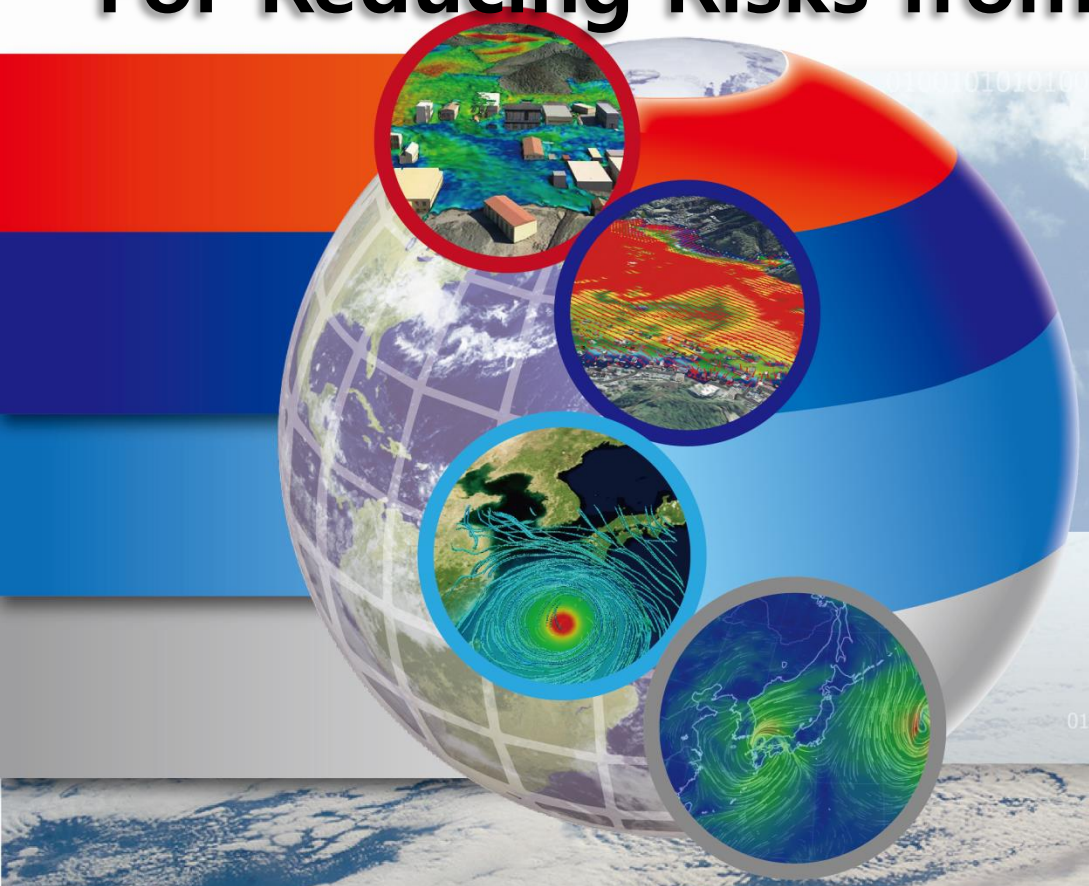
Introduction to the K-DMSS

KISTI - Decision Making Support System

For Reducing Risks from Natural Disasters



Minsu Joh

Atmospheric Scientist (Ph. D)
Director of Disaster HPC Research Center

KiSTi www.kisti.re.kr Korea Institute of Science and Technology Information

Contents

Government supported
Research Institute
(Since January,1962~)

The National
Supercomputing Center
(On September, 2012)

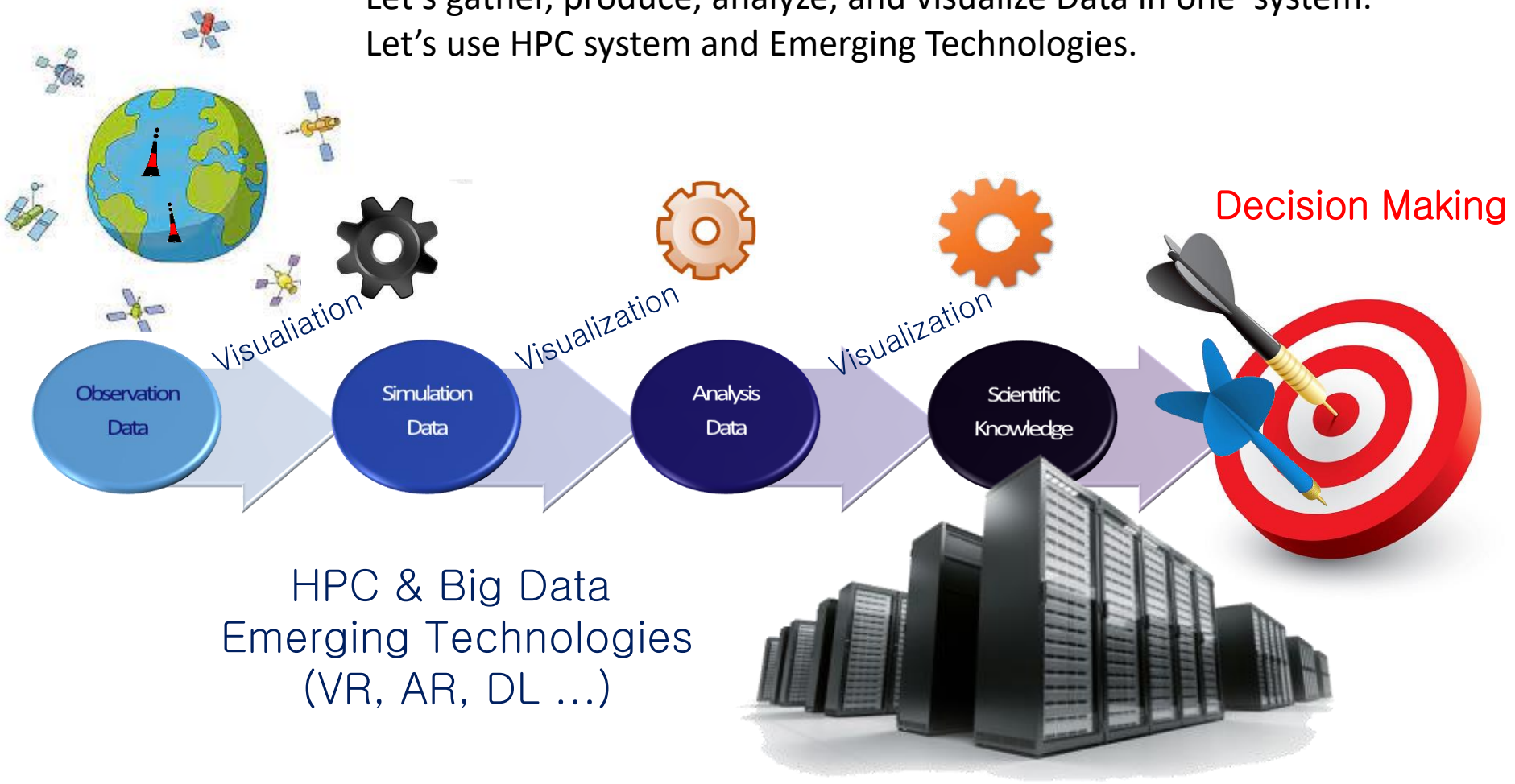
Personnel : ~ 380
Annual revenue : ~ $120M
Location : Daejeon

KiSTi www.kisti.re.kr

- ✓ R&D Motivation → MOVIE
- ✓Overview of the **K-DMSS**
- ✓Modeling & Simulation Models
- ✓**Achievements & Delivery Plans**
- ✓**Future R&D Plans ('18~)**

Right Information – Right Decision

Let's make a Decision-making support system.
Let's gather, produce, analyze, and visualize Data in one system.
Let's use HPC system and Emerging Technologies.



How make a DMSS?

To Provide
the Right Information
to the Right People,
at the Right Time,
to Make
the Right Decisions.

