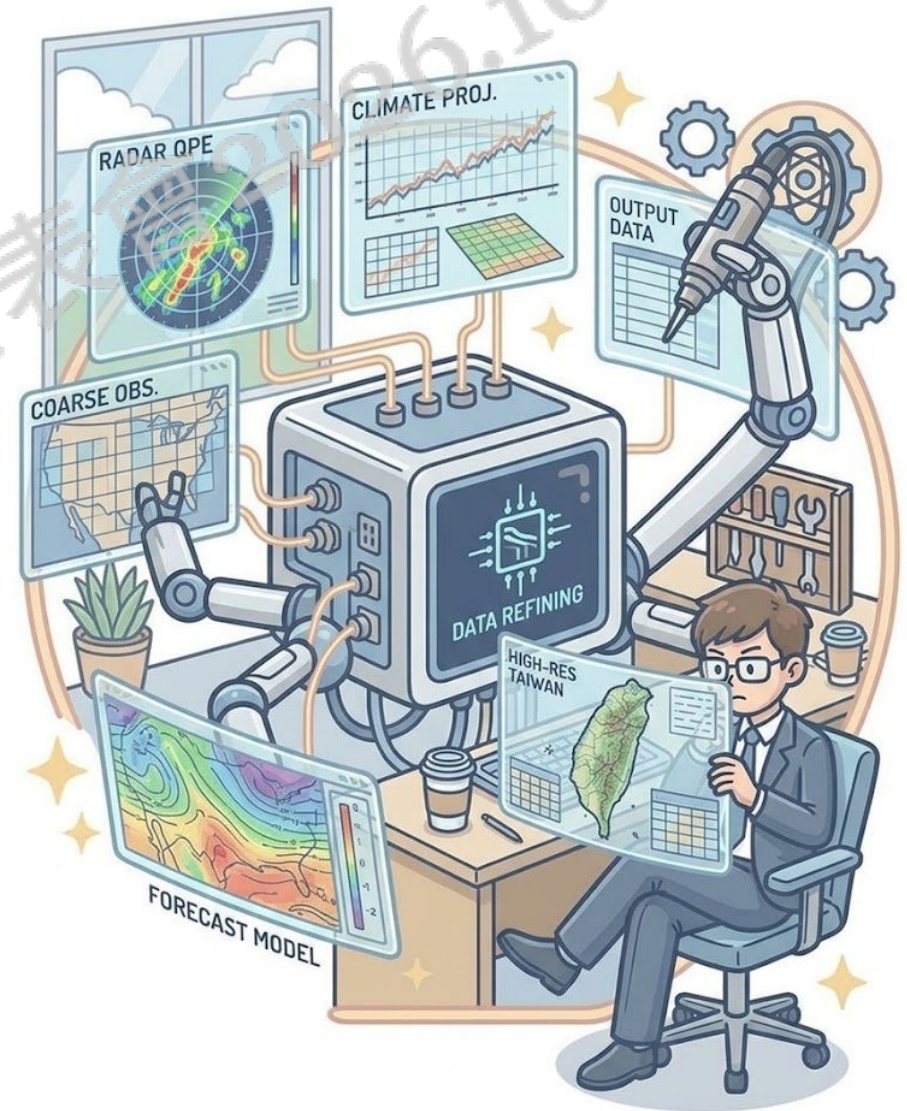


➤ 3. The challenge of storage capacity



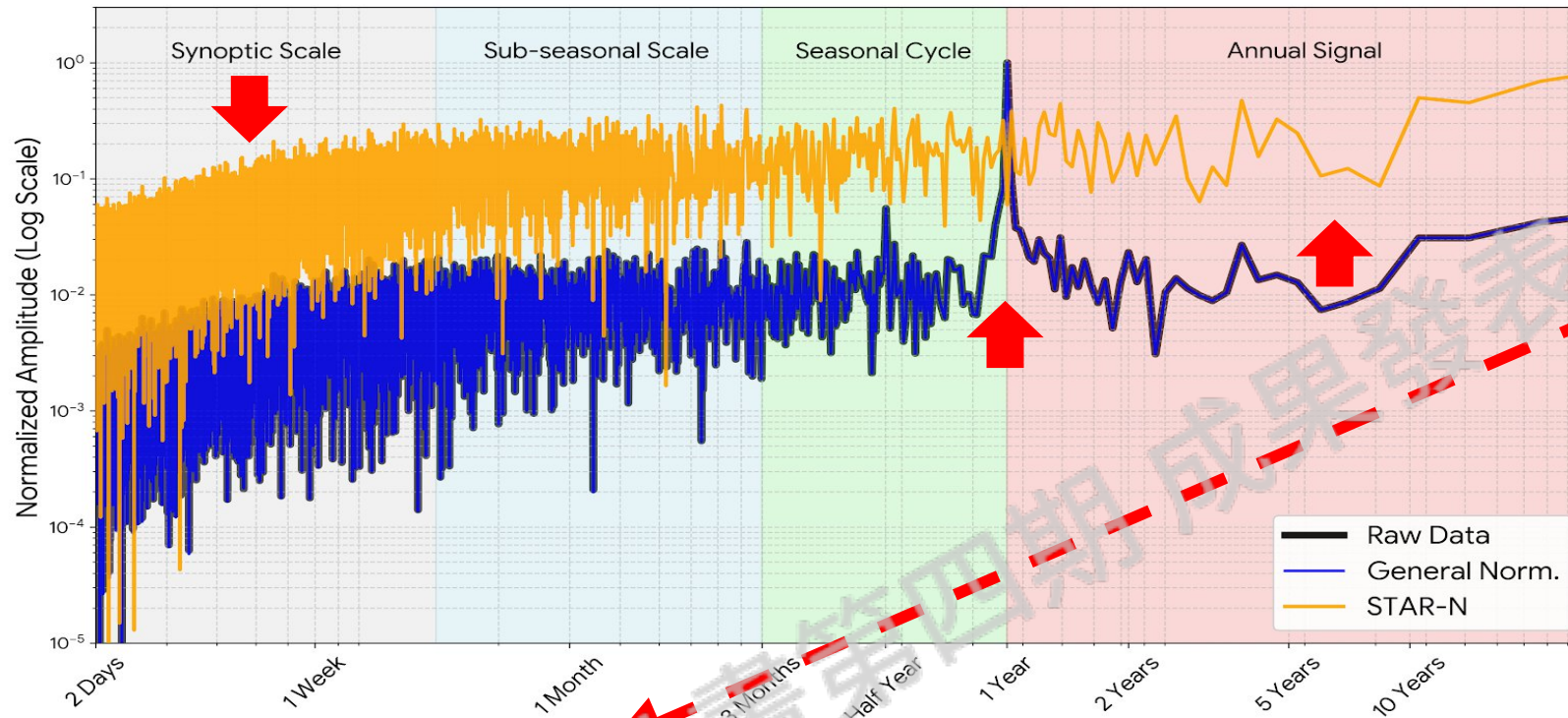
Why Do We Need “AI” Downscaling? (為什麼需要 “AI” 降尺度?)

