2018 S2S

Seasonal prediction experiments in a global coupled system based on a non-hydrostatic global atmospheric model

KIAPS
KOREA INSTITUTE OF ATMOSPHERIC PREDICTION SYSTEMS

Song-You Hong,
Jung-Eun Kim, and Myung-Seo Koo

2018. 9. 18

Korea Institute of Atmospheric Prediction Systems (KIAPS)

www.kiaps.org

2018 S2S

Seasonal simulation experiments In a non-hydrostatic global atmospheric model

KIAPS
KOREA INSTITUTE OF ATMOSPHERIC PREDICTION SYSTEMS

Song-You Hong,
Jung-Eun Kim, and Myung-Seo Koo

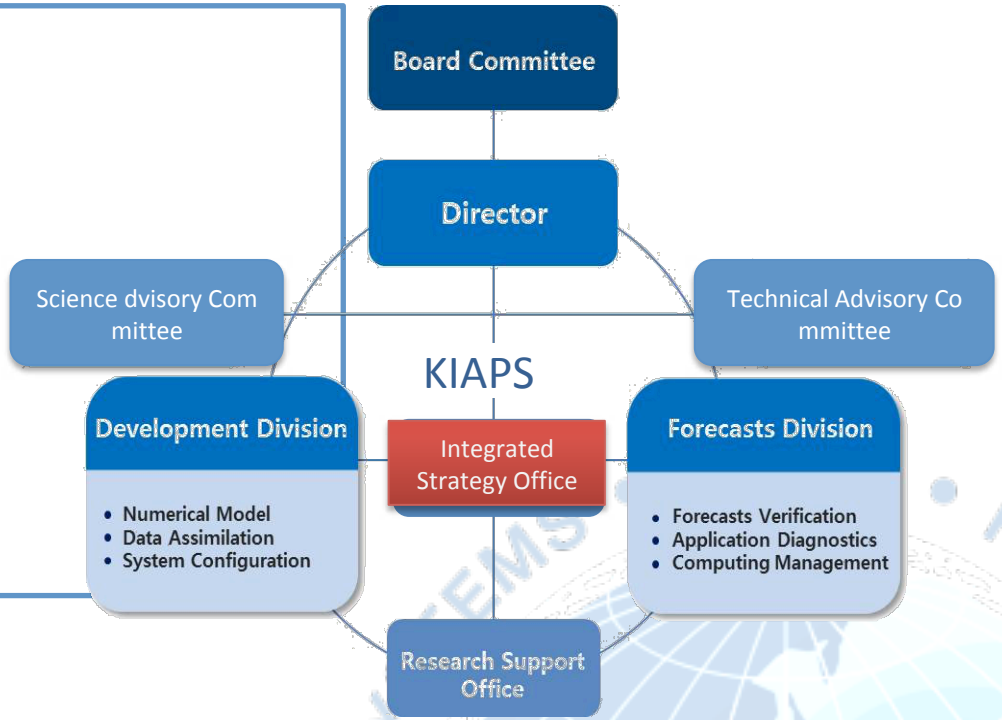
2018. 9. 18

Korea Institute of Atmospheric Prediction Systems (KIAPS)

www.kiaps.org

Organization of KIAPS

- ❒ Purpose : Developing a next generation global operational model for KMA
- ❒ Project period : 2011~2019 (total 9 years)
- ❒ Total Budget: $95 million
  - 2018 budget -$10 million
- ❒ Public institution sponsored by government
  - ○ organization: 2divisions, 6teams, 2office
  - ○ Man power: 58/58 + 12

