Center Report from KMA

Forecasting System Operation & Research

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Outlines

- KMA's Operational NWP System Overview
  - Hardware and NWP Systems
- Major R&D Activities in 2014 and Performance
  - Operational NWP System upgrade
  - Verification Scores
  - KIAPS Development
- Further Development / Research Plans

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Operational NWP Systems

Hardware(HPC) and Software

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Current Operational HPC (Cray XE6)

Main System
(20 Cabinets, 379TFlop/s)

Backup / R&D System
(20 Cabinets, 379Tflop/s)

Ref	**Main (HaeOn)**	**Backup (HaeDam)**	**Total**
Installation Year	2010. 12		
Core Number	45,120	45,120	90,240
Core Type	AMD 2.1 GHz, 12 core		
Peak performance	**379 TF**	**379 TF**	**758TF**
Main Memory	60 TB	60 TB	120TB
Capacity of Disk	4 PB		
Capacity of Tape drive	8 PB		
OS	Suse Linux 11		

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New HPC Introduction

- Contract : June 2014
- Installation of Initial Stage System : November 2014
- Installation of Final Stage System : Q4 2015

System architecture	Peak Perf. (TF)	Processor type & Memory	# Nodes	Login nodes	I/O System
CRAY XC40-LC (3 cabinets)	447	Intel haswell 2.6GHz 24cores/node 128GB/node	computational (448nodes) Pre-post (12nodes)	4 set	3.3PB > 50GB/sec
CRAY XC40-LC (16 cabinets*2set)	5,800	Intel haswell 2.6GHz 24cores/node 128GB/node(comp) 258GB/node(pre-post)	computational (2,904nodes*2set) Pre-post (56nodes*2set)	8 set	> 13.5PB > 248GB/sec

- The initial stage system (Uri) was ranked #148 on Top 500 list (Nov.2014)

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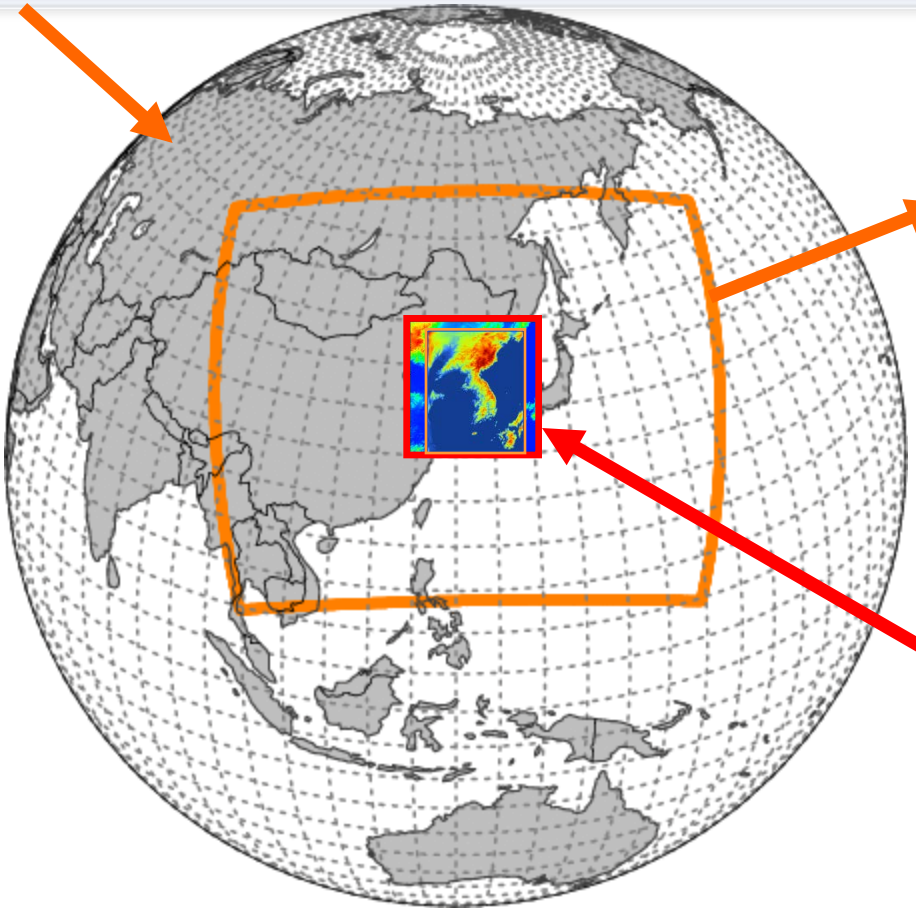
Operational NWP Systems

Global Medium-range Prediction

- Deterministic : UM 25km L70 / T+288hrs (00/12UTC), T+87hrs (06/18UTC) / Hybrid Ensemble 4DVAR
- Ensemble : UM 40km L70 / T+288hrs (00/12UTC) / 24 Members / Perturb. : ETKF, RP, SKEB2



Short-range Prediction (E-Asia)

- UM 12km L70 / T+87hrs (6 hourly) / 4DVAR / Deterministic

(Very) Short-range Prediction (Local)

- Deterministic : UM 1.5km L70 / T+36hrs (6 hourly) / 3DVAR (3 hourly)
- Ensemble : In preparation (Q3 2015)

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Operational NWP Models (March '15)

	Model	Resolution	Target Length	Target / Purpose
Seasonal	GloSea5(Global)	N215(60km) L85	220 days(M2) 60 days(M2)	Seasonal prediction (~6months)
Medium -range	GDAPS (Global)	N512(25km) L70	T+288 (00/12) T+87 (06/18)	Global deterministic
	Global EPS (Global)	N320 L70 M24	T+288	Global probabilistic
(Very) Short-range	RDAPS (E.Asia)	12km L70	T+87	East Asia / Short-range
	LDAPS (Korea)	1.5km L70	T+36	Korea / Short-range
	KLAPS (Korea)	5km	T+12	Korea / Very short-range
Applica -tion Models	Wave Watch III	55km	T+288	Global
		8km	T+87	Northeast Asia
		1km	T+72	Coastal
	ADAM (Dust & Aerosol)	30km	T+72	Asia dust
	DBAR (Typhoon)	35km	T+72	Track
	Tide/Storm Surge	9km	T+87	Northeast Asia