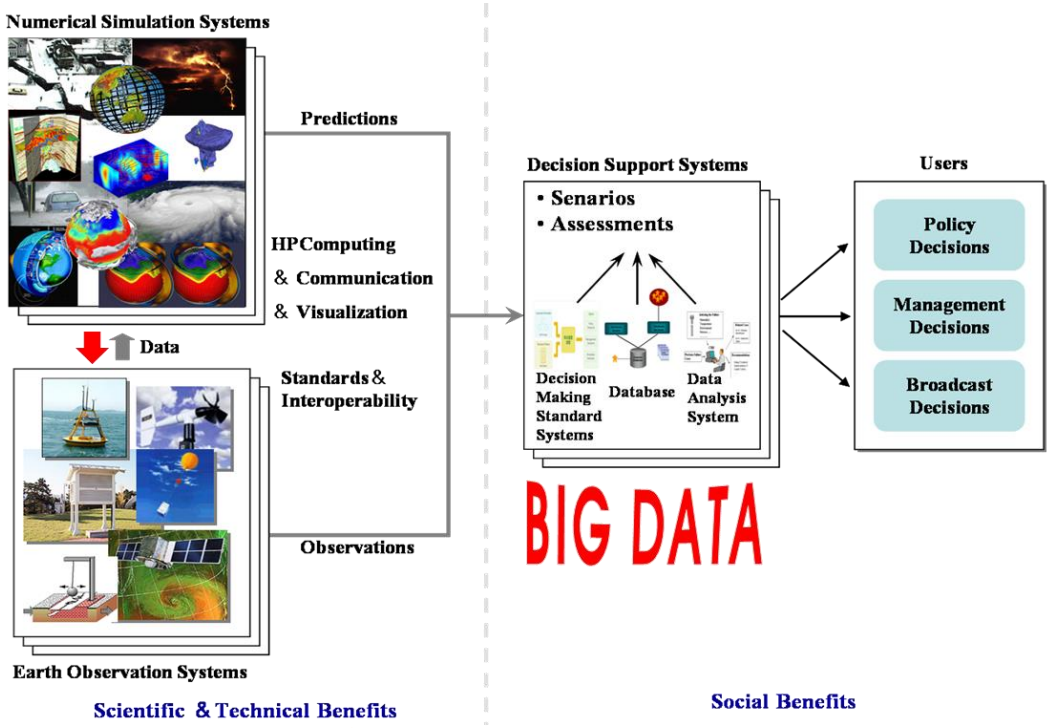
HPC

Research Background of Developing The **K-DMSS**

GEO GROUP ON EARTH OBSERVATIONS

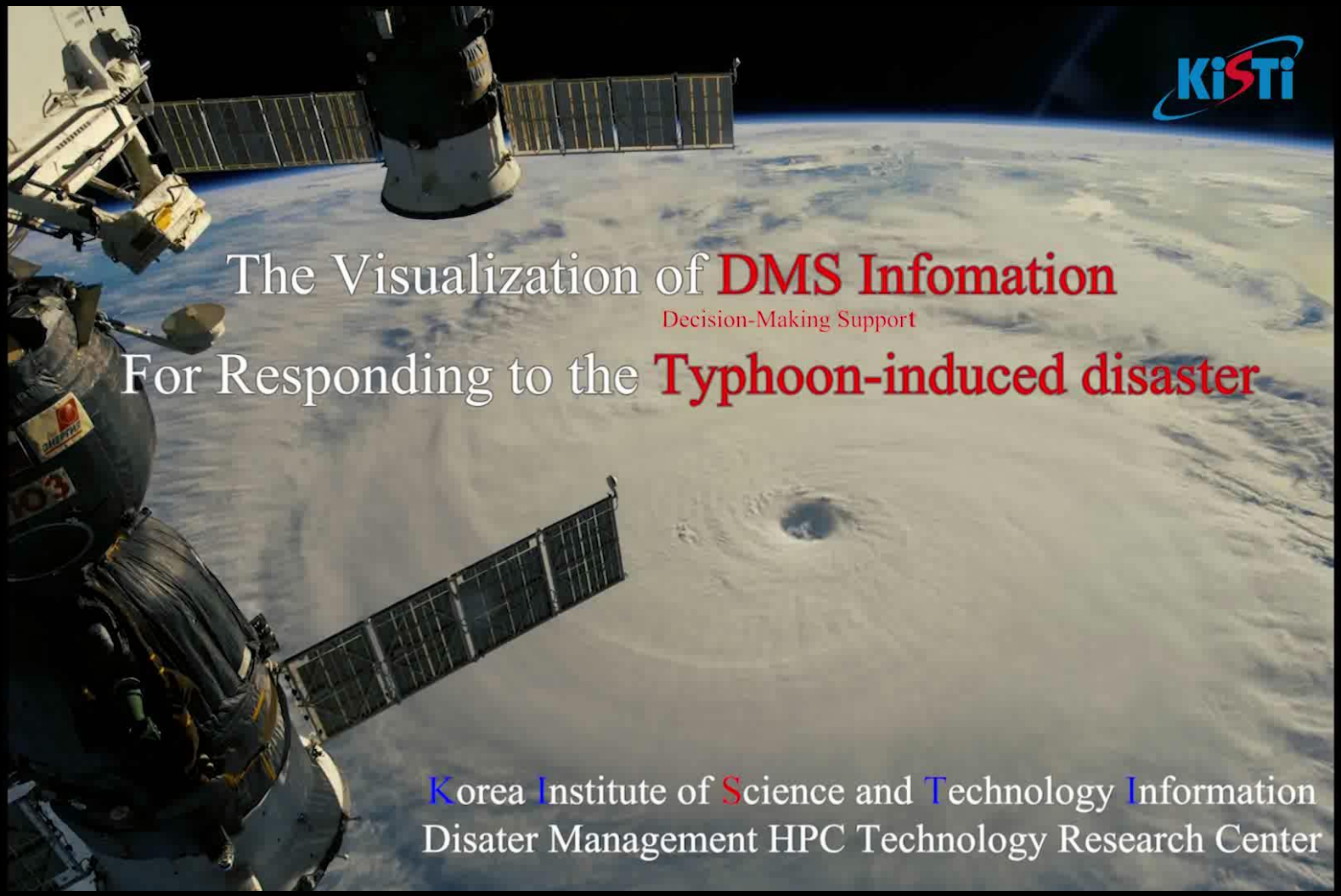
GEOSS Global Earth Observation System of Systems

A central part of GEO's Mission is
to build the Global Earth Observation System of Systems (GEOSS)



9 SBAs GEO 1st Phase (2005~2015)

Numerical Simulation System



Assessment System: DIPDAS

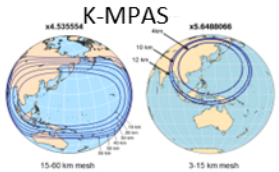
Overview of K-DMSS

- Integrated
  S/W Package for Predicting Disasters & Damage Assessment
- Developed on
  HPC (high performance computing) & Big Data Platforms
- Supports for High resolution
  Modeling & Simulation for Atmosphere-Ocean & Hydrology
- Supports for Huge data
  Visualization & AR (augmented reality) for Scientific Analysis
- KISTI's independent
  Decision-Making Support System for Disaster Management

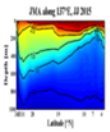
Components of K-DMSS

K-DMSS : Software system

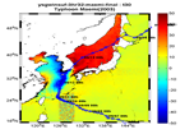
A High Resolution M&S



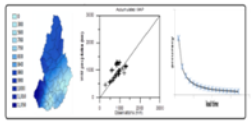
High Resolution Weather prediction



Surge Prediction



Tide Surge Prediction



River Flooding Prediction

B Disaster Information System

Web Portal Service

Data Register/Search

Scenario Operation

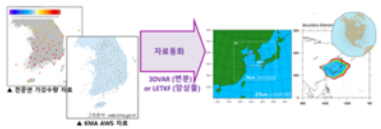
Data Storage

Disaster Information Management

Data Exchange

C

Data Assimilation



Predicable water, AWS 등

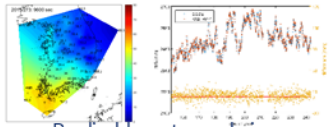
Data Collection/ Information Extraction

Sensors, WWW, Open API, SNS

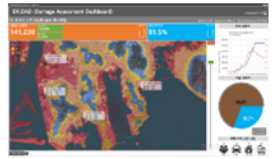
Big Data Analysis

Knowledge Detection Framework

D Analysis System

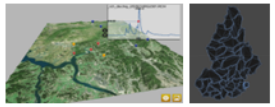


Predicable water analysis system Based on GNSS

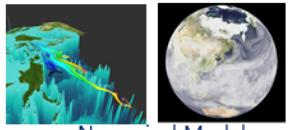


Disaster Prediction & Damage Assessment System

Visualization System



3-Dimensional Integrated Visualization System



Numerical Model Visualization System

HPC Testbed

OpenMP Fortran MPAS Model for Prediction Across Scales OpenACC More Science, Less Programming VAPOR Visualization & Analysis Platform

hadoop Spark NotOnlySQL TensorFlow NVIDIA CUDA

Big Data Testbed

HPC & Big Data Testbeds

√ Total 169.4 TF

√ Intel CPU (Xeon) + NVIDIA GPU (K40M) Cluster system

Firewall(UTM)

1G switch

IB switch(108 ports)

112.8TF

Cluster for M&S*
(30 nodes)

56.6TF

Cluster for big data analysis**
(15 nodes)

Cluster for user service
(2 nodes)

Cluster for data management
(6 nodes)

Cluster for 3-D visualization
(9 nodes)