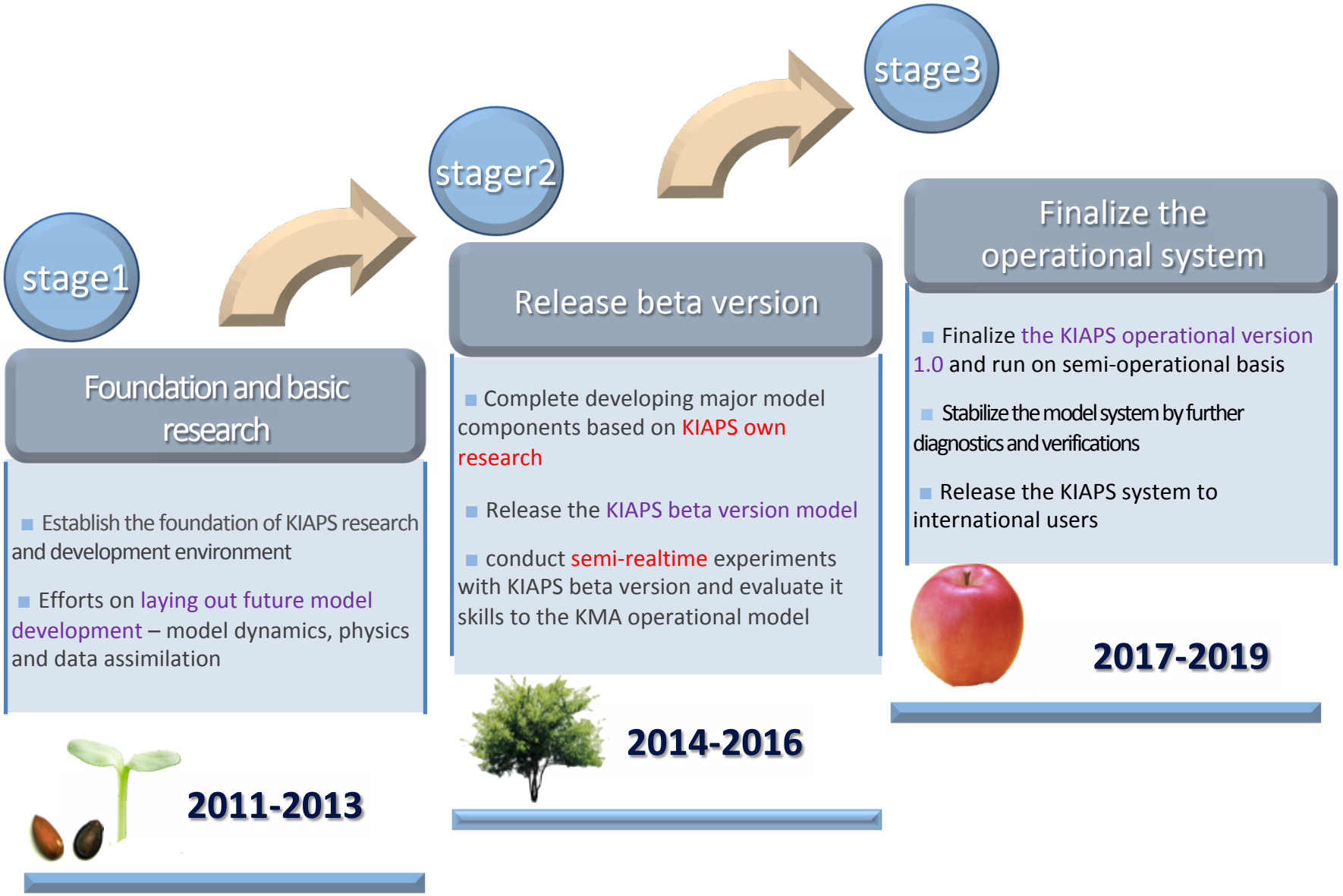


Total	Director	Research Staff				Administrative staff			
		Principal Researcher	Senior Researcher	Researcher	Assistant	Principal S taff	Senior sta ff	Staff	Assistant
58+12	1	13	26	12	5	1	2	3	5

List of presentation

- ✓ Overview of KIAPS
- ✓ Development strategy of KIM
- ✓ NWP performance of KIM
- ✓ Stochastic perturbation tendency for NWP and season run
- ✓ Stochastic physics perturbation for ocean-atmos interaction

Three-stage development plan



Setup the standard modules (2011-2013)