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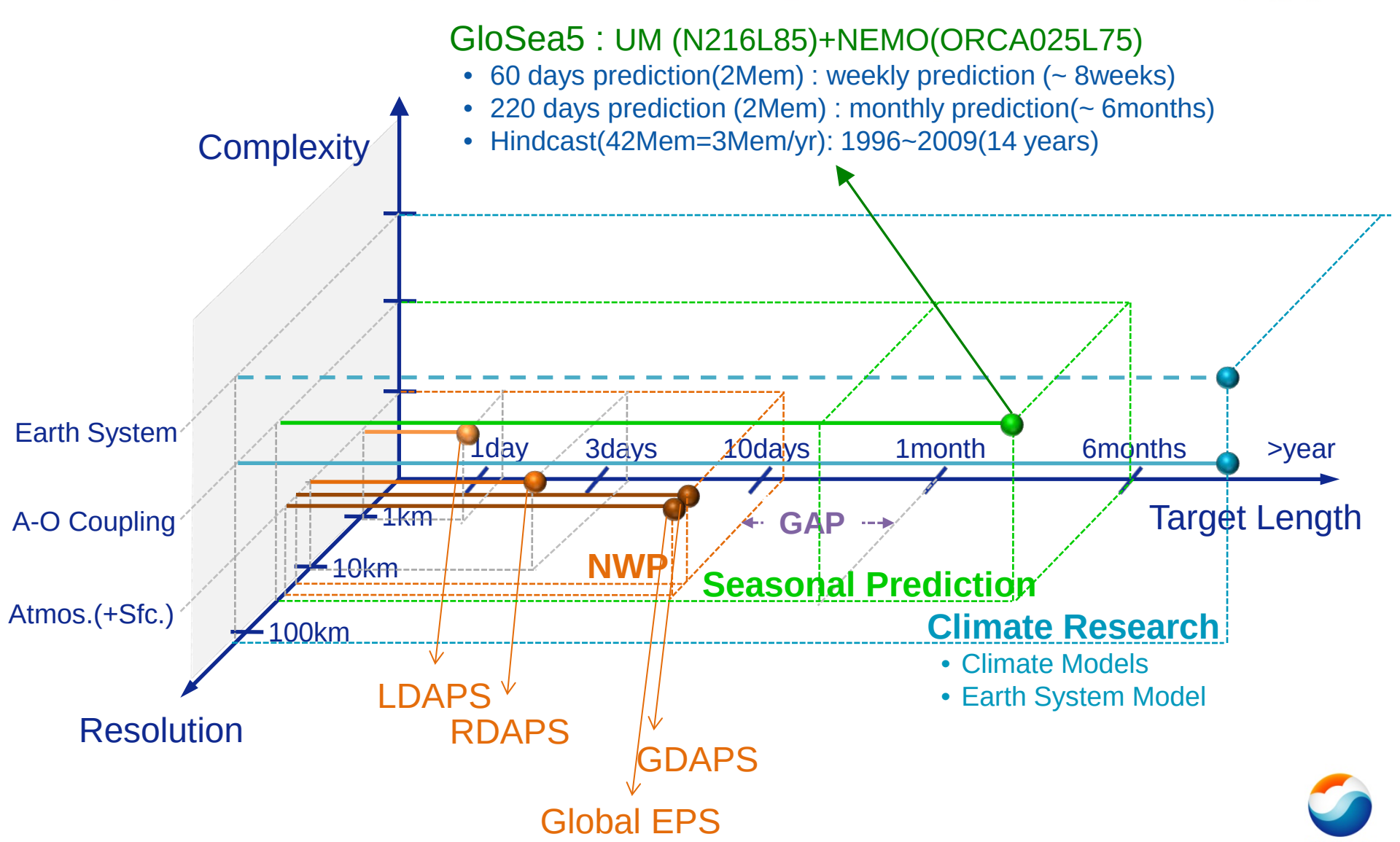
Operational NWP Models (March '15)



Major Upgrades in 2014 and NWP Performance

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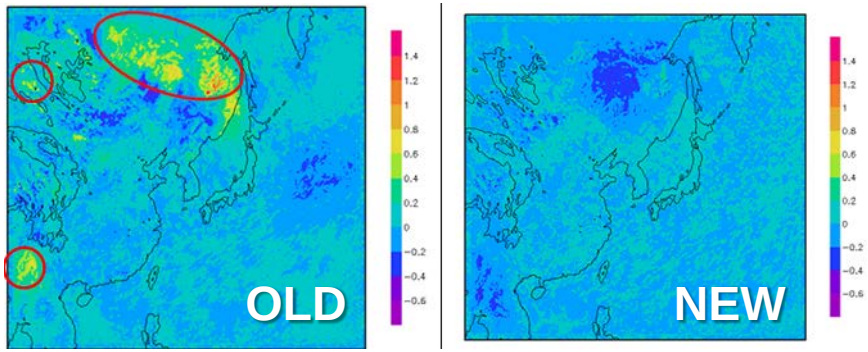
Operational System Upgrade (2014)

❖ Global NWP System (GDAPS)

- No major upgrade in 2014
- MetOp-B (ATOVS, IASI) data is used since Nov. 2013

❖ Regional NWP System (RDAPS)

- Revision of Background Error Covariance for the East Asia domain



T+12 Forecast Error

- Reduction of Continental (China) Warm Bias in the New D.A. System

- Software version upgrade of observation pre-processing (OPS), variational D.A. (VAR) and atmospheric model (UM)
- Ancillary data (LAI) update : Heat/Moisture flux improved

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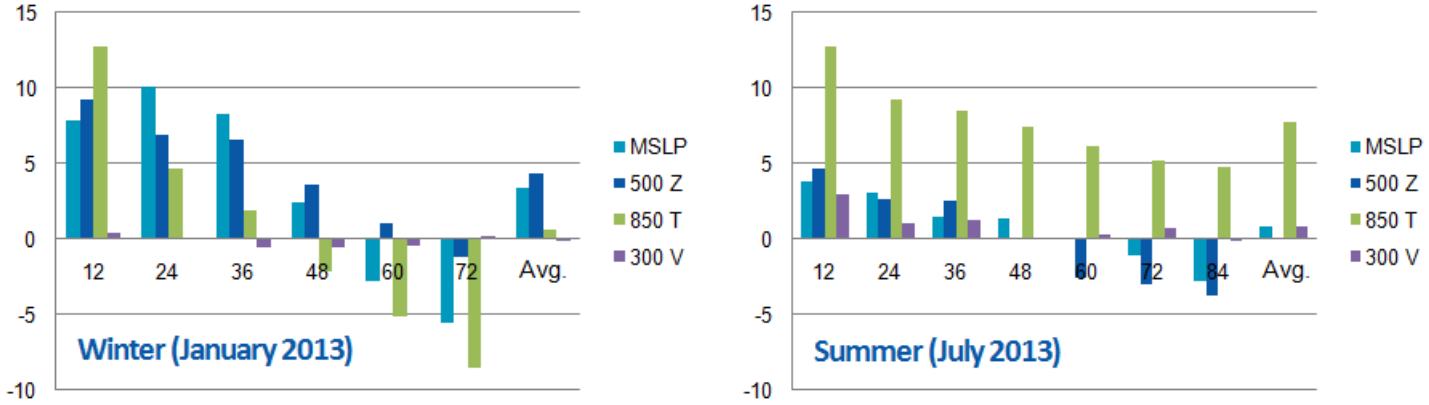
Operational System Upgrade (2014)