- Can be used for downscaling of various types (observations or simulations) of raw data (可用於各種型態的輸入資料)
- Reducing Errors from Arbitrary Assumptions (減少人為假設誤差)
- Introducing more physical information to the AI model (加入更多物理過程)
- Continuously and rapidly updated AI models (能夠快速且持續更新)

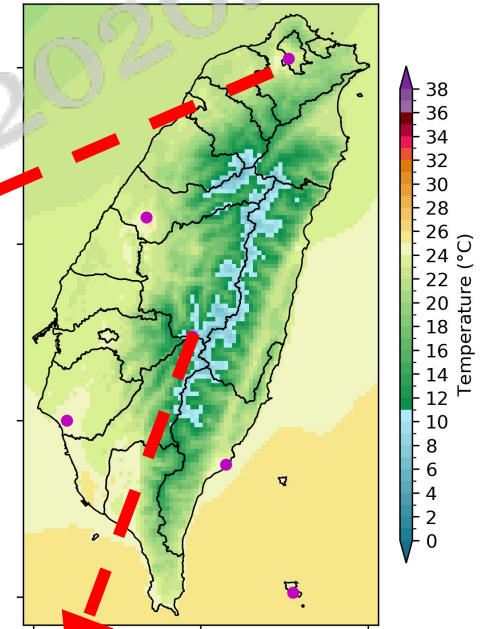


How Can We Help AI Truly Learn Meteorological Signals?

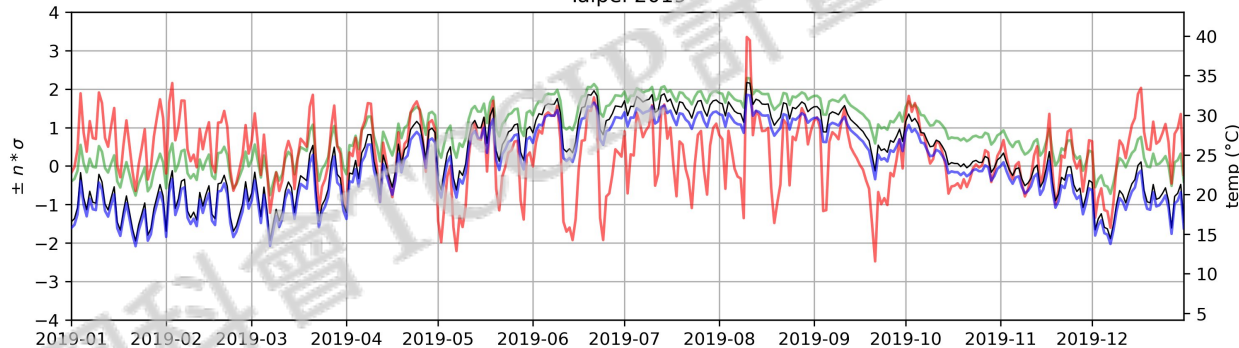
(如何讓AI 真的學到氣象訊號?)



