# Taiwan Typhoon and Flood Research Institute, National Applied Research Laboratories

## Outline

Taiwan Typhoon and Flood Research Institute (TTFRI), one of ten members in National Applied Research Laboratories (NARLabs), was established in 2011 (Figure 1). The mission at TTFRI is to advance prediction techniques for typhoons and floods, and to serve as a platform for bridging the gap between academia, industry, and government in order to benefit the public users. TTFRI combines theories, observations, and models, with particular emphasis on developing core techniques for typhoon forecasts and hydrological applications. Further, it assists the national meteorological and hydrological services and the national disaster reduction operation.
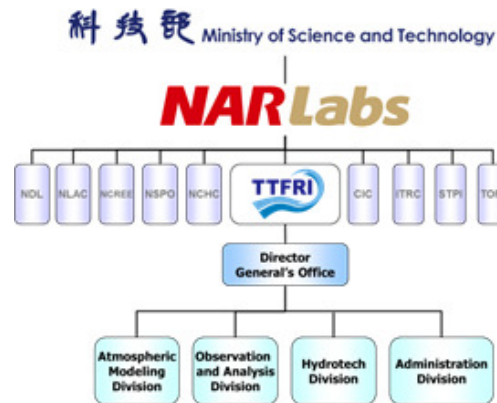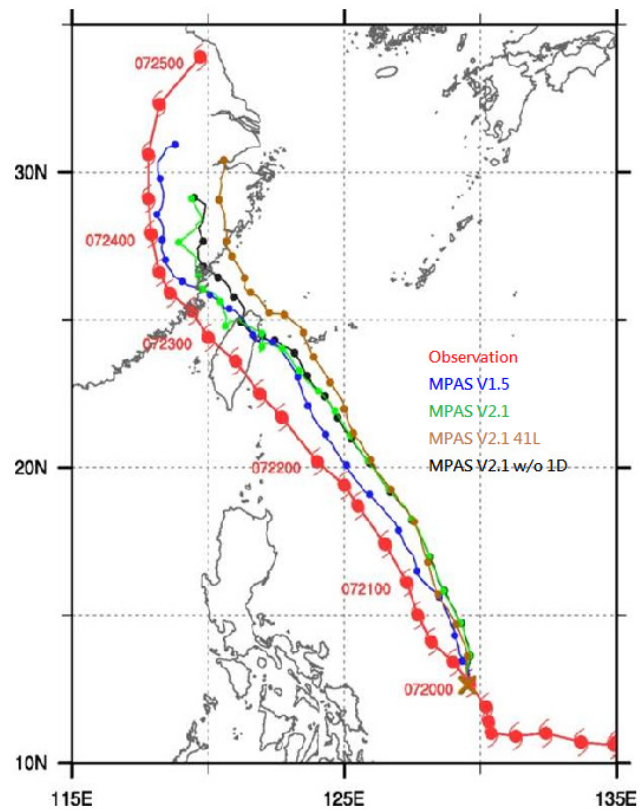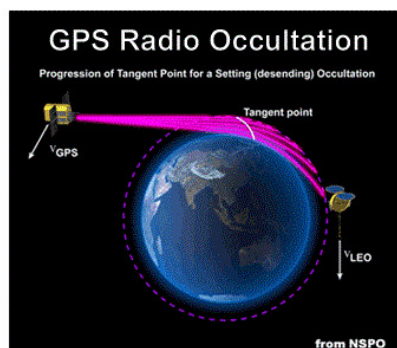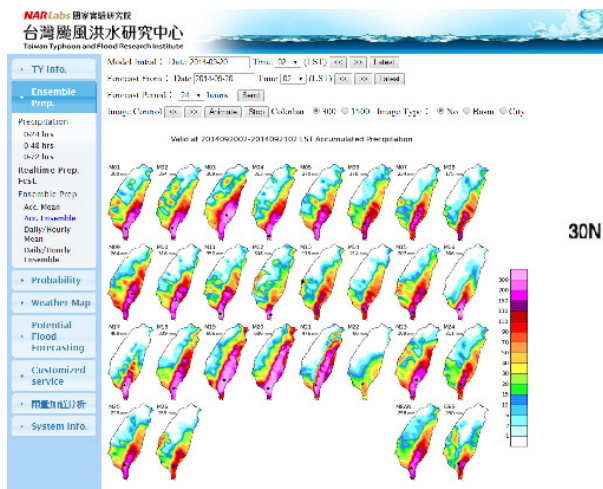
Figure 1: TTFRI organization chart