❖ Regional NWP System (RDAPS) - continued



Percentage Improvement (New vs. Oper.) / RMS Error / Verification against Analysis

❖ Local NWP System (LDAPS)

- Software version upgrade of atmospheric model (UM)
- Physics configuration update : Improvement of surface temperature and fog prediction performance

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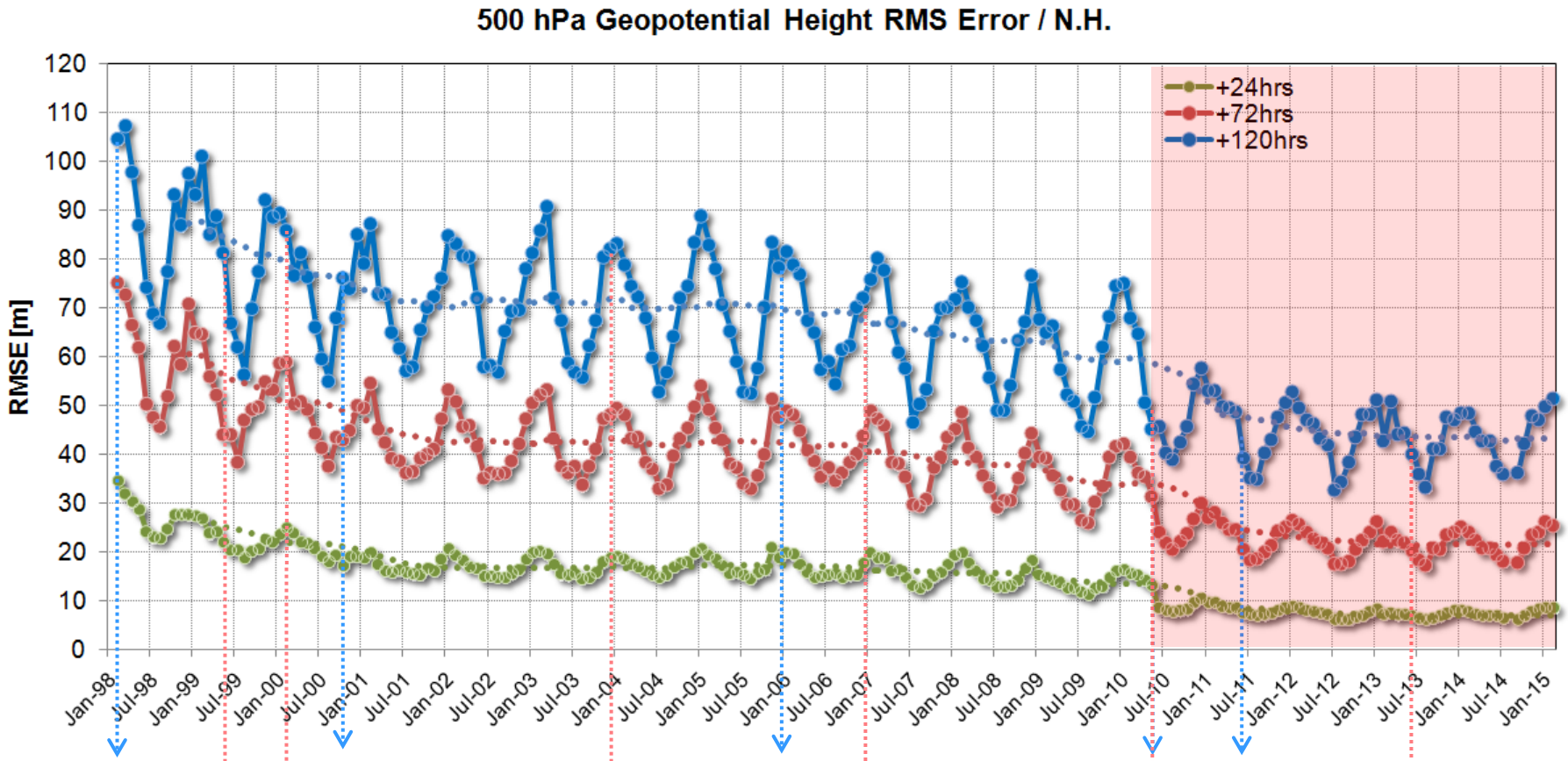
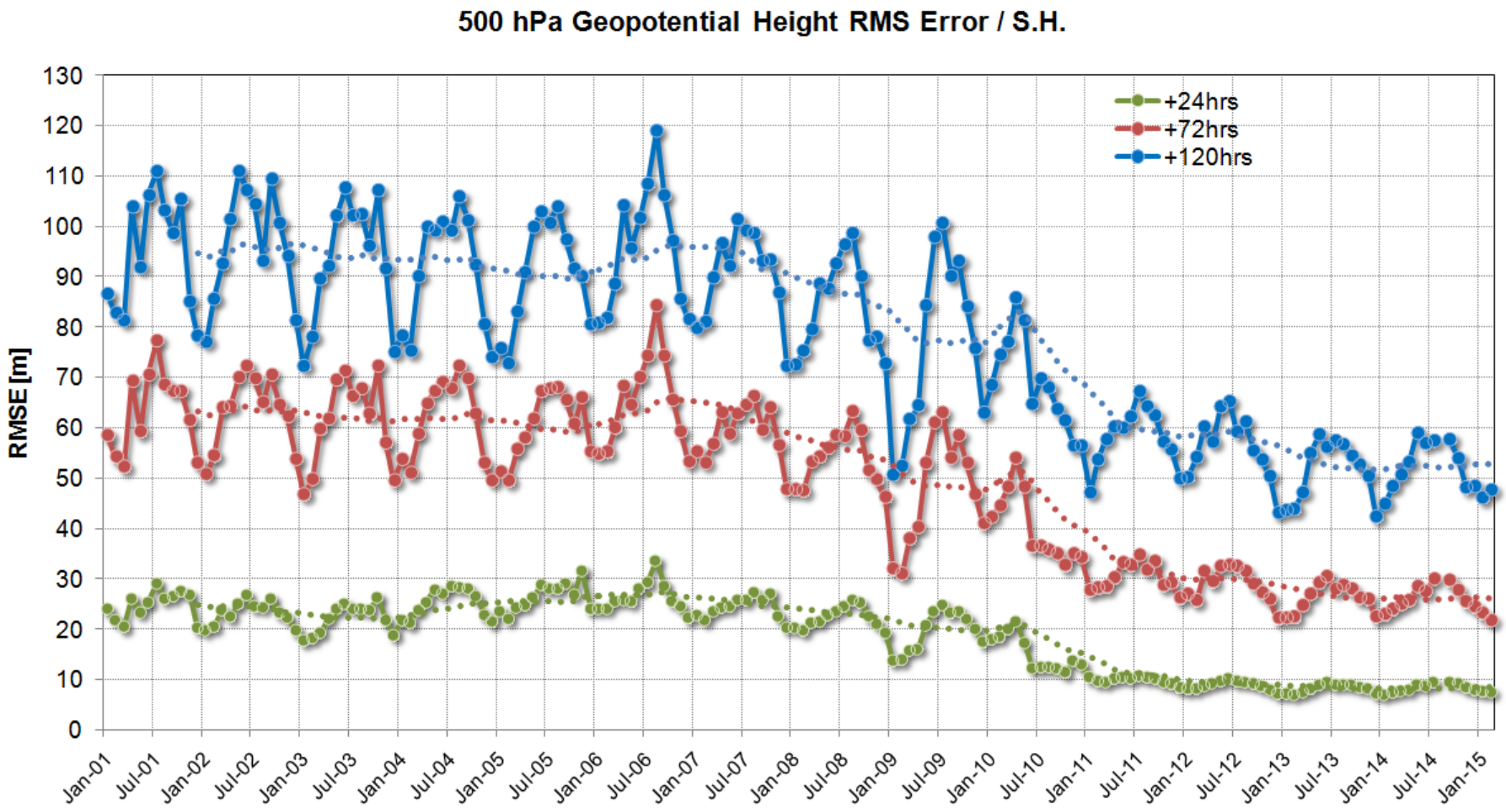
Operational Global Model Performance