768TB

Lustre

70TB

NAS

Trial Service Construction & Service Development 169.4TF
(Service for collecting, producing, analyzing, and visualizing information)

Storage System 838TB
(Service for storing input/output data)

* **Cluster for M&S:** 30 nodes(CPU+GPU), 12TF + 100.8TF = 112.8TF / 600 cores + (172,800 cores) = 173,400 cores

** **Cluster for big data analysis:** 15 nodes(CPU+GPU), 6.2TF + 50.4TF = 56.6TF / 300 cores + (86,400 cores) = 86,700 cores

Modeling & Simulation Models

- International Collaboration with NCAR/MMM
  Development of K-MPAS & Kr-MPAS based on MPAS
  South Korea is located in the middle

- KISTI's independent
  Development of EDAS for K-MPAS based on LETKF
  Ensemble Data Assimilation System Local Ensemble Transform Kalman Filter

- KISTI's independent
  Development of GPU Acceleration Code of MPAS (Physics Part)
  OpenACC (2017) → CUDA (2018)
  NCAR developed MPAS GPU code (Dynamic Part)

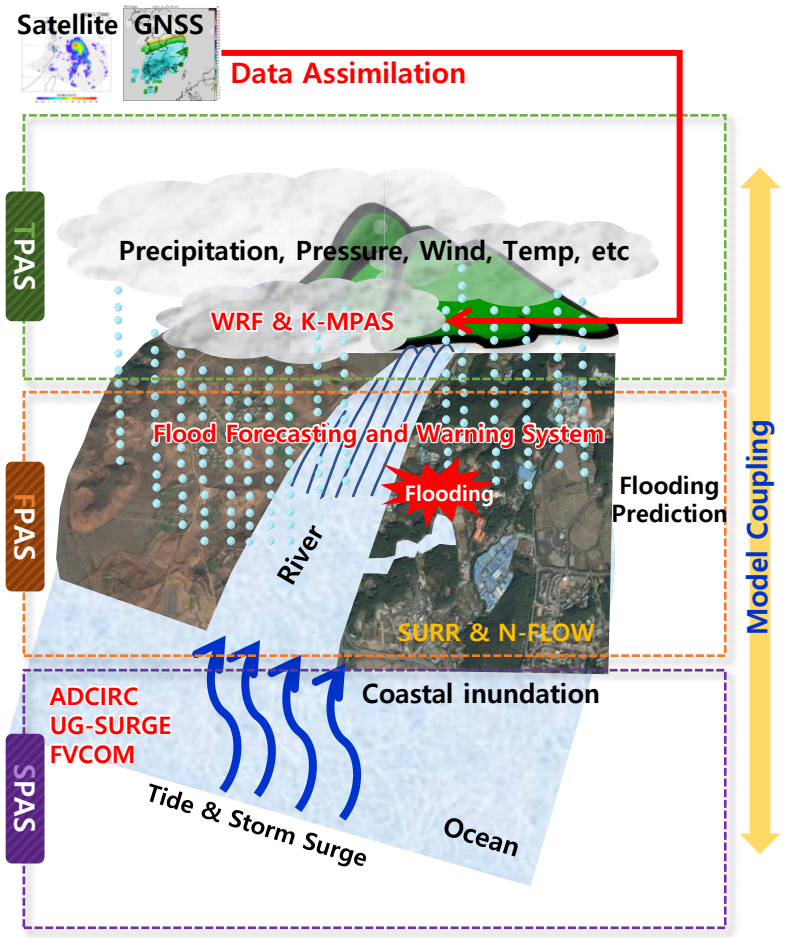
- **Development of Integrated Prediction System of W-O-W models**
  Weather-Ocean-Water
  (WRF/K-MPAS) – (ADCIRC/FVCOM) – (SURR)

- **Simulation of Typhoon-Surge-Flood for specific regions**
  Weather-Ocean-Water The Imjin River, Busan City, etc.

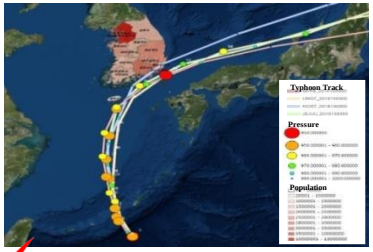
MPAS = Model for Prediction Across Scales | K-MPAS = KISTI MPAS focused on Typhoon Prediction

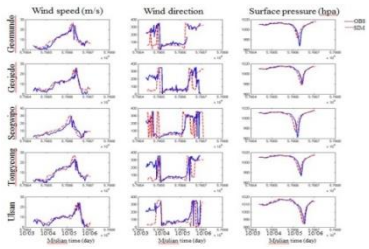
Prediction & Analysis Systems

High Resolution Coupled Modeling System Based on HPC



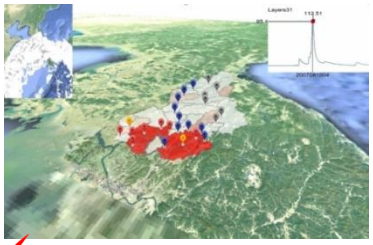
T TPAS (Typhoon Prediction and Analysis System)



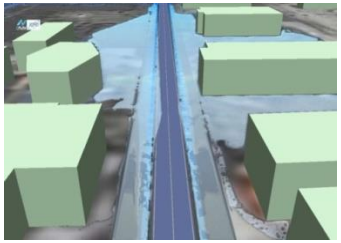


WRF & K-MPAS : Weather Prediction

F FPAS (Flood Prediction and Analysis System)

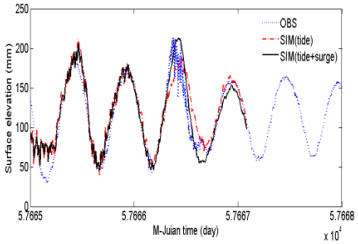


SURR : Flood Prediction

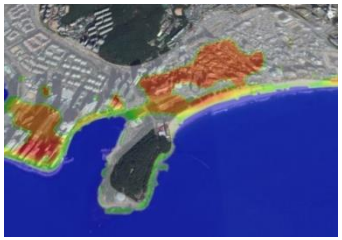


N-FLOW – SPH Modeling

S SPAS (Surge Prediction and Analysis System)