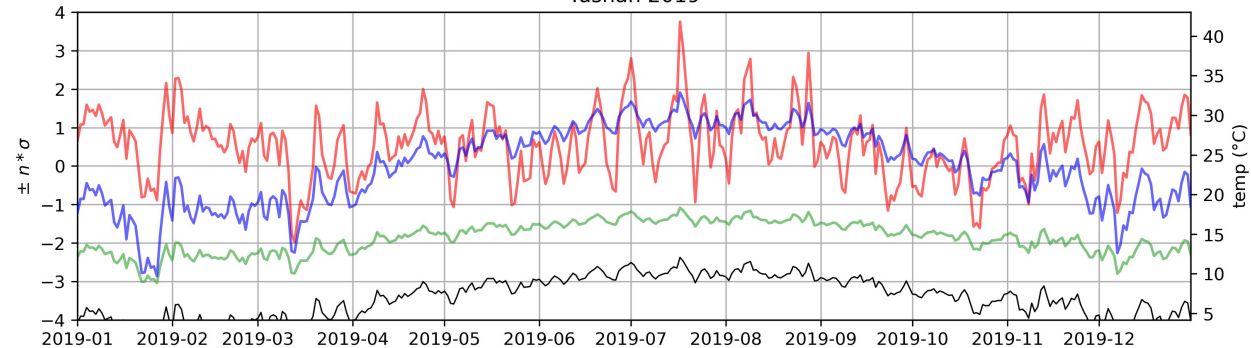
T2MEAN daily 1980-2020 climatology



Taipei 2019

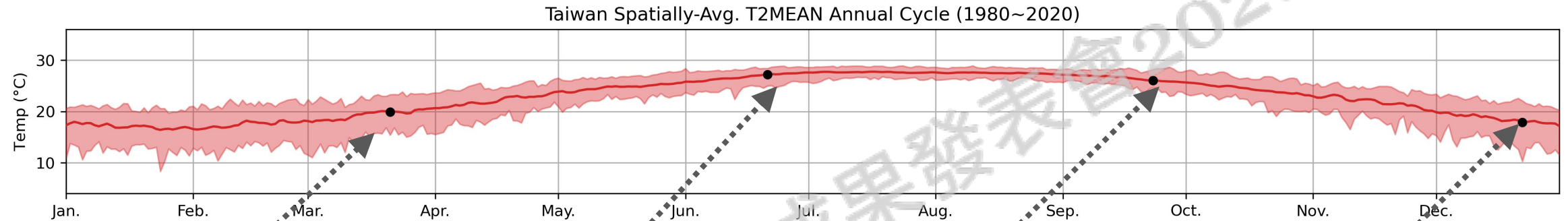


Yushan 2019

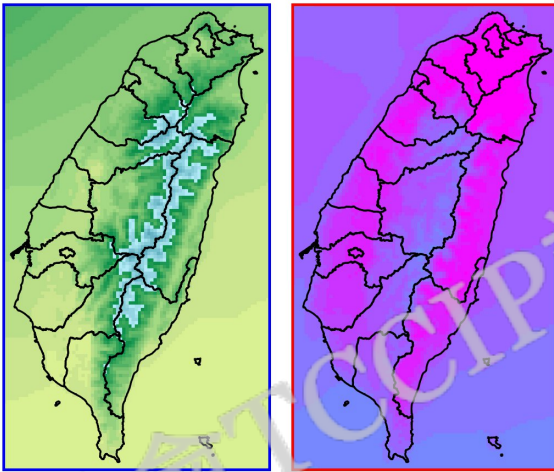


— raw — Global Min-max — Global Z-score — STARN-6

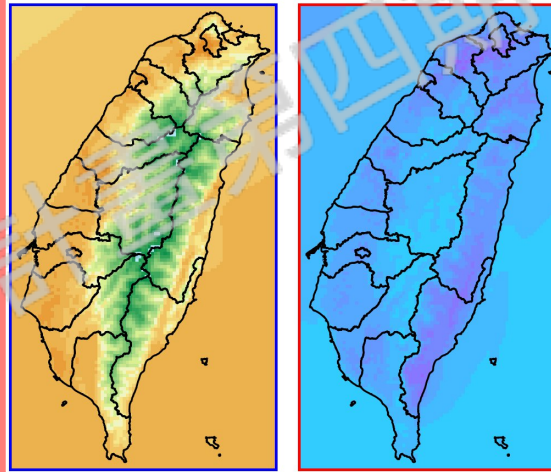
Spatial-Temporal Adaptive Rescaling Normalization (STAR-N/時空自適應標準化)



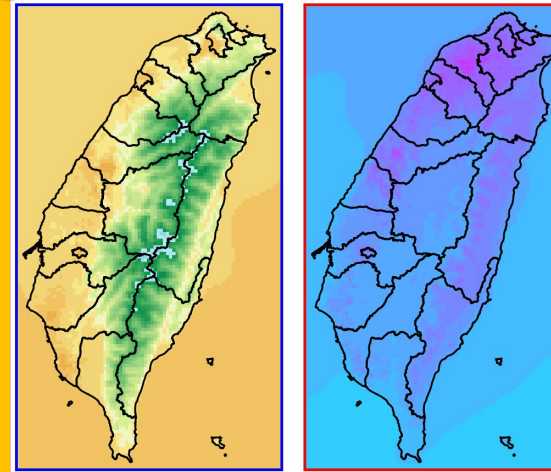
Spring Equinox (春分)



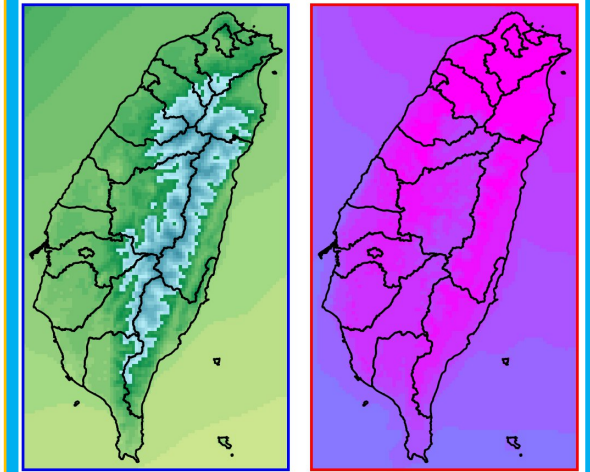
Summer Solstice (夏至)



Autumnal Equinox (秋分)

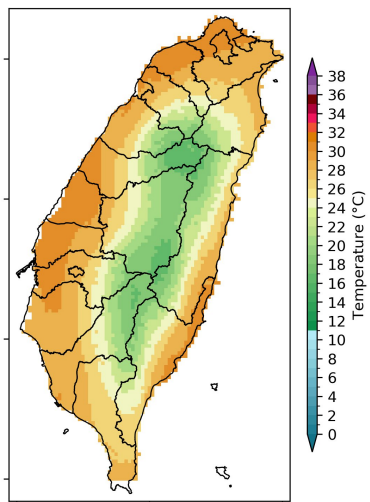


Winter Solstice (冬至)

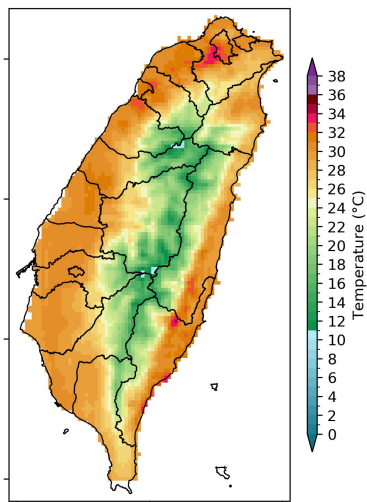


Capable for fine-scale features (特徵更清晰)