Operational Global Model Performance



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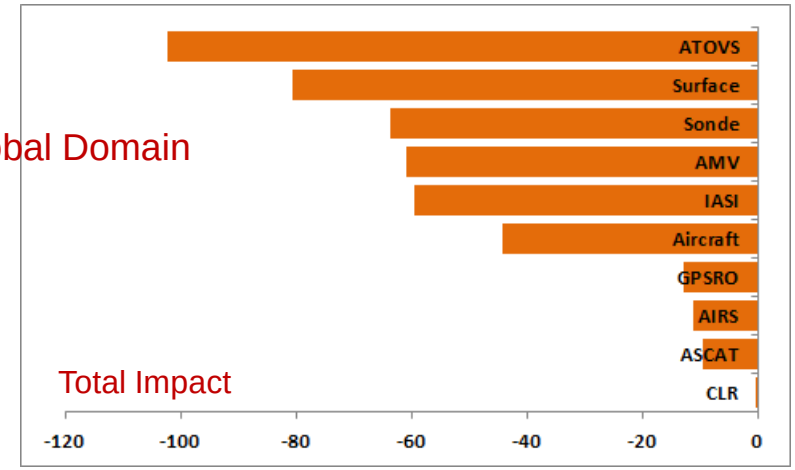
Forecast Sensitivity to Observation

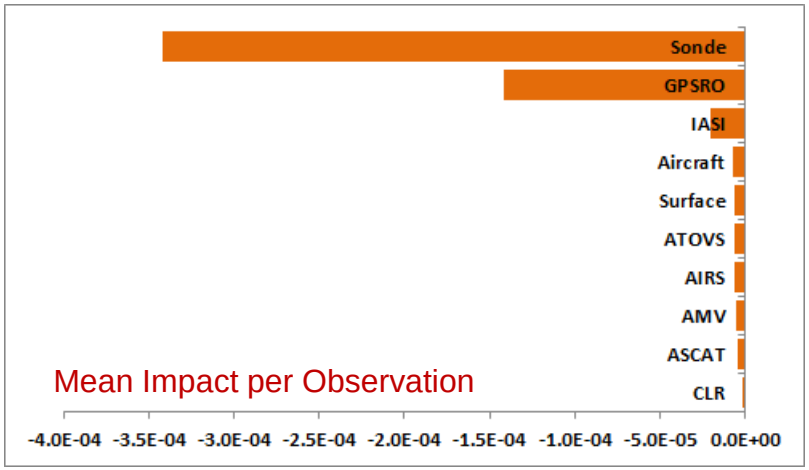
- FSO based on the operational global NWP system

(Dry Energy Norm, J/kg)

- Global Domain

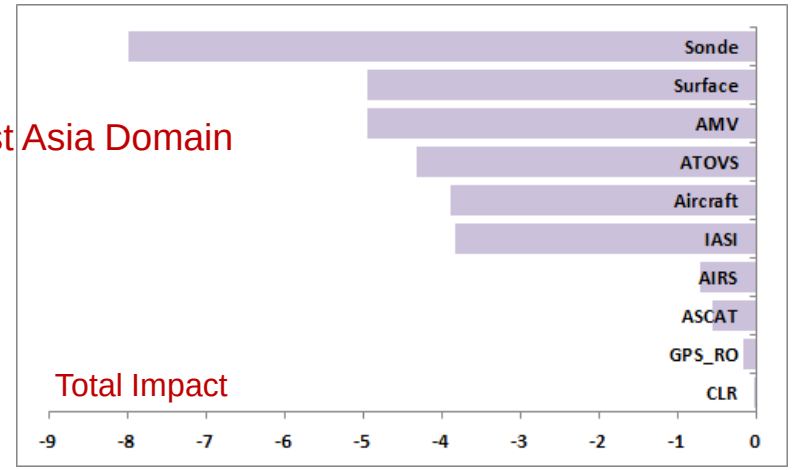


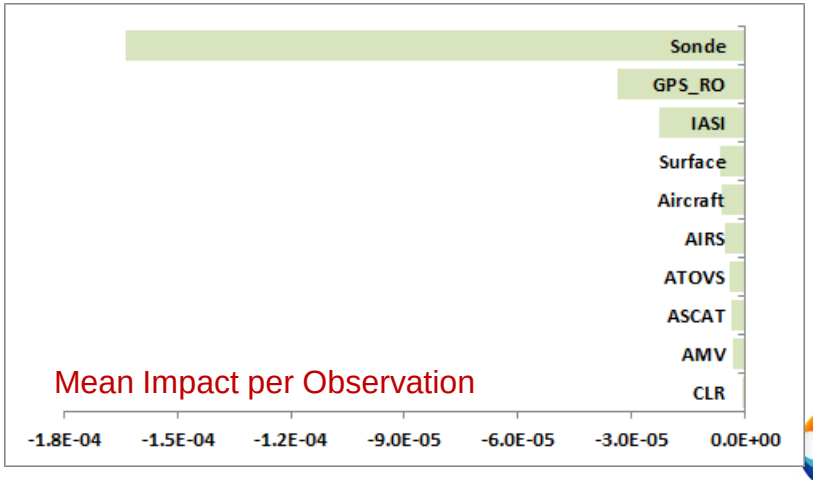
Satellite Data 58% , Non-Satellite Data 42%



Sonde >> GPS_RO > IASI (vertical sounding)