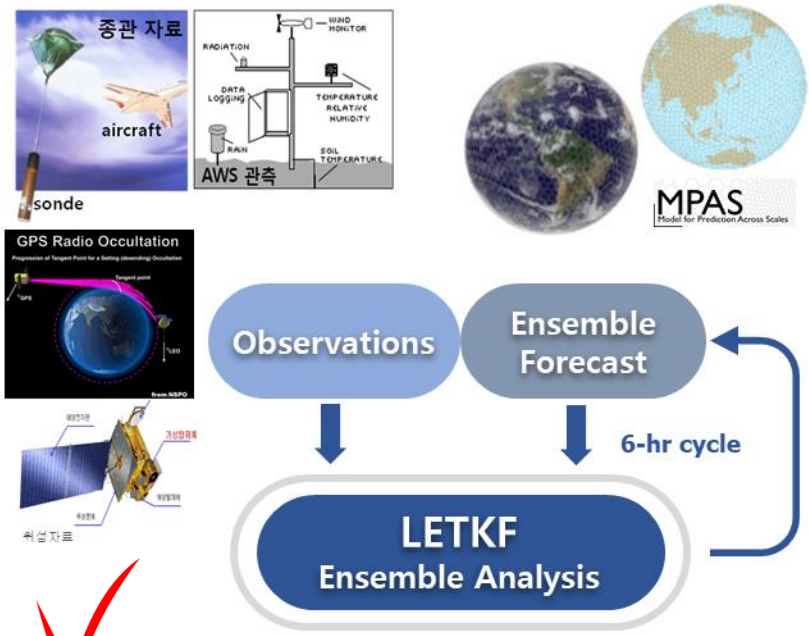
FVCOM : Surge Prediction



Coastal Inundation

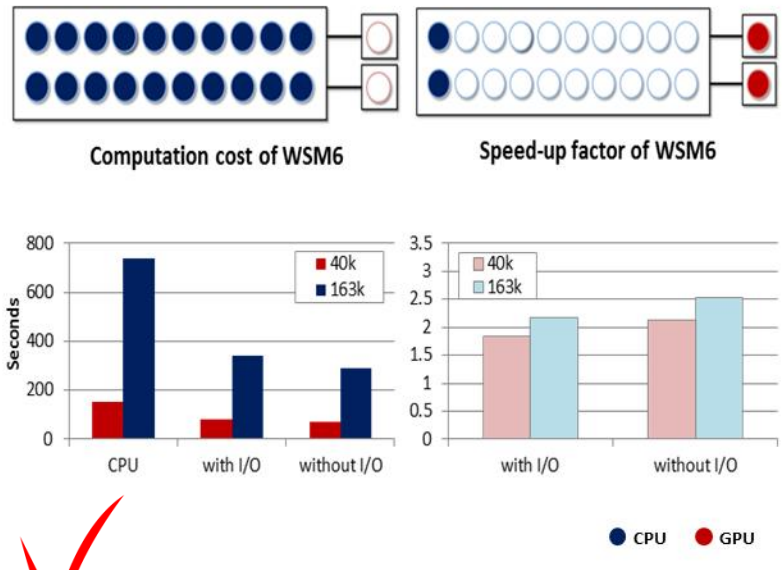
Prediction & Analysis Systems

A MPAS Ensemble Data Assimilation System



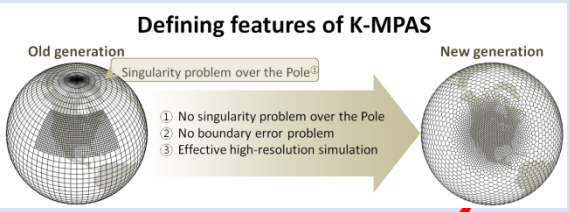
Increasing Accuracy of Prediction

CPU-GPU Heterogeneous code of MPAS



Increasing Speed of Simulation

Defining features of K-MPAS

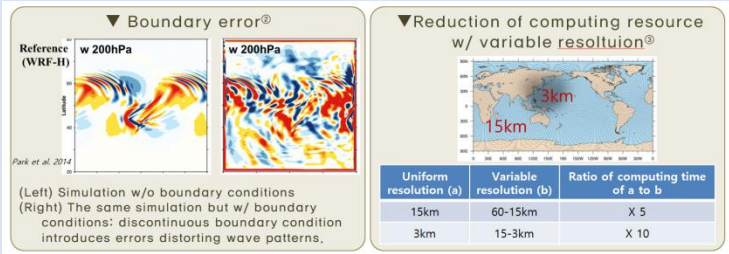


Comparison of track errors among three NWP models

MPAS(60-15km), UM(N768, ~17km in mid-lat), ECMWF(T1279, ~16km)

Fcst hr	# of cases	MPAS	UM	ECMWF
24	60	67.6	80.3	68.4
48	44	110.9	148.0	112.8
72	32	182.1	269.2	224.1
96	21	214.6	364.7	279.6
120	14	272.5	432.5	374.7

(For the 1st ~ 18th typhoon in 2016, data collected till 20161004UTC)



K-MPAS is developed
Under the KISTI-NCAR international
Collaboration Project (2014~2017)

Comparison of Typhoon track errors
done by KMA (18 typhoons in 2016)

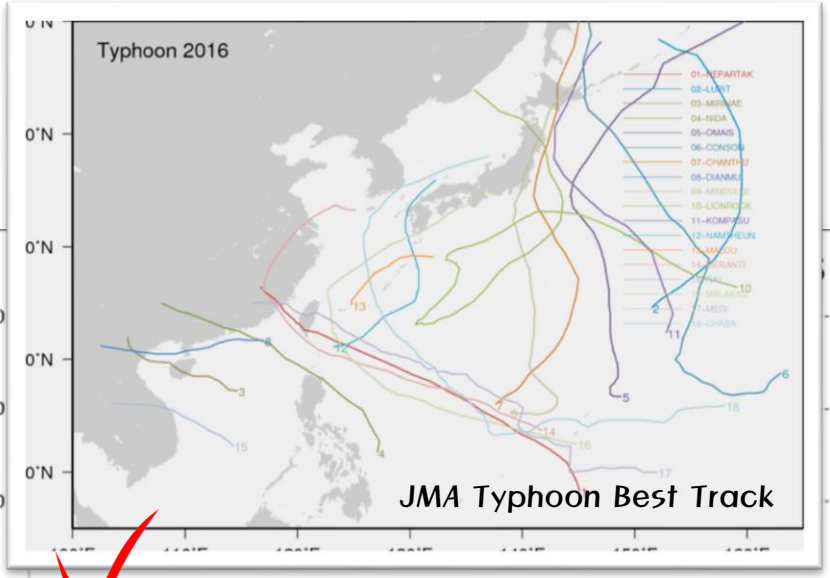
Best Better Good

K-MPAS > ECMWF > UM

24h, 48h, 72h, 96h, 120h (forecast hours)

Prediction & Analysis Systems

A

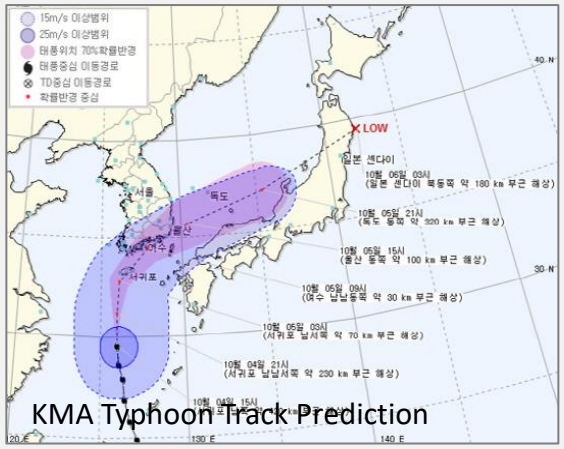


K-MPAS

Typhoon Track Prediction in 2016

CHABA

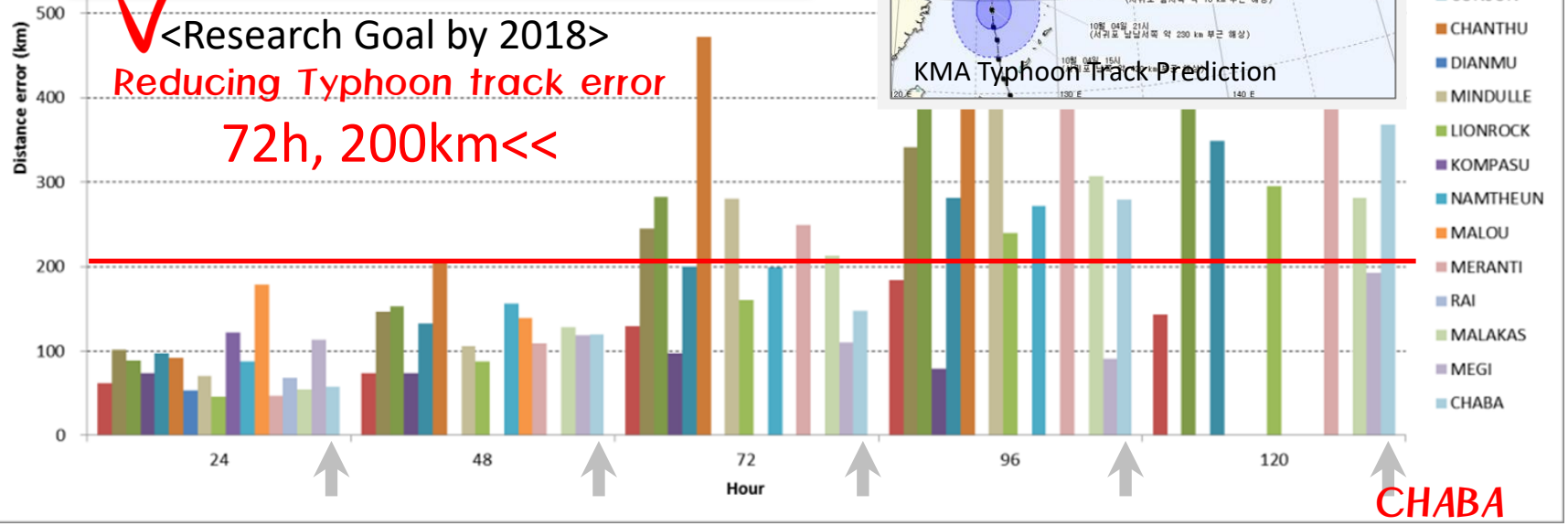
Typhoon influence on the Korean Peninsula