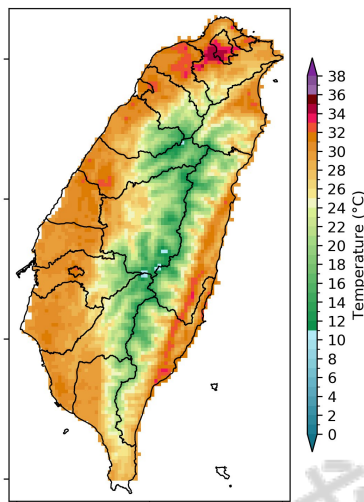
W/O Normalization



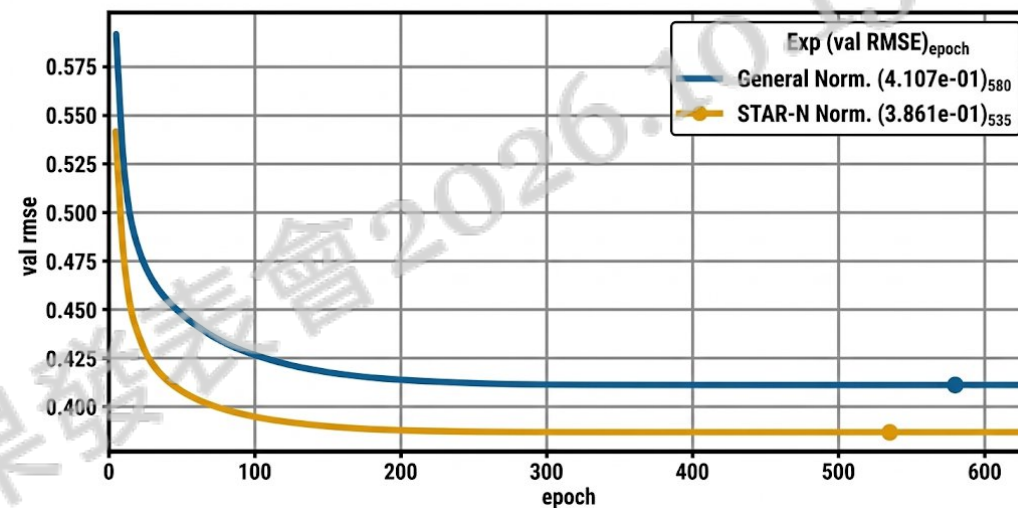
General Normalization



STAR-N

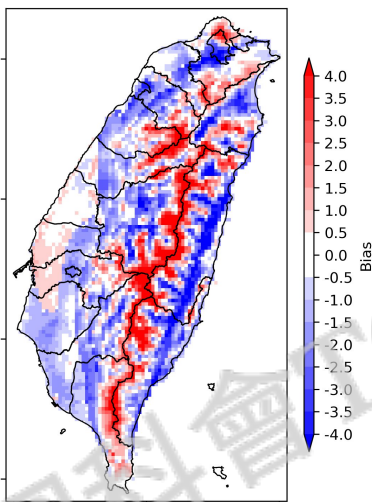


AI models converge faster (收斂更快)

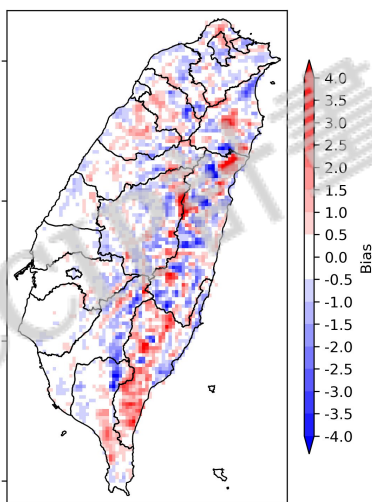


Generates data with smaller errors (誤差更小)