- East Asia Domain





Impact of Synoptic Obs. (Sonde) is still dominant in the East Asia domain

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KIAPS Development

Korea Institute of Atmospheric Prediction Systems (2011~2019)

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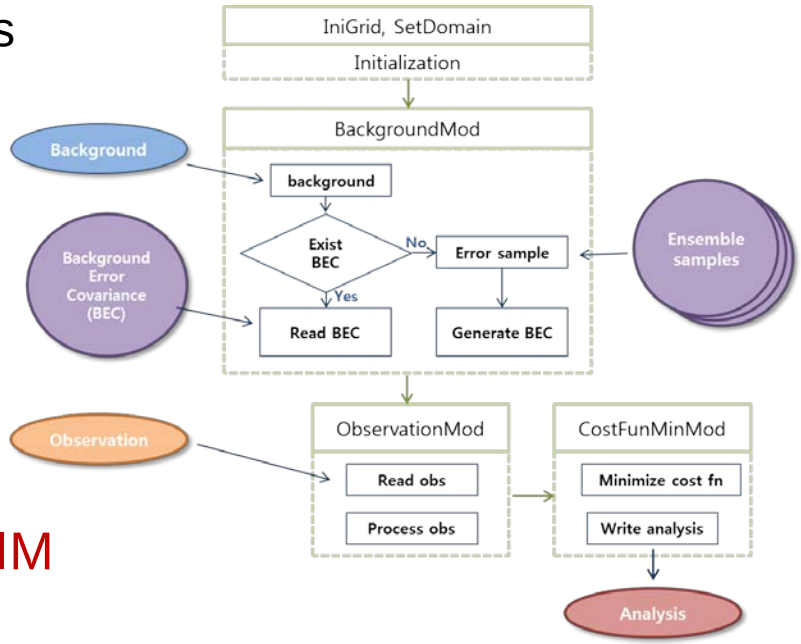
Major Achievement in 2014 (D.A.)

❖ Building 3DVAR System on a Cubed-Sphere

- 3DVAR system on a cubed-sphere
  - Spectral filter and Eigenvalue analysis
  - Background error covariance
- Variable transform method
- Improvement of cost-function minimization
  - enhanced computational efficiency
- Combination of 3DVAR system and KIM (KIAPS Integrated Model)
  - Successful generation of analysis field via 3DVAR



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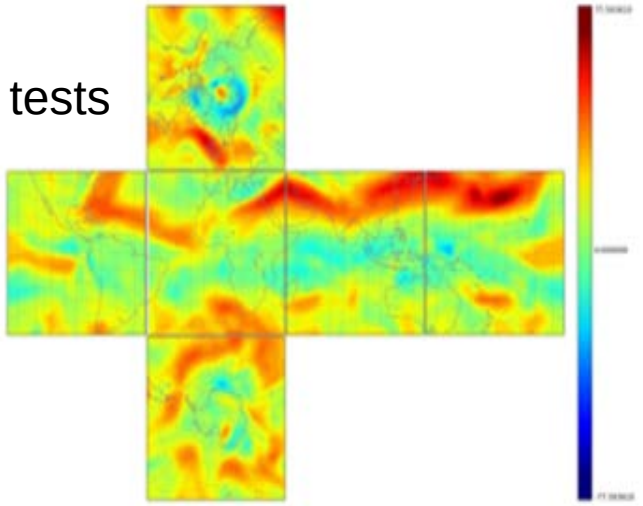
Major Achievement in 2014 (Model)

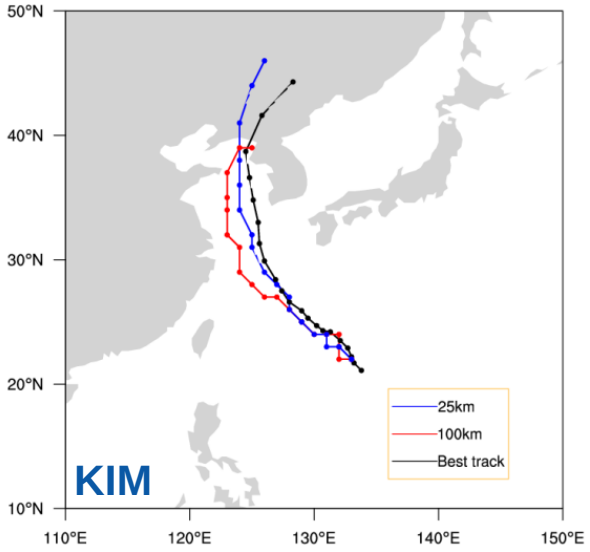
❖ Building β-version of KIAPS global model

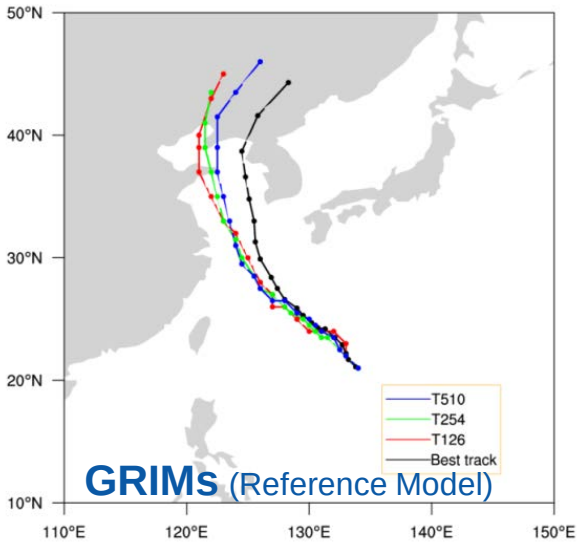
- Horizontal resolution : 25km (ne120np4)
- 50 vertical layers / Top = 0.3hPa
- Dynamical core : Hydrostatic/Non-hydrostatic system on a cubed sphere (based on CAM-SE HOMME)
- Dynamical core and physics packages are successfully combined
- Preliminary Evaluation
  - DCMIP(Dynamical Core Model Intercomparison Project) tests
  - Severe weather events
  - Medium-range (10-day) experiments