<Research Goal by 2018>

Reducing Typhoon track error

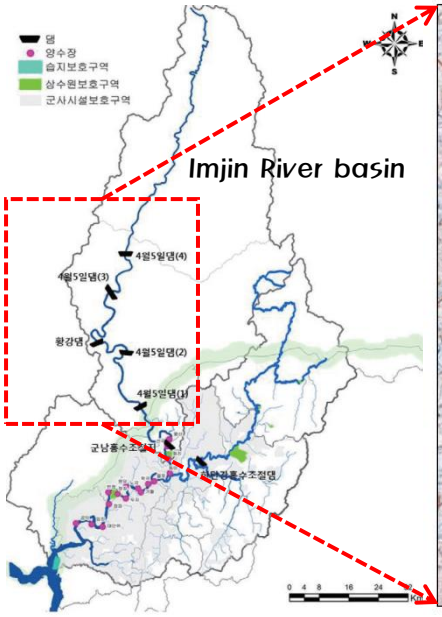
72h, 200km<<



Prediction & Analysis Systems

A

Flood prediction system with the Hydraulic structure in North Korea



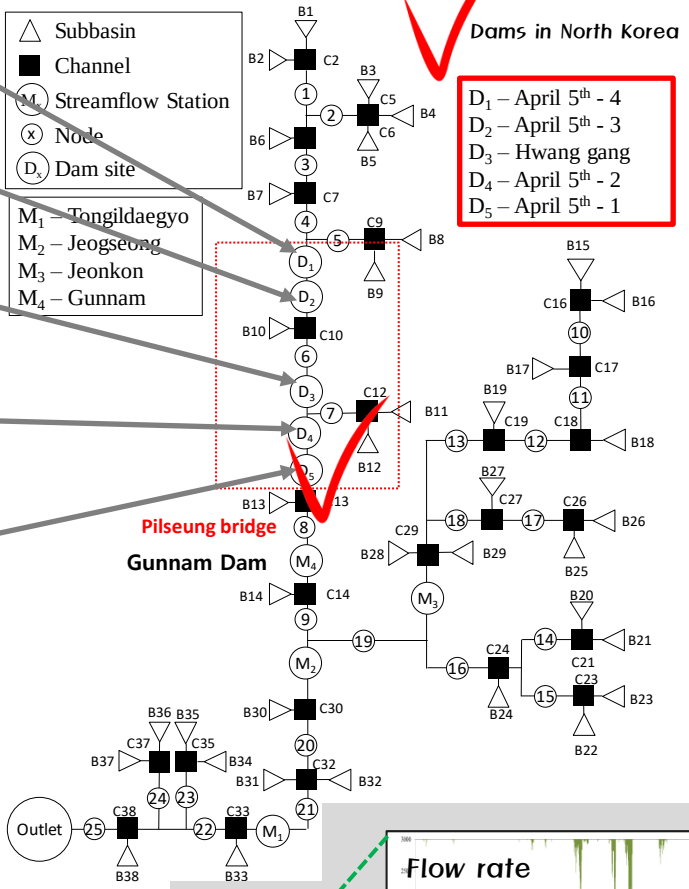
군남댐 Gunnam Dam

△ Subbasin
■ Channel
Ⓜ Streamflow Station
ⓧ Node
Dx Dam site

M_1 – Tongildaegyo
M_2 – Jeogseong
M_3 – Jeonkon
M_4 – Gunnam

Dams in North Korea

D_1 – April 5th - 4
D_2 – April 5th - 3
D_3 – Hwang gang
D_4 – April 5th - 2
D_5 – April 5th - 1



EL. 105.8 m
(Maximum Flood elevation)

Hwanggang dam
황강댐

Dam crest elevation
댐정고 EL. 107m

댐 붕괴시 16,4467 m³/s
(Dam failure)

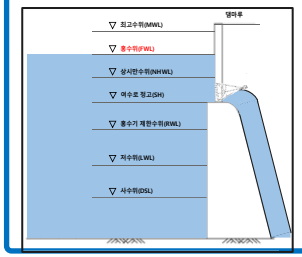
추정 총 저수용량
약 400백만톤
Total storage Volume
~ 400 million m³

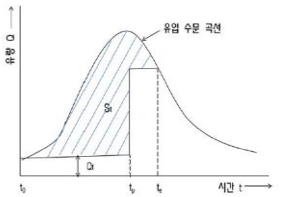
Dam data

댐바닥고 EL. 73m
(Bottom elevation of Dam)

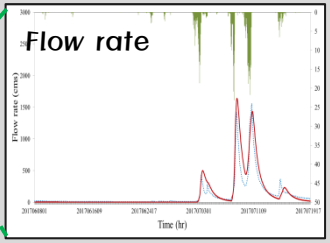
Auto ROM

(Dam operation when dam water level reaches the designed water level)





Pilseung bridge 8



Disaster Information System

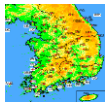
DIS is the integrated information system which has several features including

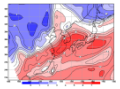
- **Data Management & Search based on Standard Metadata**
  Such as GNSS data from KASI
- **Metadata Harvesting from External Information Sources**
- **Open API to share Disaster Information**
- **High Scalability in Computing Power and Data Storage**
- **Workflow Environment for Creating Integrated Scenarios**
  Such as Military Weather Scenario, Flood Scenario

Architect of Disaster Information System

B

Observation Data


AWS Data


GNSS Data


Satellite Image


Ocean Observation Data


River Waterlevel Data


GIS Data

Scenario Operation

Scenario Generation
- Workflow Generation & Management

Scenario Monitoring
- Real-time Workflow Monitoring

Process Registration
- Workflow Action Registration

Statistics Service
- Analysis of Scenario Use

Data Management

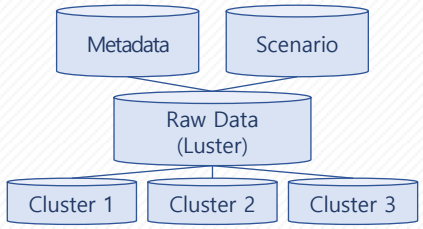
Data Collection
- Observation/Prediction Data Collection
- Standard Metadata Registration

Data Search
- Metadata Search
- Open-API

Data Processing
- Data Compression/ Decompression
- Data Movement/ Format Conversion

Data Exchange
- Metadata Exchange (OAI-PMH)
- Observation/Prediction Data Distribution

Data Storage



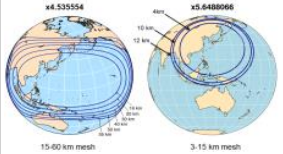
Metadata/Raw Data Storage

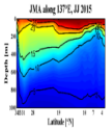
Scenario Storage

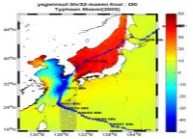
Cluster-based File System for Massive Data