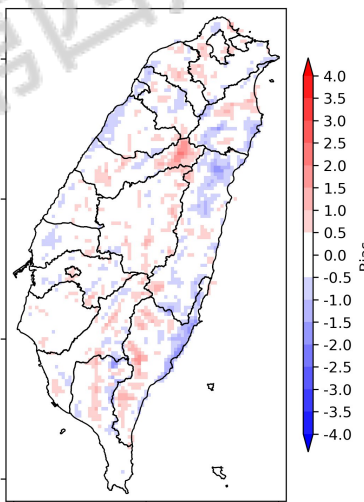
W/O Normalization



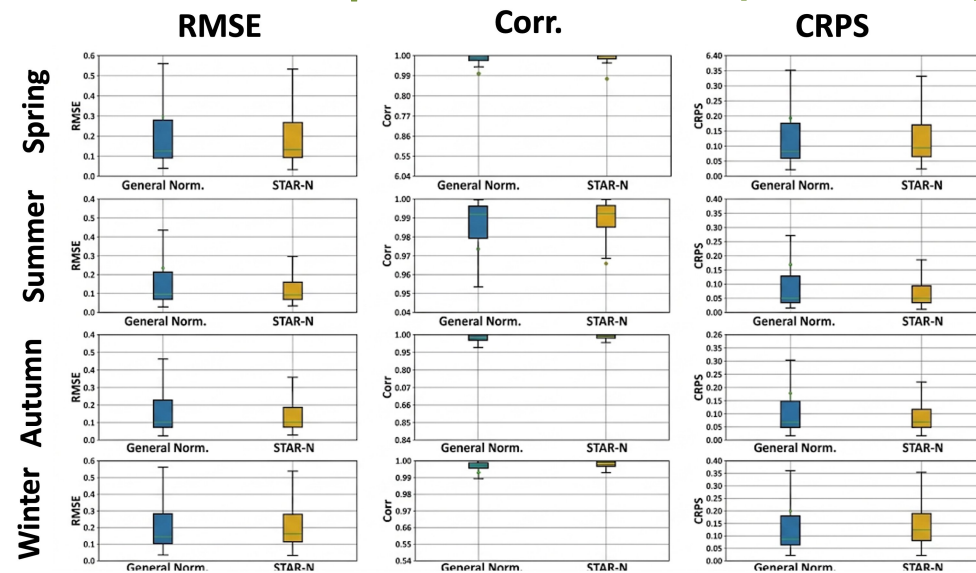
General Normalization



STAR-N



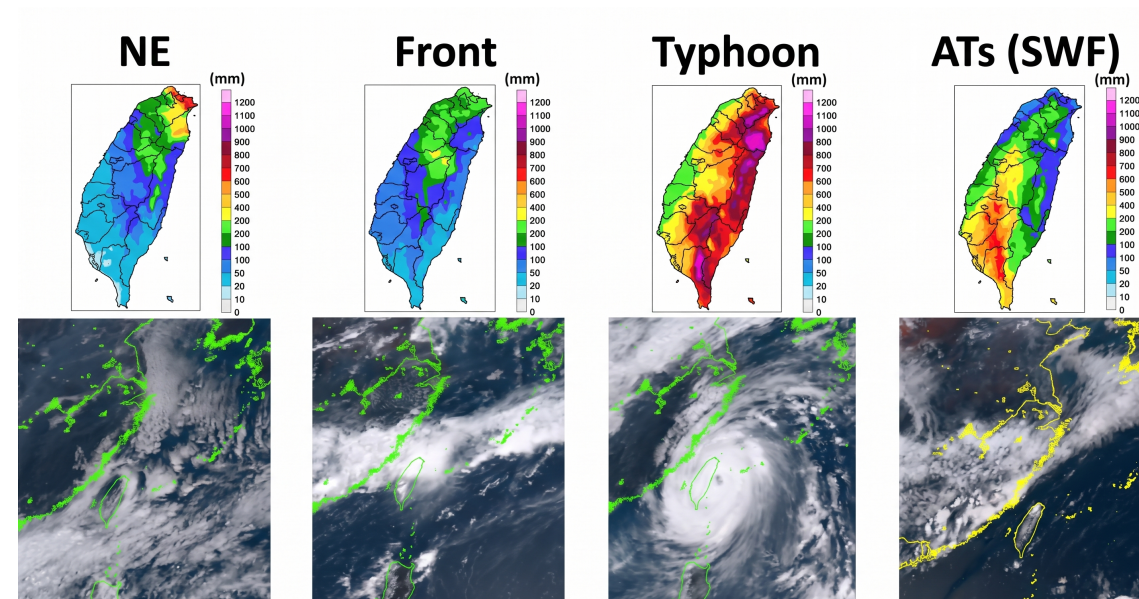
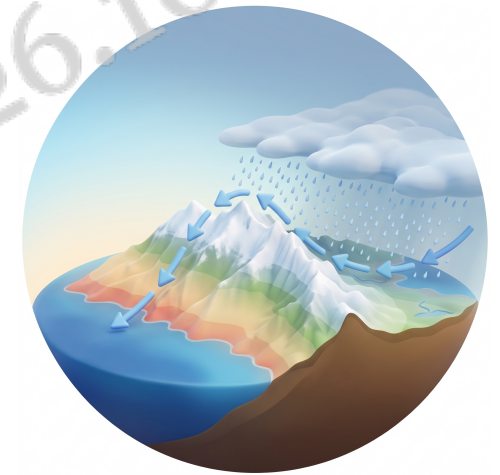
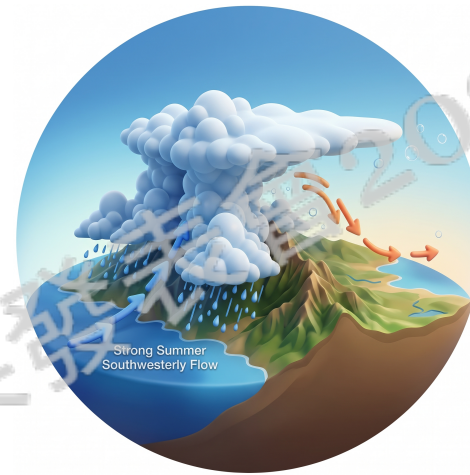
Overall better performance (表現更好)



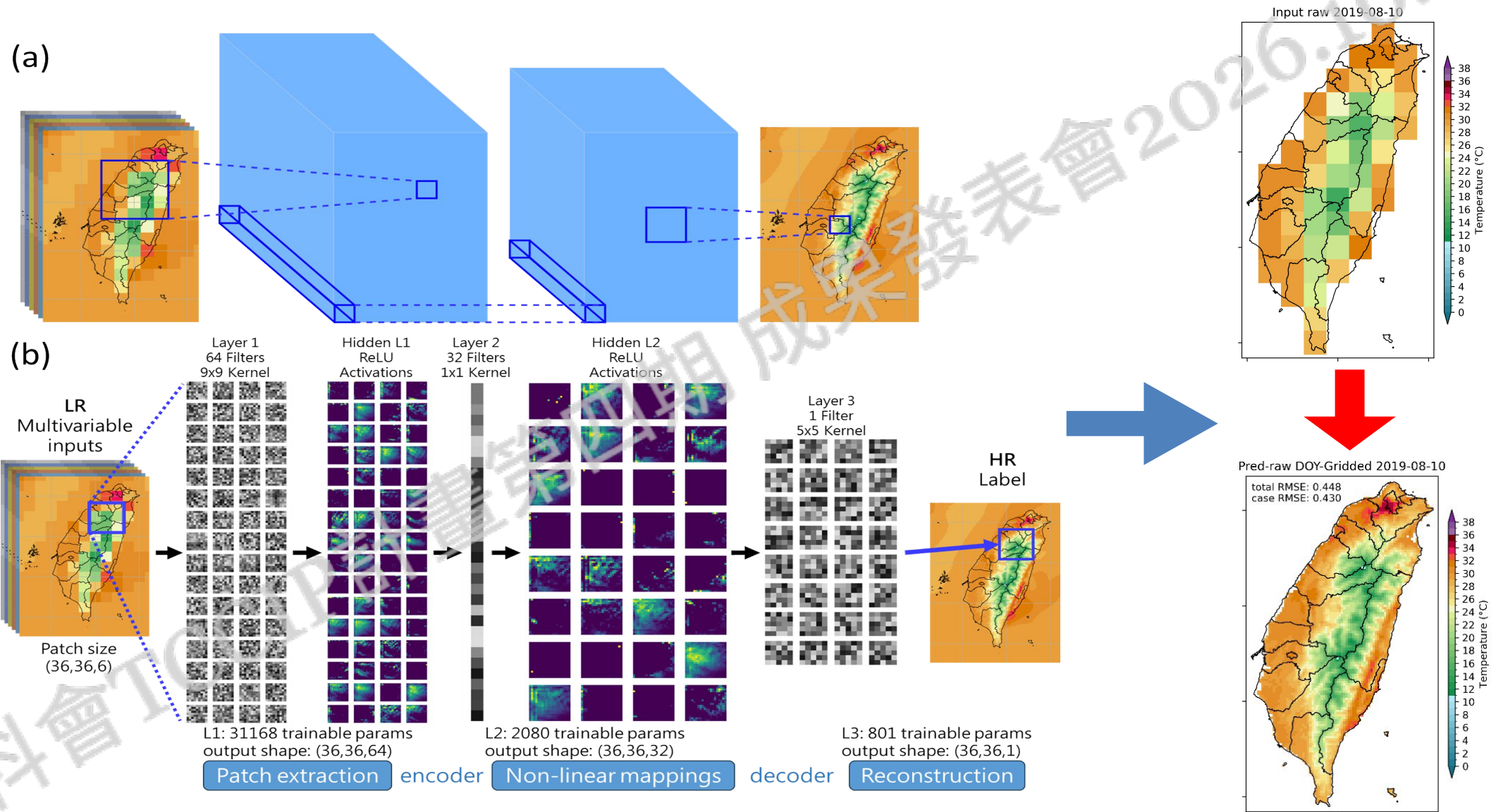
An AI Downscaling Model Designed for Taiwan (為台灣而設計的 AI 降尺度模型)