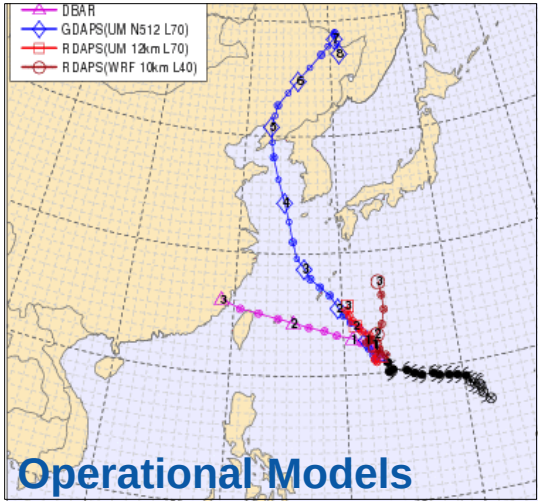


KIM Results

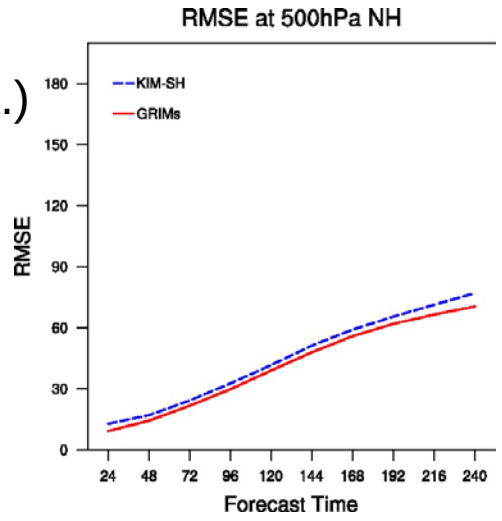
Typhoon Bolaven Case (August 2012)

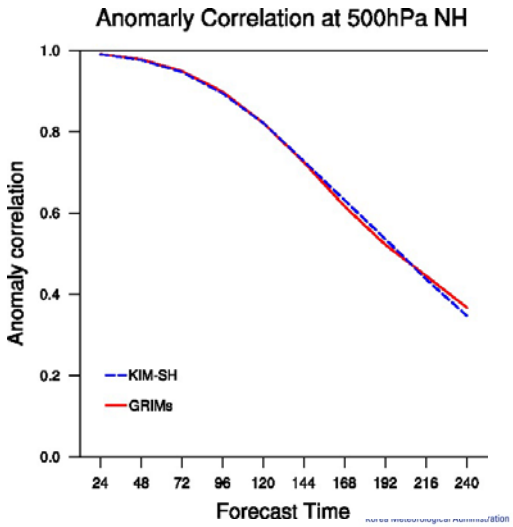






- Initial Condition : GFS Analysis (No D.A.)
- Verification score from 10-day forecast for a month (July 2013)
- RMSE, AC are comparable to the reference model

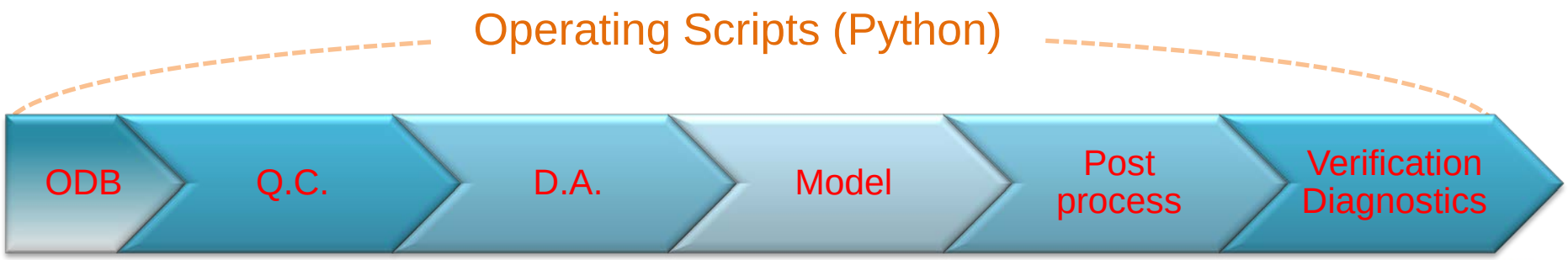




KIAPS Development Plan for 2015

❖ Further development of β-version KIAPS NWP System

- Complete building a 3DVAR-EnKF Hybrid D.A. cycling system
  - Design end-to-end system from observation data acquisition to post-processing/verification system
- Refine dynamical core and physics package of KIM
  - More emphasis on non-hydrostatic version
- (Near) real-time run and evaluation of KIM system



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On-going Research/Development and Further Plans

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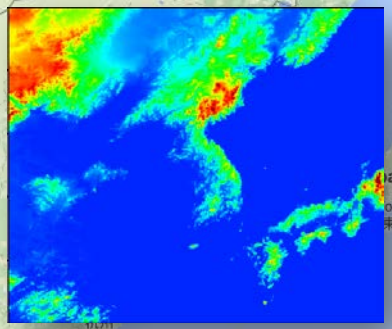
Convective scale EPS

Local ENsemble prediction System (LENS)

- Resolution : 3km (horizontal) / 70 vertical layers (~40km)
- Target length : T+45 hours (03/15UTC)
- # of Members : 11+1 (or 23+1)



- Initial Perturbation : from global EPS (LETKF to be tested)
- Model Perturbation : None (Random Parameter to be tested)