## Research Achievements

**Numerical Weather Prediction** TTFRI's research uses cutting-edge techniques in data assimilation, physical parameterization, and ensemble forecasts to develop numerical models suitable for the complicated terrain of Taiwan that improve typhoon forecasts. In cooperation with the Central Weather Bureau (CWB), academia, and research institutes in Taiwan and the United States, TTFRI's major research achievements are as follows: (i) development of the Taiwan cooperative precipitation ensemble forecast experiment (TAPEX) which provides 72-hour rainfall forecasts during typhoon warning periods (Figure 2); (ii) development of data assimilation technologies from GPS RO data which are used to improve weather forecasts (Figure 3); and (iii) establishment of advanced numerical weather models such as the Model for Prediction Across Scales (MPAS) which generates long-range typhoon and seasonal rainfall forecasts (Figure 4). TTFRI provides the forecast results to government agencies and helps them make efficient decisions during disasters and for future water resources management.

Figure 2: TAPEX rainfall forecasts



Figure 3: GPS RO - Atmospheric profiling with Global Navigation Satellite Systems



Observation
MPAS V1.5
MPAS V2.1
MPAS V2.1 41L
MPAS V2.1 w/o 1D

Figure 4: 2014 Matmo 5-day track forecasts using different versions of MPAS models

**Advanced Observation Facilities** To provide a better data set for hydro-meteorological research, TTFRI has deployed and developed many observation facilities and advanced techniques. For example, an advanced monitoring network was implemented in the southwestern part of Taiwan and includes a transportable C-band polarimetric radar (Figure 5), a wind profiler, a S-band vertic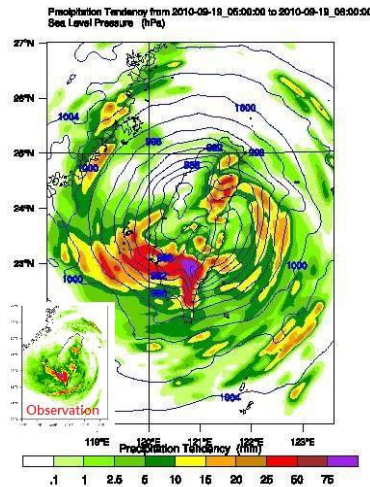ally pointing radar, disdrometers, flux towers and flow gauges. The C-band radar was installed in the Jilai mountain area to improve rainfall estimation in this complex terrain. The Jilai mountain area is near the location where the devastating landslide occurred due to heavy rainfall during Typhoon Morakot in 2009. The radar needed to be carefully situated such that the terrain did not block the path of the radar's beam. Site-specific sampling strategies may be required to avoid beam blockage and to obtain a better observation. In addition, TTFRI develops radar-based data assimilation techniques (e.g., 3D-Var and 4D-Var) to improve typhoon and rainfall forecasts (Figure 6). All of the collected observation data and techniques can be used to improve the accuracy of weather forecasting and to reduce damage from disasters.