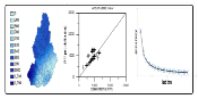
Prediction Data

K-MPAS


Weather Prediction


Surge Prediction


Tide Surge Prediction


River Flooding Prediction

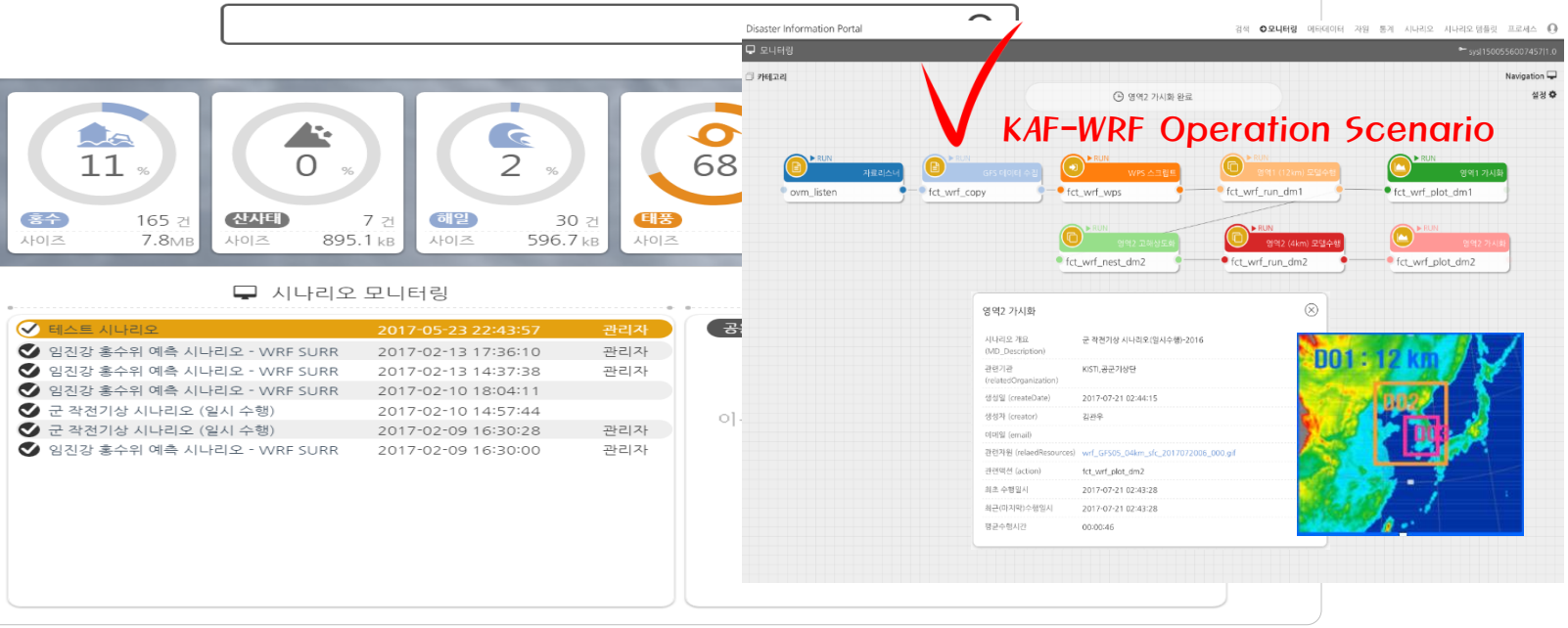

Damage Prediction

Disaster Information Web Portal

Korea Institute of Science and Technology Information

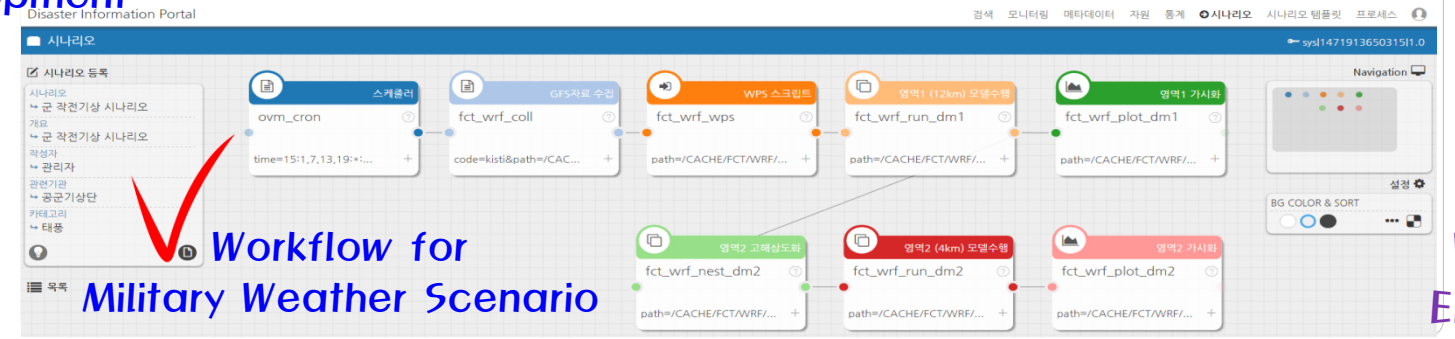
▼ Disaster Information Web Portal (Main Page)

Scenario Monitoring Page



Scenario Development Page

▼ Disaster Information Web Portal (Scenario Page)



Workflow for Military Weather Scenario

Workflow Environment

Achievements & Delivery Plans

KiSTi www.kisti.re.kr

K-DMSS (KISTI-Decision Making Support System)

System Delivery In 2017~2018

Korean Airforce Weather Wing

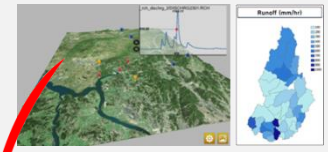
Military Weather Info. Service

K-DMSS Subsystems & Models

- TPAS (Typhoon Prediction and Analysis System)
- FPAS (Flood Prediction and Analysis System)
- SPAS (Surge Prediction and Analysis System)
- EDAS (Ensemble Data Assimilation System)
- K-MPAS CPU-GPU Hybrid Weather Prediction Model
- DIPAS (Direct damage Prediction & Analysis System)
- IPAS (Indirect damage Prediction & Analysis System)
- Deep Learning Typhoon Track Prediction Model
- Disaster Information Integrated System
- Disaster Information Portal System
- 3D integrated Visualization System
- Numerical Model Visualization System

Deliverable in 2017

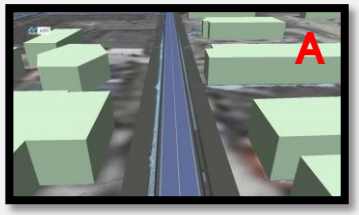
Military Operation Scenario in the South Korea



Flood Prediction Scenario on the Imjin River

- 3D integrated Visualization System
- Numerical Model Visualization System
- FPAS (Flood Prediction and Analysis System)
- Disaster Information Integrated System

Deliverable in 2018



Flood Prediction Scenario at the KAF airbases

Flood Prediction Scenario

한반도 공역 내 작전 (기상) 영향평가
Weather assessment system in Flight Regions

Weather Prediction Scenario for Military Operations

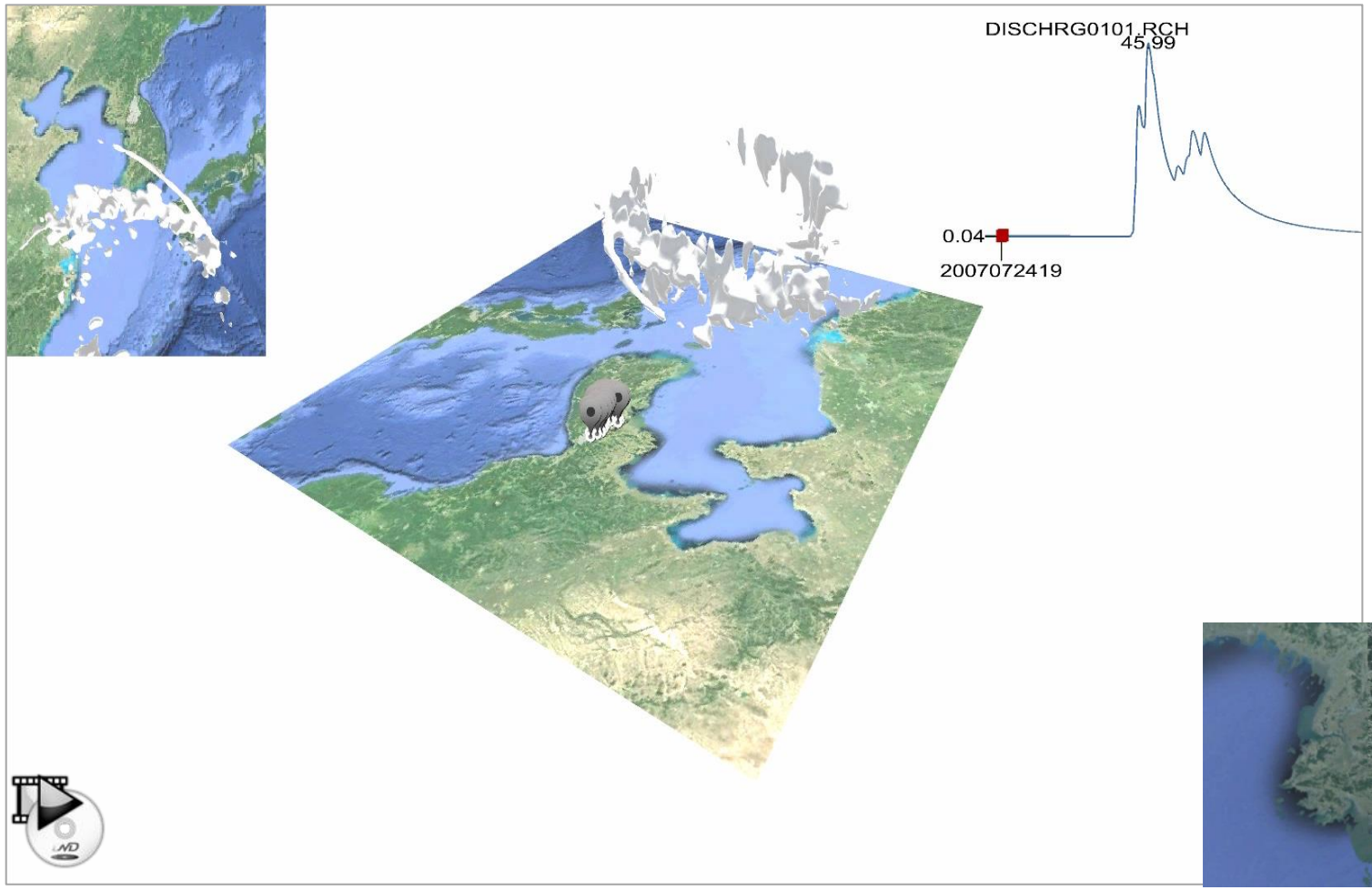
1) Web Portal for Scenario Monitoring

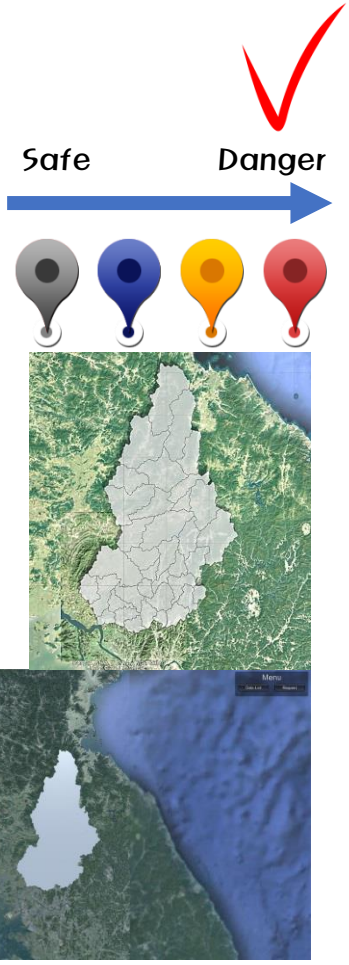
2) Client Program for Military Operations

제3차 한미국방기상심포지엄 발표자료 (2017.09.15.)