1. Steep and varied terrain - large spatial variability
(複雜地形導致空間差異性大)
2. Significantly influenced by seasonal synoptic-scale weather systems - large temporal variability
(天氣型態多變導致時間差異性大)

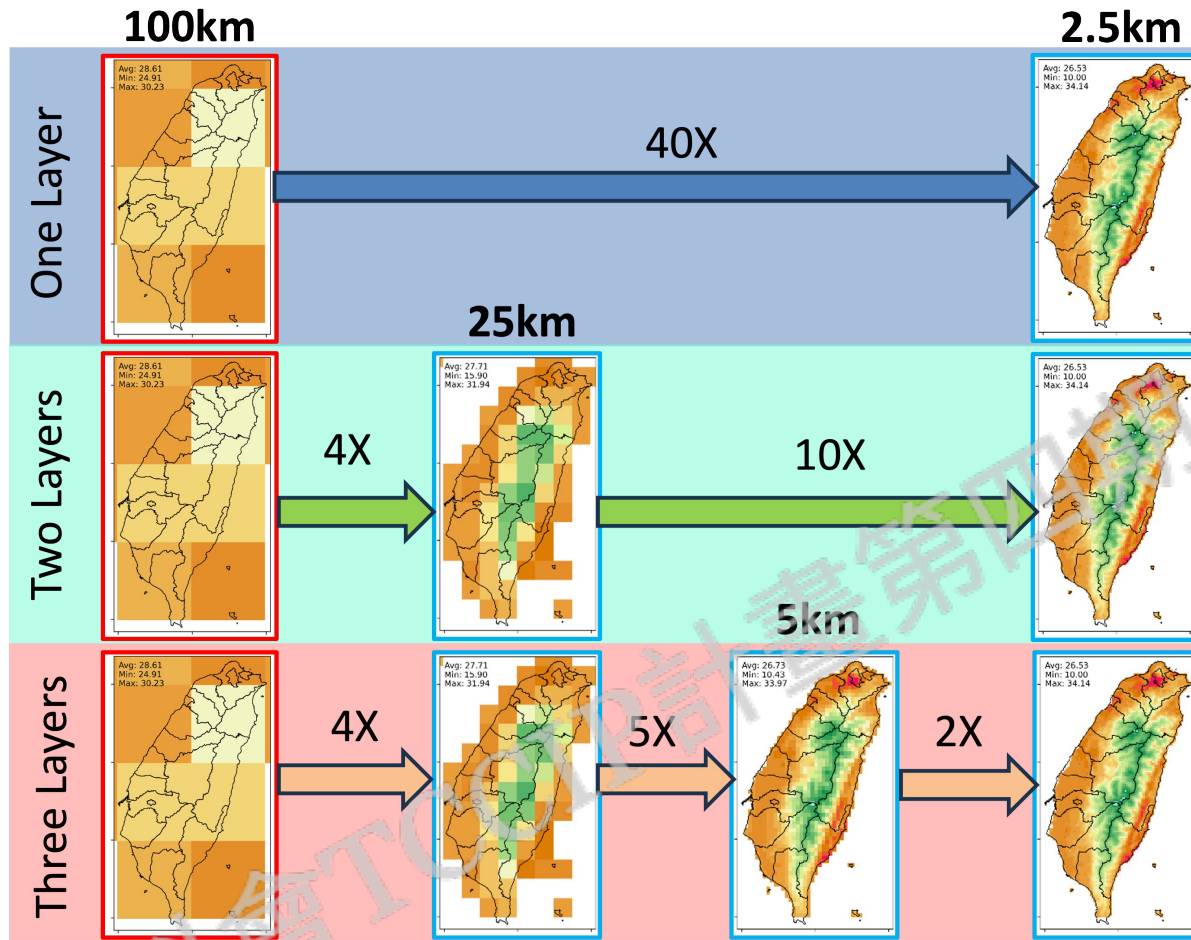
Extremely high spatiotemporal variability in meteorological parameters