Figure 5: TTFRI's C-band polarimetric weather radar in Jilai mountain area



Figure 6: 1-h rainfall forecast using radar data assimilation technique

**Disaster-related Forecasts** Hydro-meteorological modeling techniques, which unify mesoscale precipitations and surface inundations, are developed by TTFRI to help improve the effectiveness of disaster prediction and to provide better early warning information. Using above mentioned observations as model input, TTFRI integrates atmospheric and hydrologic models to provide disaster-related forecasts for authorized users to access the forecasts through a hydro-meteorological service platform (Figure 7). The platform is updated with the latest modeling results every six hours. To date, there are more than 80 universities, research institutes, and disaster relief agencies accessing the information when an extreme event happens.
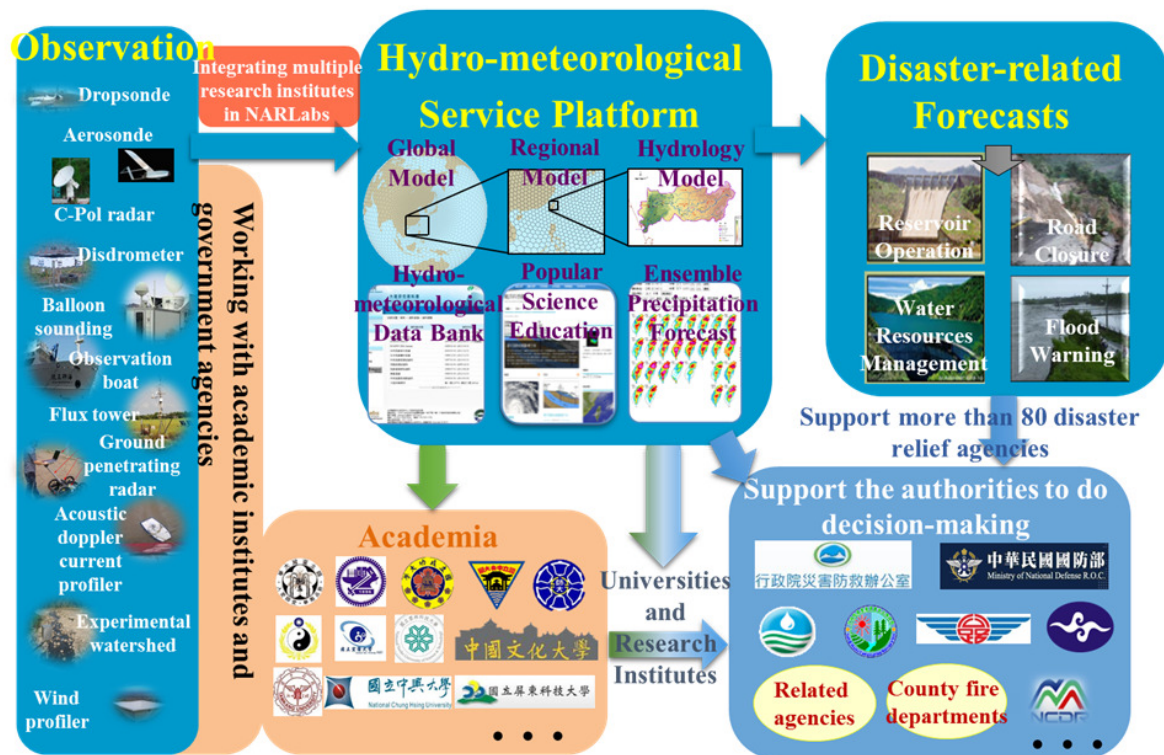
Figure 7: TTFRI's integrated researches and service platform