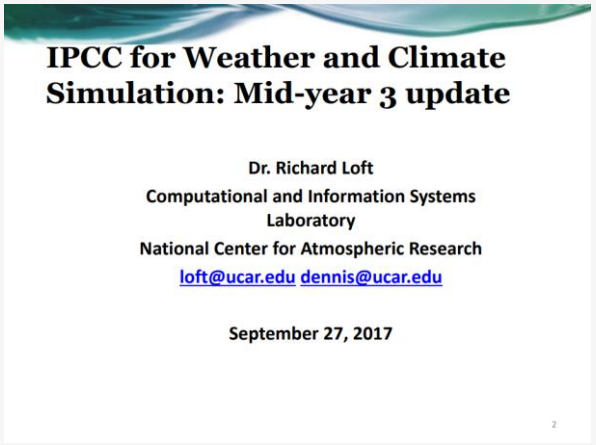
Flood Prediction Scenario

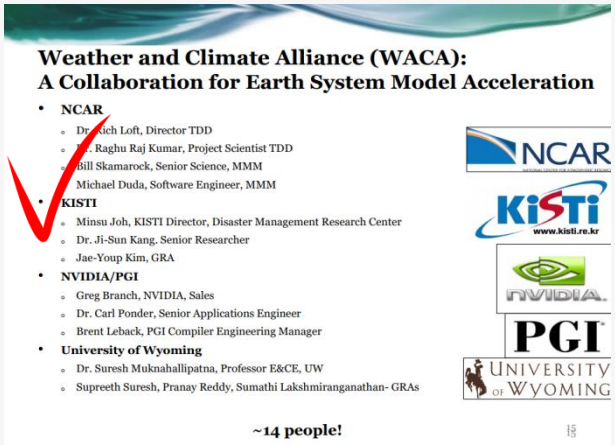
Obs. Data	DA	Typhoon	Surge	Flood	SV
As-Is	PWV	3DVAR	K-WRF	UG-SURGE	SURR
To-Be	+ Etc.	LETKF	Kr-MPAS		

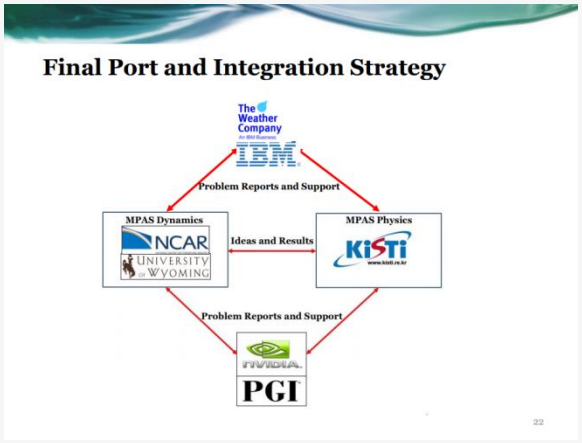


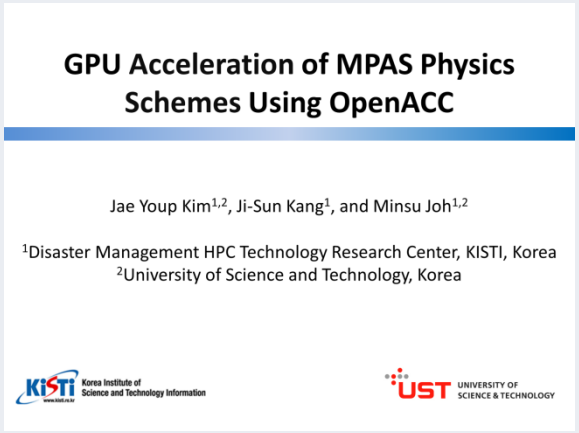


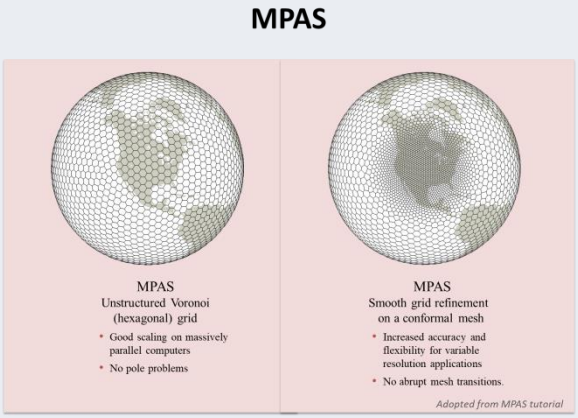
Weather/Climate Simulation Model GPU Acceleration

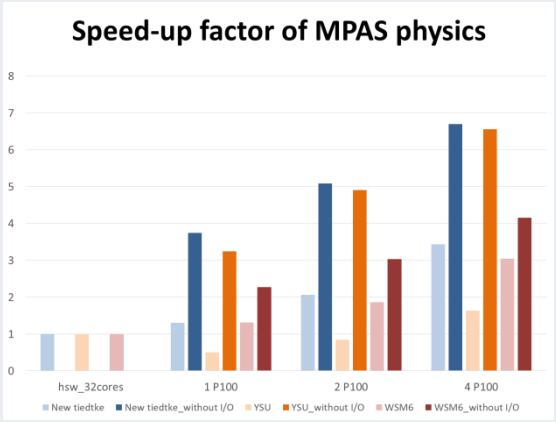












MultiCore7 Workshop at NCAR (2017.09.28.)

Weather/Climate HPC & AI Research Collaboration

NVIDIA.

Recognition of Excellence in Research

09 Sep 2017

Dr. Minsu Joh
Principal Director, Decision Support Technology Research Lab
Disaster Management HPC Technology Research Center
Korea Institute of Science and Technology Information (KISTI)
Daejeon, Korea, (http://www.kisti.re.kr)

Dear Dr. Joh,

Thank you for recent updates regarding the next phase of KISTI leadership-class research in high performance computing (HPC) and Artificial Intelligence (AI). Following a review of past collaboration between our organizations, your recent scientific contributions and achievements in HPC and AI, NVIDIA would like to express our recognition of your excellence in research, and offer support for related future research. NVIDIA considers weather prediction and climate science as an important domain that has advanced significantly from application of HPC and AI, and we are very excited at the potential of application software from KISTI that can model extreme weather events with high-fidelity and scale-resolution in a practical way owing to GPU technology.

NVIDIA Corporation headquartered in Santa Clara, CA, invented the GPU in 1999 that sparked dramatic growth in PC gaming, redefined modern computer graphics, and revolutionized parallel computing. More recently, GPU-based deep learning ignited modern AI - the next era of computing - with the GPU acting as the brain of computers, robots and self-driving cars that can perceive and understand the world. NVIDIA continues to achieve milestones in parallel computing that lead to breakthroughs in advanced, energy efficient, and cost-effective HPC. As a result of this strategic collaboration between KISTI and NVIDIA, and in recognition of recent achievements, NVIDIA would like to contribute the following resources to your research:

- An award of 4 x P100 GPUs (valued at more than $40,000 USD) for use by your organization at KISTI
- Remote access to the latest GPU technology at NVIDIA Santa Clara for performance testing
- Pre-release access to next-generation NVIDIA GPUs (e.g. Volta) and CUDA software environment
- Technical guidance on applications engineering from the NVIDIA Developer Technology group
- Technical support on hardware and software implementation; GPU cluster use; bug fix support, etc.