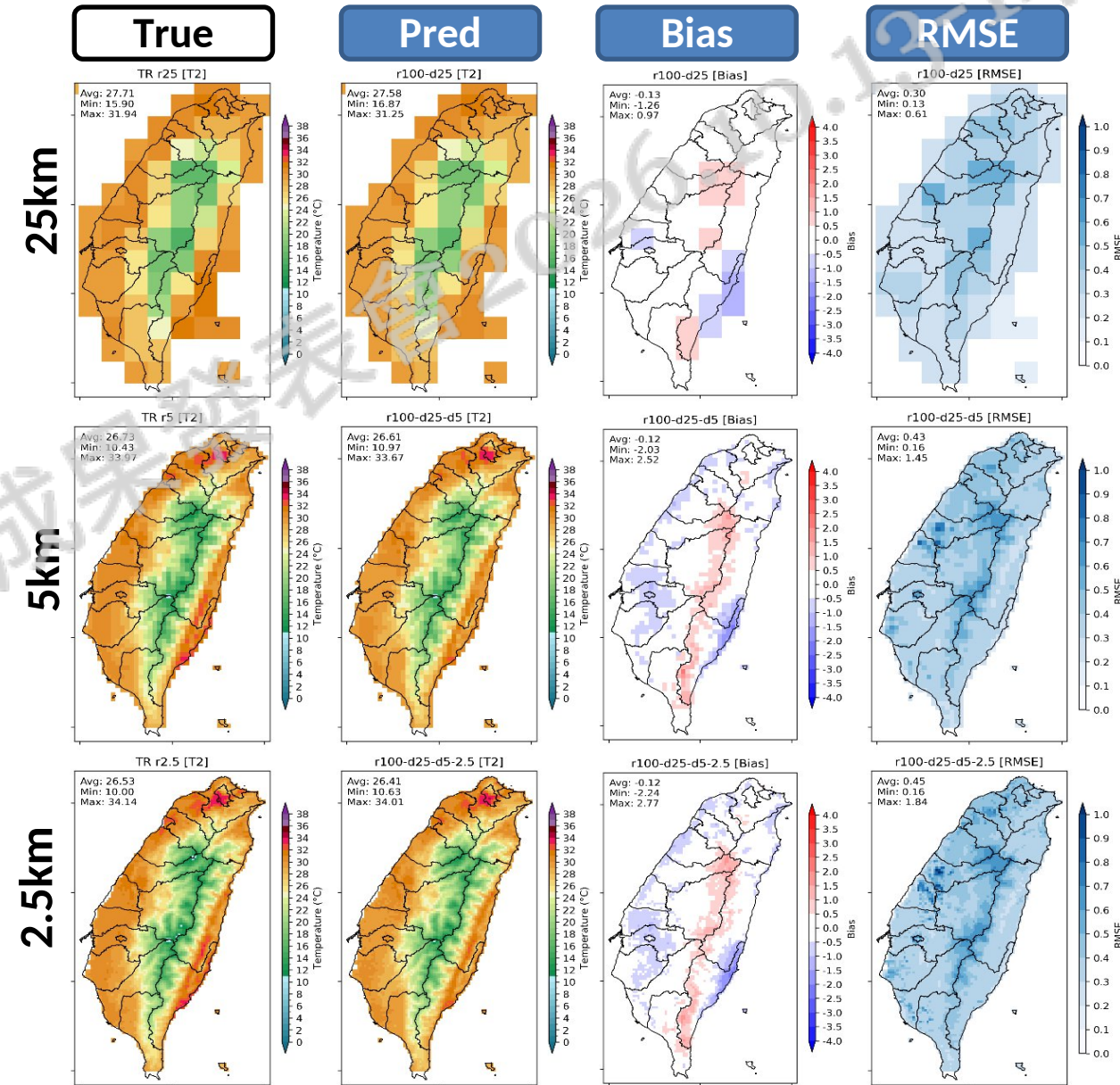
A Multivariable Integrated Super-Resolution Framework (多變數整合超解析度模型框架)



The advantage of the stacking framework (堆疊式框架的優勢)