- Planned to be in Operation in Q4 2015

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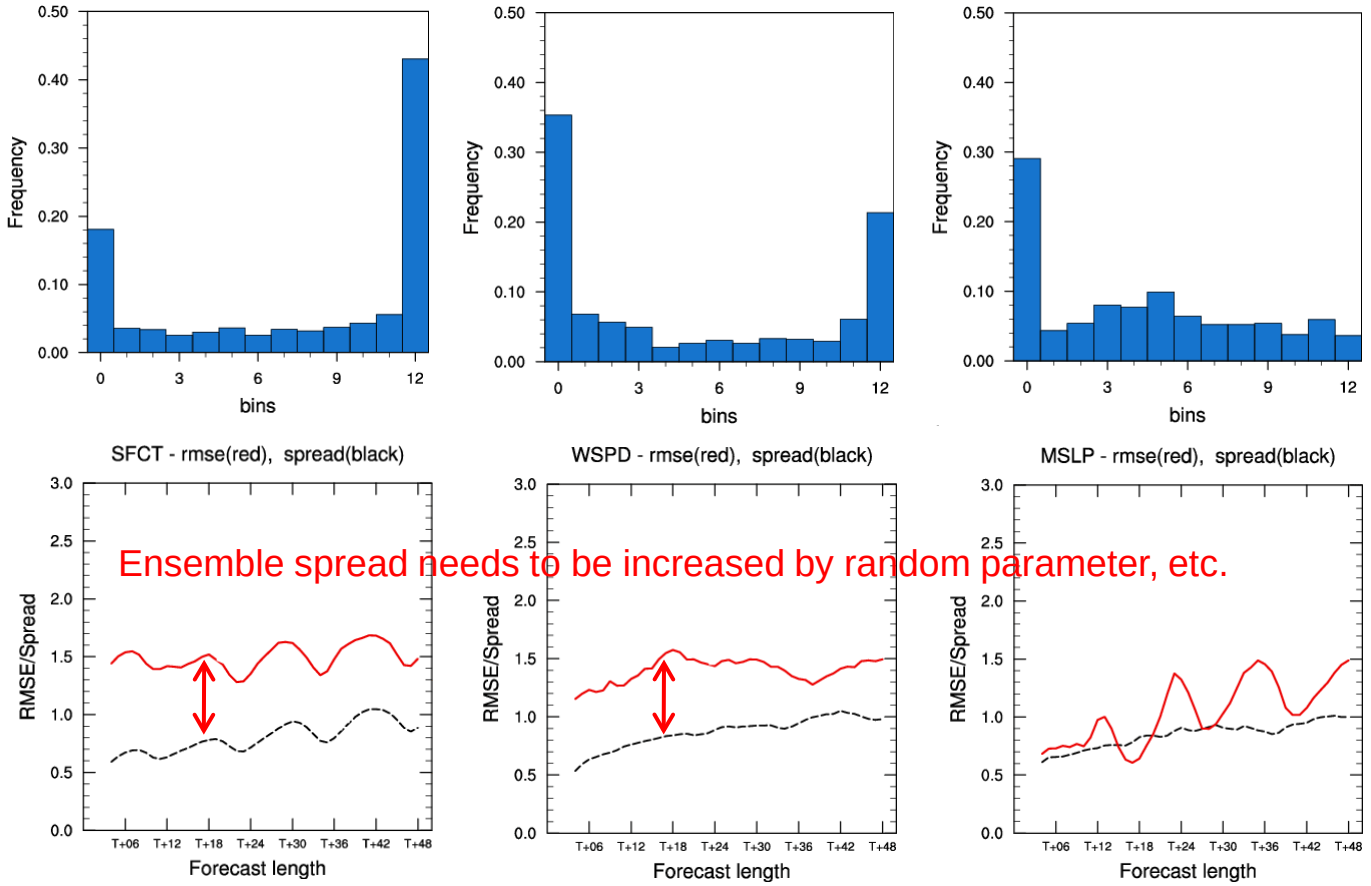
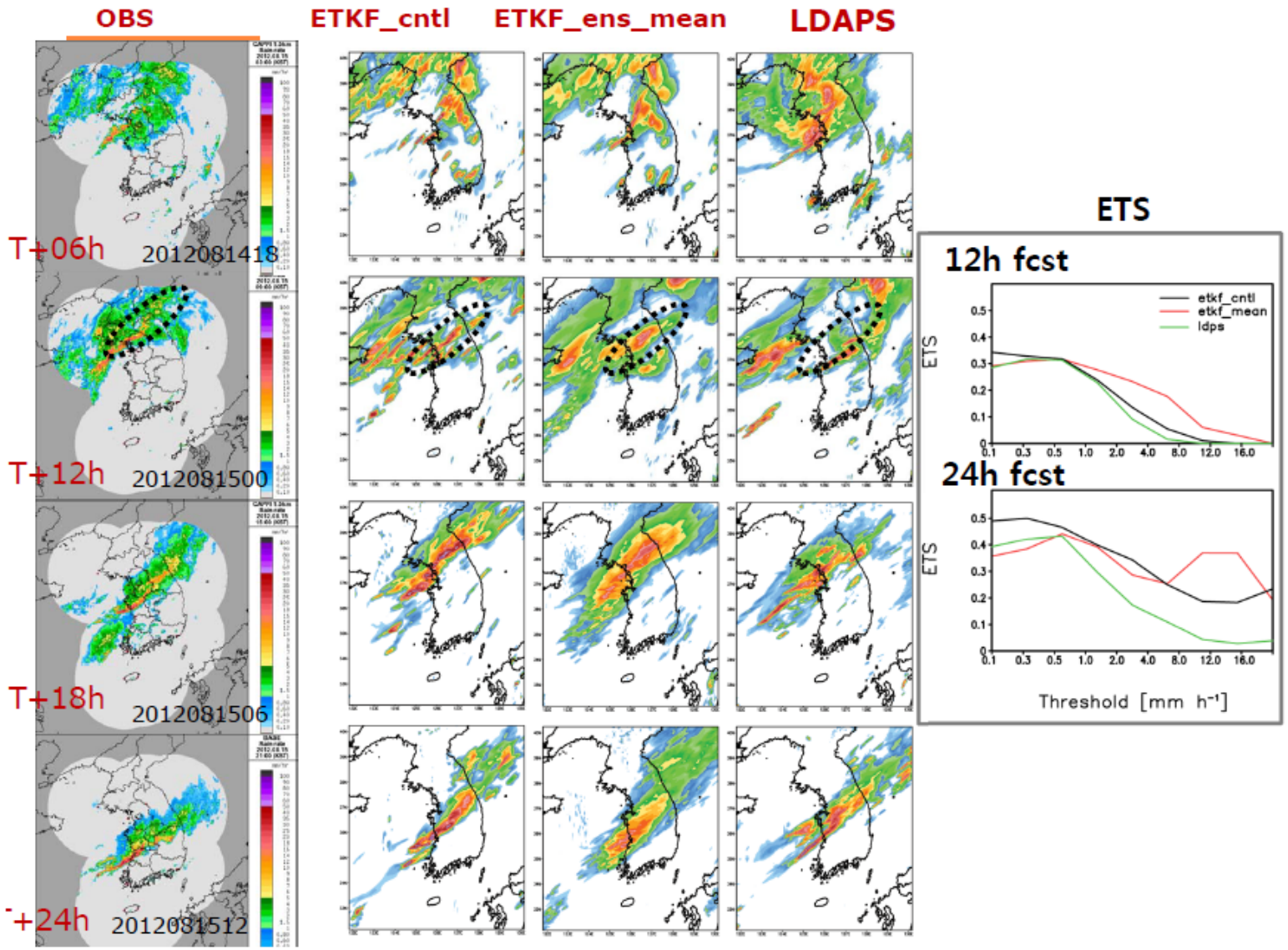
Convective scale EPS – Preliminary Evaluation

- Rank histogram and time series show small ensemble spread
  - Initial ensemble spread needs to be increased
- Warm temperature bias and negative 10m wind bias



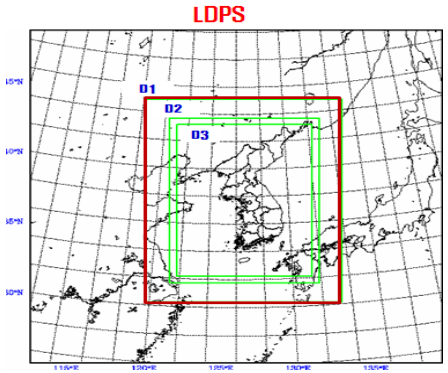
Convective scale EPS – LETKF Initialization



Further Development of Local NWP System

- Expanding the outer (low-resolution [4km]) domain
  - Mitigating negative impact of lateral B.C. from global model which sometimes degrades the forecast accuracy