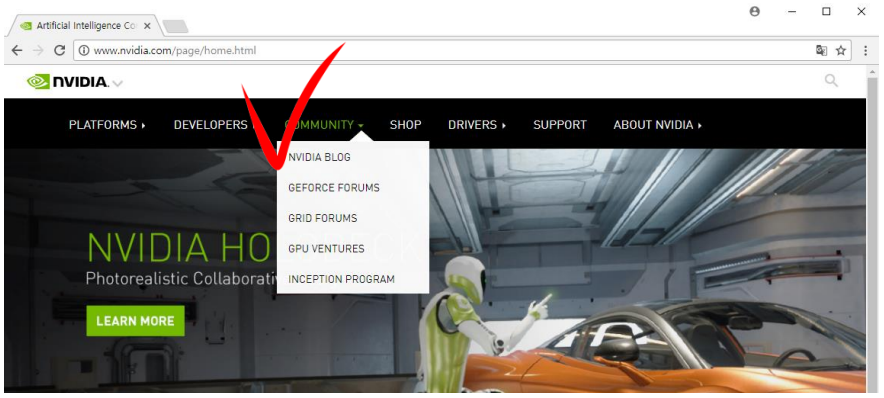
NVIDIA are interested in your research in two respects. We are generally interested in supporting innovative and promising approaches that demonstrate the capabilities of GPU-based system architectures with relevant real-life applications. Further, NVIDIA have interest in the experiences gained from a continued KISTI collaboration on implementation of optimized GPU-based solutions that can apply to simulations of Earth's environment.

Thank you for the valuable contributions towards NVIDIA technology and solutions in weather and climate research, and we look forward to further collaboration and breakthroughs working together with your team at KISTI.

Sincerely,

< NVIDIA Corp Signature >

2701 San Tomas Expressway | Santa Clara, CA 95050 | T 408.486.2000 | F 408.486.2200 | www.nvidia.com



As is 29 October, 2017

If you wonder why we need a better way to predict hurricanes, just ask the people of Houston.

Authorities knew Hurricane Harvey was heading to south Texas, but forecasters couldn't say precisely which areas would be hardest hit. So, most Houstonians stayed put. The consequences: more than 75 deaths, 30,000 people in shelters and tens of thousands who needed rescuing.

And Harvey was just the start. Irma, Jose, Maria, Nate and Ophelia — with more than five weeks to go, the 2017 Atlantic hurricane season has already been one of the worst on record. The year is the first since 1893 to see 10 storms in a row reach hurricane strength, and only the fourth in recorded hurricane history. Without knowing where the brunt of a powerful storm will strike, officials are often puzzled about where and when to evacuate.

Halfway around the world, a team of scientists in Korea is using GPU-accelerated deep learning to help keep people out of harm's way.

"We can't prevent natural disasters, but with the right information, we can minimize the risks," said Minsu Joh, director of high-performance computing research at the Korea Institute of Science and Technology Information (KISTI).

Better Predictions in Less Time

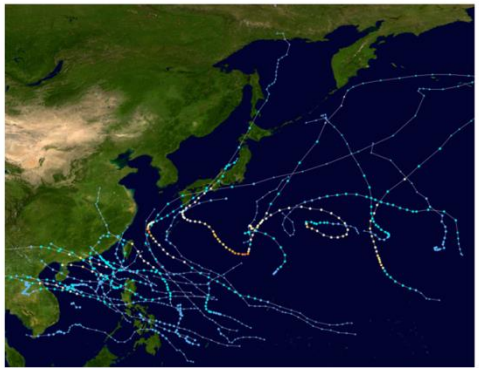
Today, meteorologists rely on numerical models to predict wind speed, precipitation, air pressure and other factors that indicate the path and intensity of a hurricane over its lifetime. Instead, the KISTI team used observed data from satellites and radars to train their two deep learning systems — GlobeNet, which predicts the track of a typhoon, and DeepRain, which predicts heavy precipitation.

The researchers used data from numerical models to train a third system, DeepTC, which predicts tropical cyclones.

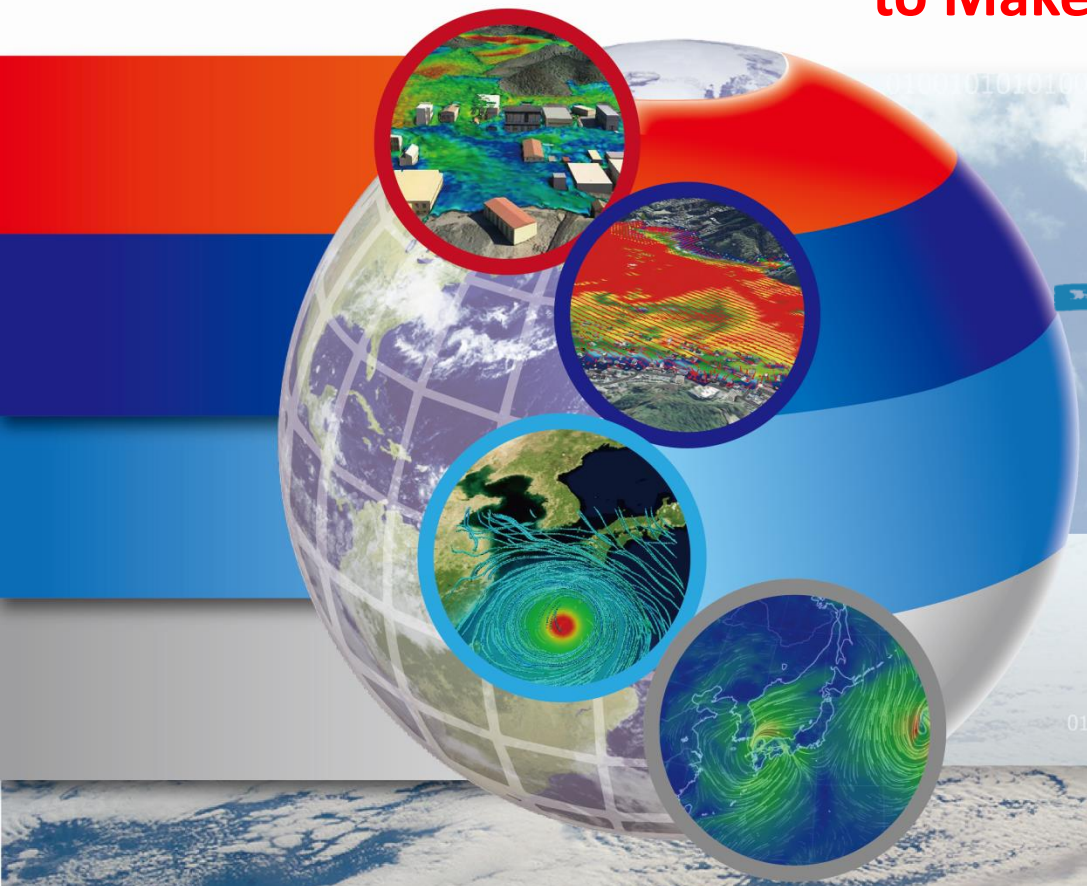
"Although these three models are still experimental, so far we've boosted accuracy over existing methods," said Sa-kwang Song, the lead scientist developing the KISTI deep learning systems.

The KISTI scientists trained their models using the Keras toolkit and TensorFlow deep learning frameworks with cuDNN running on the institute's NVIDIA GPUs and also on our GPUs in the Amazon Web Services (AWS) cloud. They also used our GPUs in AWS for inference.

So far, the KISTI system can predict typhoons and their associated rainfall just one to two hours in advance. The team plans to increase that range to six hours next year, and eventually to three days, which could be a real life-saver.



To Provide the Right Information
to the Right People, at the Right Time,
to Make the Right Decisions.



THANK YOU!

KiSTi
www.kisti.re.kr

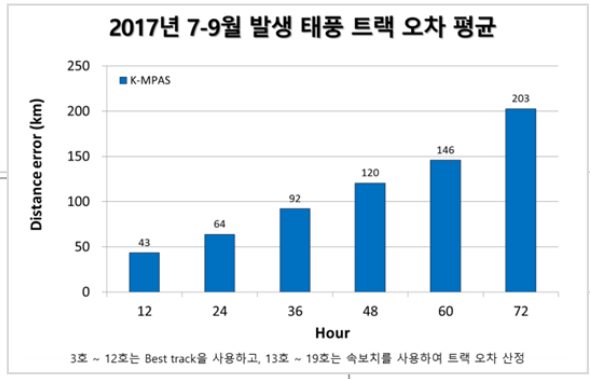
Korea Institute of Science and Technology Information

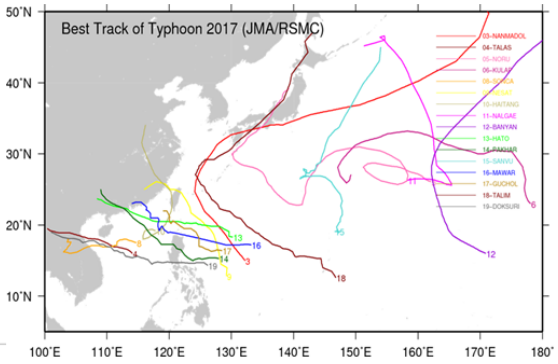
2017

IV.1 예측 정확도 향상: TPAS

√ 태풍 트랙 오차: 목표 60h 예측 200km 이내

기상청/국가태풍센터에
태풍 트랙 예측 정보 제공
(7~9월 발생 태풍)





(최종목표)

72h 예측
200km
이내

('18)