## Challenges

A lack of observation data is always an issue that will have an impact on the accuracy of forecasts, but it is especially a challenge to obtain correct and timely observation data during extreme events such as typhoons and floods. To mitigate the issue, TTFRI is developing an advanced monitoring network that integrates ground-based observing facilities (e.g., Jilai weather radar and wind profiler), and dropsonde and aerosonde observations (Figure 8). The network is being designed to enhance the understanding of the convective structure of extreme weather events, including typhoon, Mei-Yu, and mesoscale convective systems. The network was initiated in 2014 and will be completed in 2016. Once complete, the obtained observation data will be used to improve the forecast accuracy and strengthen disaster preparedness.
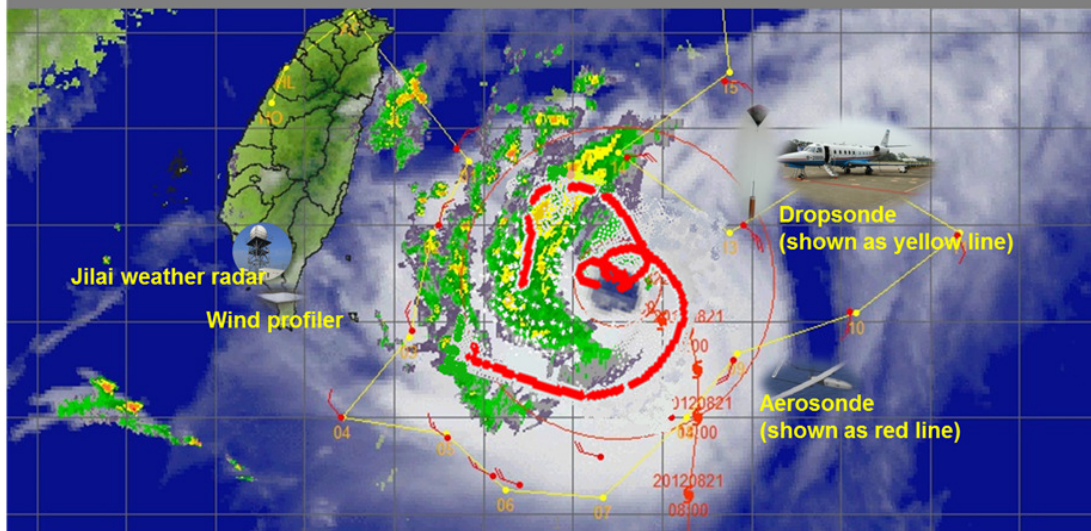
Figure 8: TTFRI work with government agencies to develop direct typhoon observation techniques

TTFRI has the responsibility to develop key technologies to observe, analyze, simulate, and forecast typhoons and floods, and to enhance the interdisciplinary hydro-meteorology research. In addition, TTFRI applies the technology and research to support the national meteorological and hydrological services and the national disaster reduction operation. To meet those needs, a research roadmap from 2013 to 2019 was developed and is shown in Figure 9. Four priorities for more effective disaster preparedness and mitigation in the future were identified as follows:

1. Emphasize on advanced observation techniques for extreme events such as typhoons and floods to improve forecast accuracy

2. Establish a service platform to effectively provide information to decision-makers about the risk of the disasters

3. Implement interdisciplinary approaches that combine efforts in technological innovation, applications, governances, and education

4. Strengthen transnational corporations among researchers of research institutes which are involved in disaster prevention and risk management

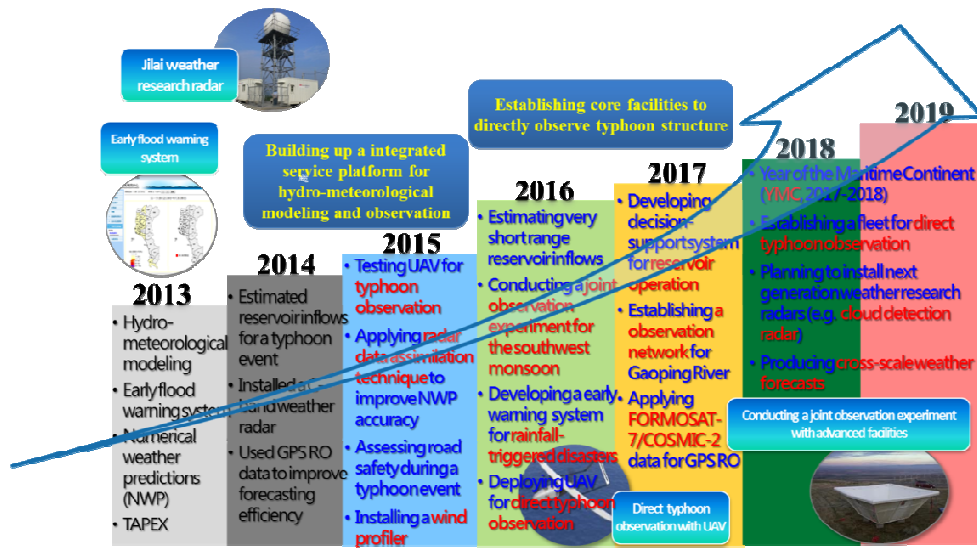# The ultimate goal: A world-class research institute on typhoon and flood



Figure 9:  TTFRI's research roadmap from 2013 to 2019