744 * 928



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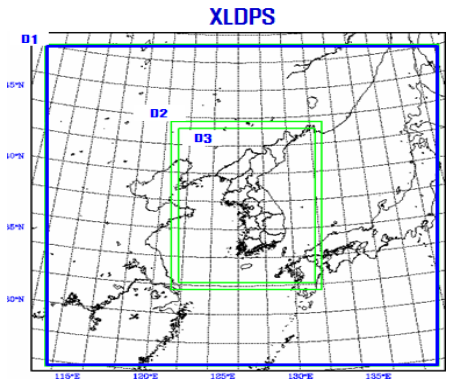
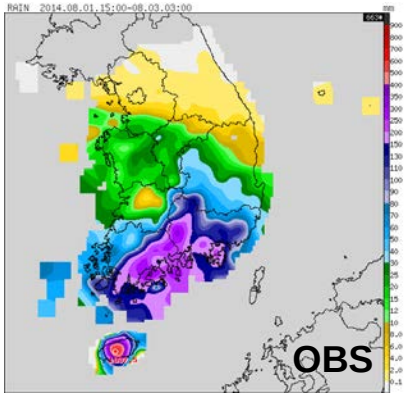
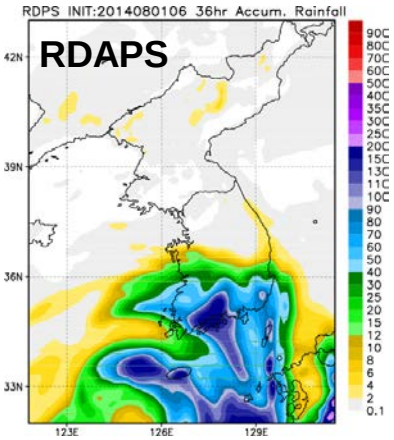
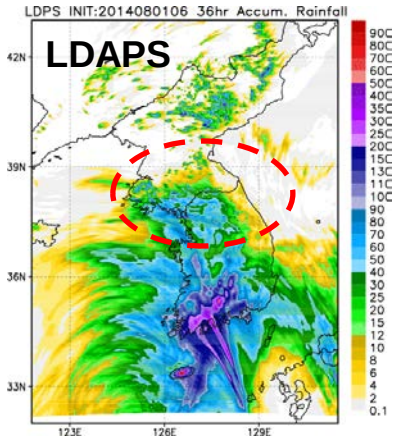


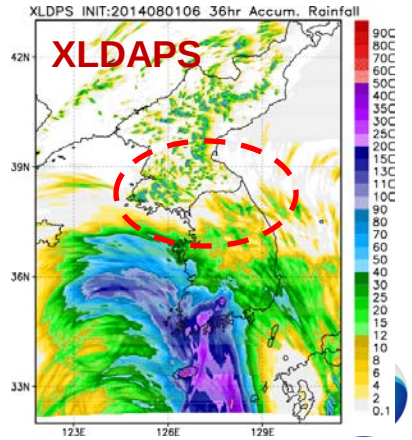
Typhoon NAKRI case (July 2014)

- 36hr accumulated rainfall amount









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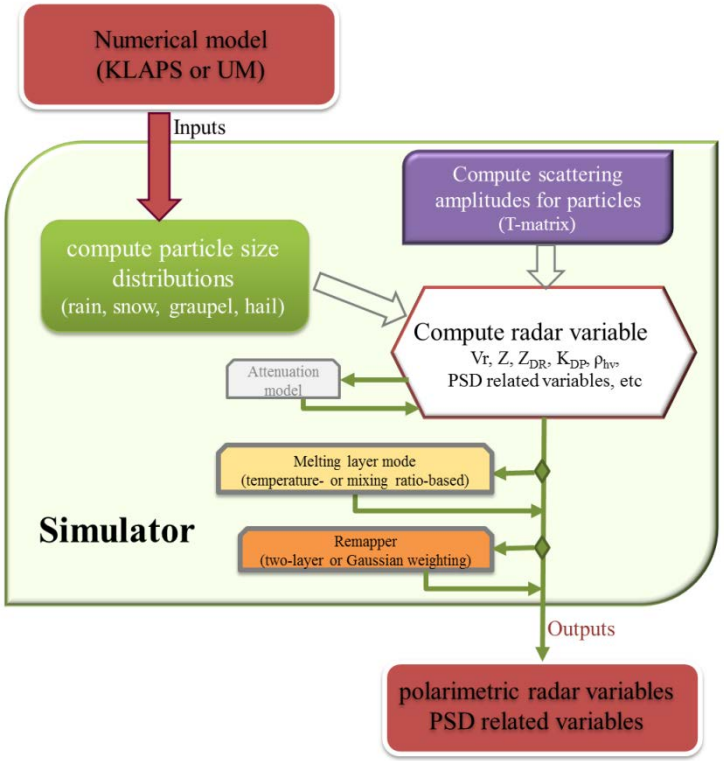
Further Development of Local NWP System

❖ Development of Atmosphere-Wave Coupled System

- Coupling of LDAPS(UM) with WaveWatch III using OASIS-MCT coupler
  - Considering the air-sea interaction to enhance the short-range forecast performance

- Optimization of physical parameterizations (especially microphysics scheme) using dual polarization radar and single column model



Summary of Future Plans

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Future Plans (Development Strategy)

Medium-range NWP (Global Model)

- Collaboration among UM Community (UK Met Office, CAWCR, etc.)
- 17km resolution Global NWP System with ENDGame DyCore
  - Real-time run and evaluation (‘15)
  - Operational Implementation (’16)

※ Use of additional observation (CrIS, ATMS, etc.)

Short-range NWP

- Tuning / Optimization of operational short-range NWP systems
  - LDAPS domain expansion (‘15)
  - Atmosphere-Wave coupled LDAPS (~’16)
- Local ensemble prediction system (LENS)
  - Operational implementation (‘15)
  - Enhancement of initial perturbation, etc. (‘16)

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Future Plans (summary table)

Year	2015	2016	2017
HPC	Cray XE6 Cray XC40 (1st stage)	**Cray XC40** (final stage)	
Short-range Deterministic	12km L70 / 4DVAR (East Asia Domain) [Frozen with minor upgrade (new observation, etc.)]		
	1.5kmL70 / 3DVAR Extended Domain	1.5kmL70 / 3DVAR (-> 4DVAR?) Extended Domain / **WW3 Coupled**	
Short-range Ensemble	3kmL70 12M (Newly Operational)	3kmL70 12M~24M (ETKF / Random Parameter)	
Medium-range Deterministic	25kmL70 Hybrid 4DVAR	**17kmL70 (ENDGame core)** Hybrid 4DVAR	
Medium-range Ensemble	40kmL70 24M	32kmL70 (or 25km) 24(44)M (ENDGame core)	
Seasonal Prediction	GloSea5 [60kmL85 (Atmos.) / 0.25deg L75 (Ocean)] Met Office – KMA joint seasonal prediction system		

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Questions

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