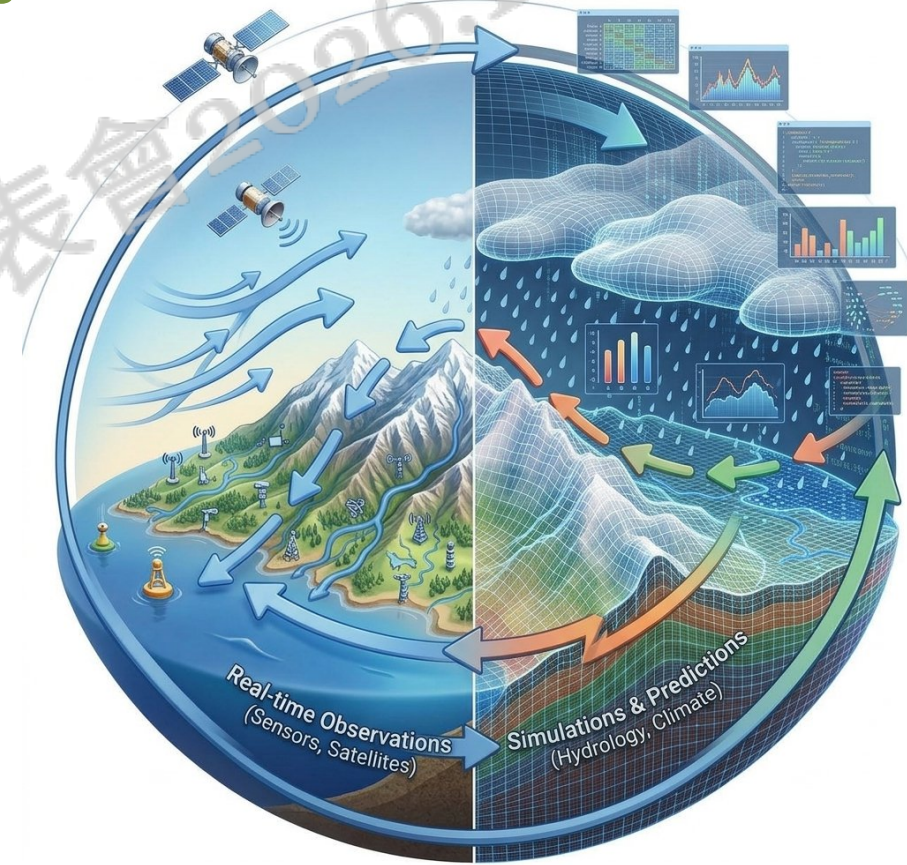
Case: 2019-08-10



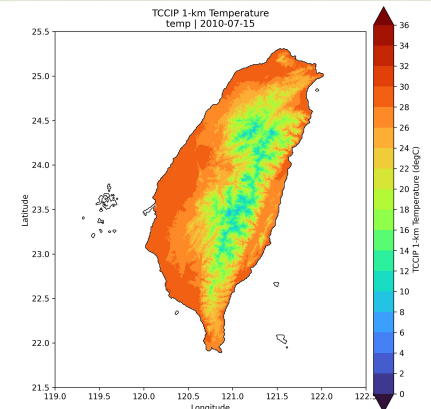
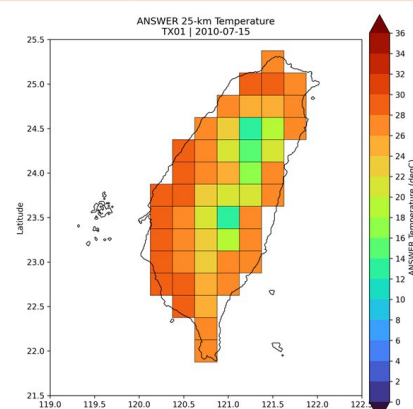
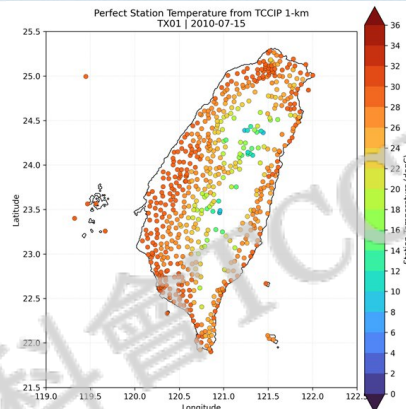
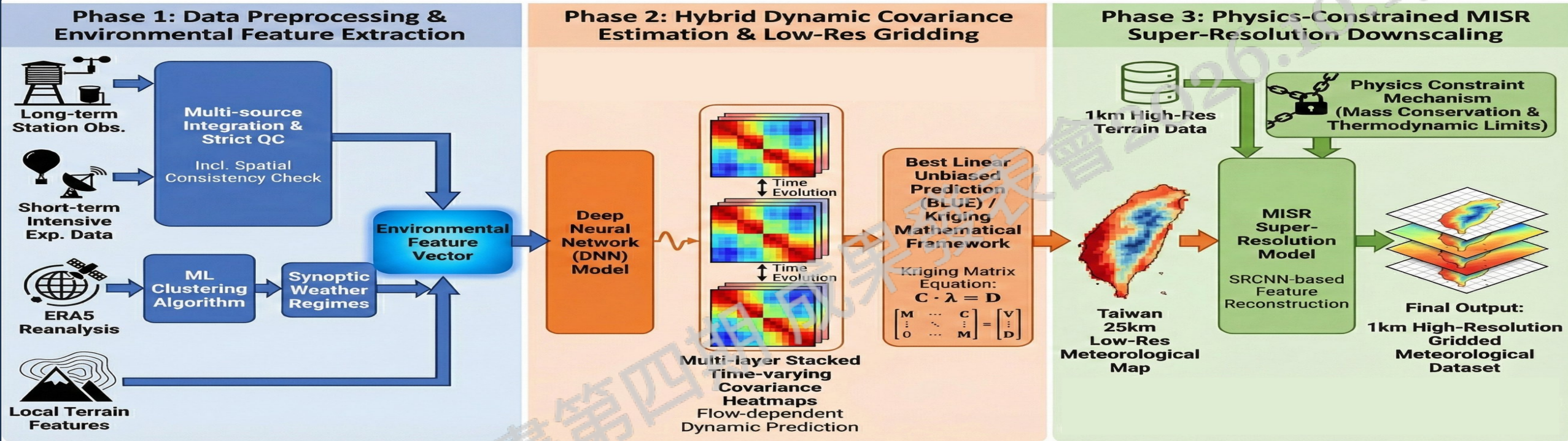
How Can We Use AI Downscaling Tools in the Future?

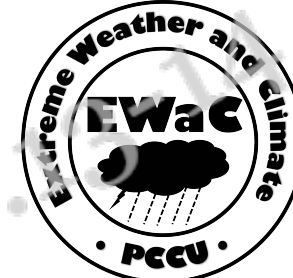
(我們可以怎麼使用AI降尺度工具?)

- Establishing Large Climate Projection Ensembles
(建構大規模的氣候系集推估系統)
- Driving Digital Twin Earths - Decision-Making Visualization
(利用數位孿生地球來強化決策視覺化)
- Extreme Weather Risk in a Changing Climate - Uncertainty & Decision-Oriented Projections
(氣候變遷下極端天氣風險的評估)
- High-Resolution Climate Impact & Risk Assessment - Critical Thresholds & Downstream Applications
(高解析度氣候衝擊與風險評估)

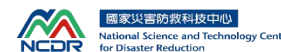


Reconstructing Long-Term High-Resolution Meteorological Data through a AI-based Framework





謝謝聆聽 敬請指教



PAPER IN PREPARATION:

1. Shih-Hao Su, Wen-Wei Tseng, Chao-Tzuen Cheng, Ting-Shuo Yo, Chou-Chun Chiang, Yi-Chiang Yu, and Yung-Ming Chen, **2027**: Beyond Global Scaling: Preserving Atmospheric Signal Integrity with Spatial-Temporal Adaptive Rescaling Normalization.
2. Shih-Hao Su, Wen-Wei Tseng, Yen-Wei Li, Chao-Tzuen Cheng, Li-Huan Hsu, Kuan-Ling Lin, and Lee-Yaw Lin, **2027**: MISR: A Multivariable Integrated Super-Resolution Framework for Meteorological Downscaling over Complex Terrain.