Sonde, Aircraft, SFC
AMSUA, GPSRO, IASI

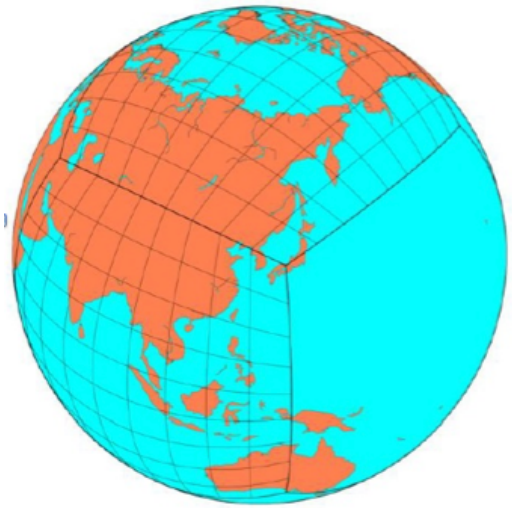
3DVAR
LETKF

3D Hydro from NCAR CAM-SE

Data	QC	DA	Dynamic core Physics modules	Verification Analysis

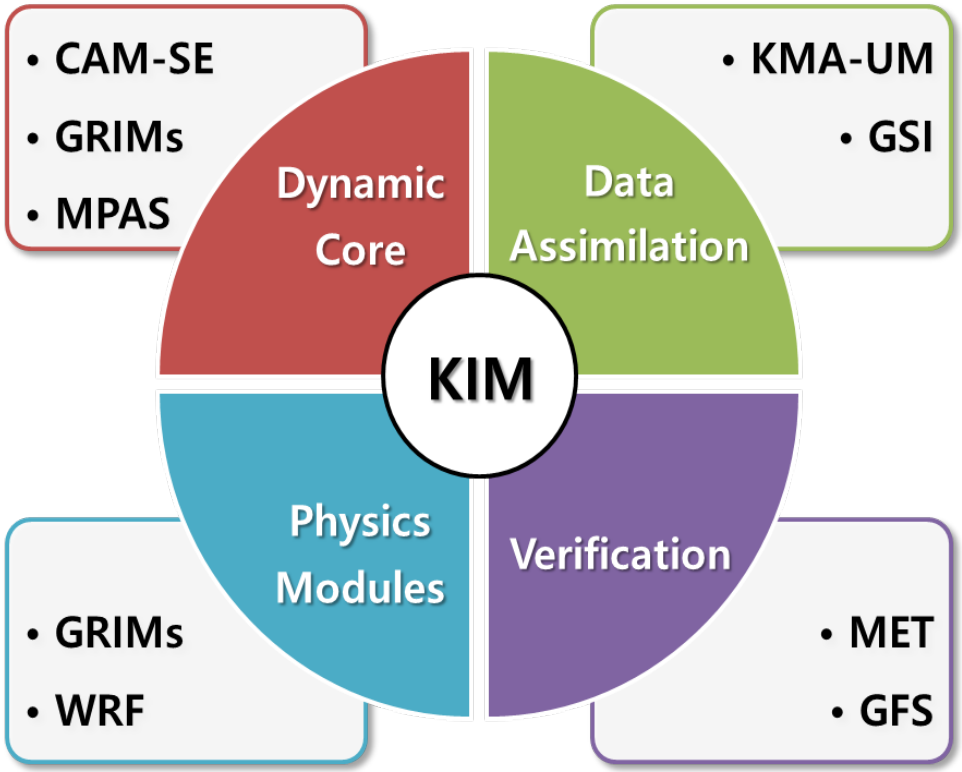
Standard physics package
(WRF, GRIMs, GFS)

Evaluation and
Feedback



Climatology simulation
=➔ NO NWP results yet !

Strategy (Sep. 2014) : Reference models



Develop major components of the model autonomously, but with the strategy of benchmarking performance of KIM with the reference models

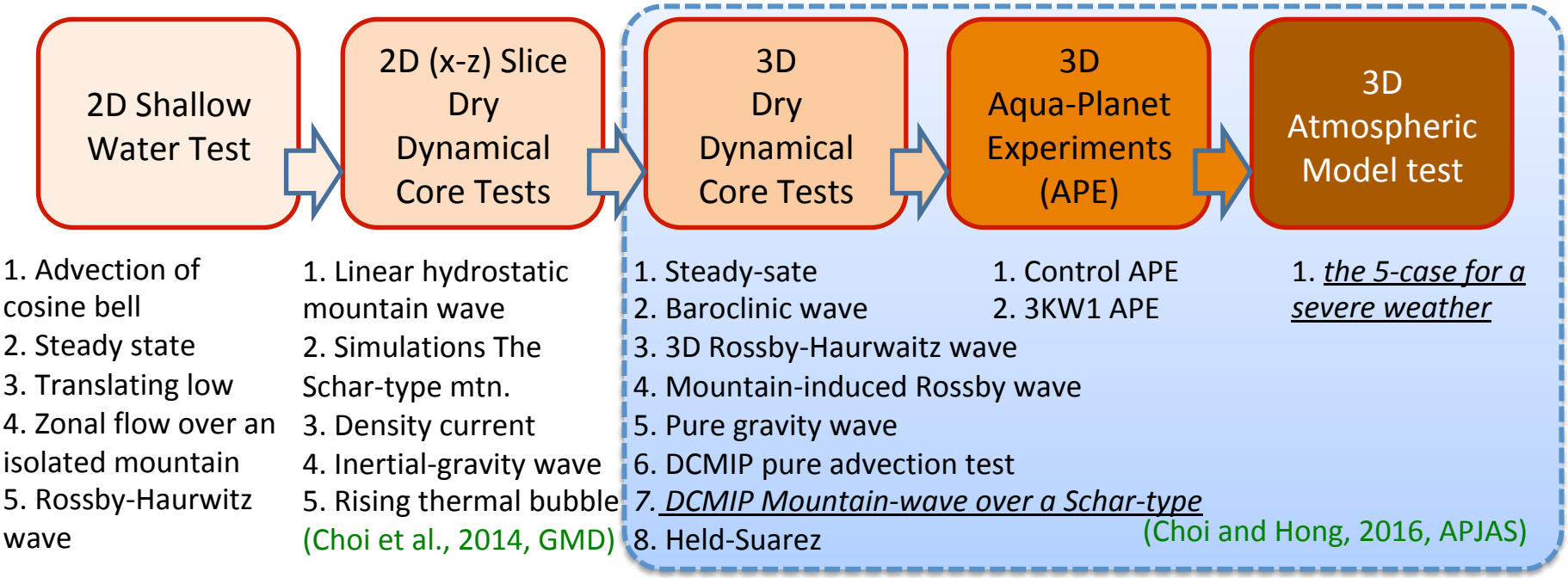
KIM was coded from scratch with major scientific elements extracted from previous developments or publications

Korean Integrated Model (KIM) system

Hong et al. (2018, Asia-Pac J. Atmos. Sci.)

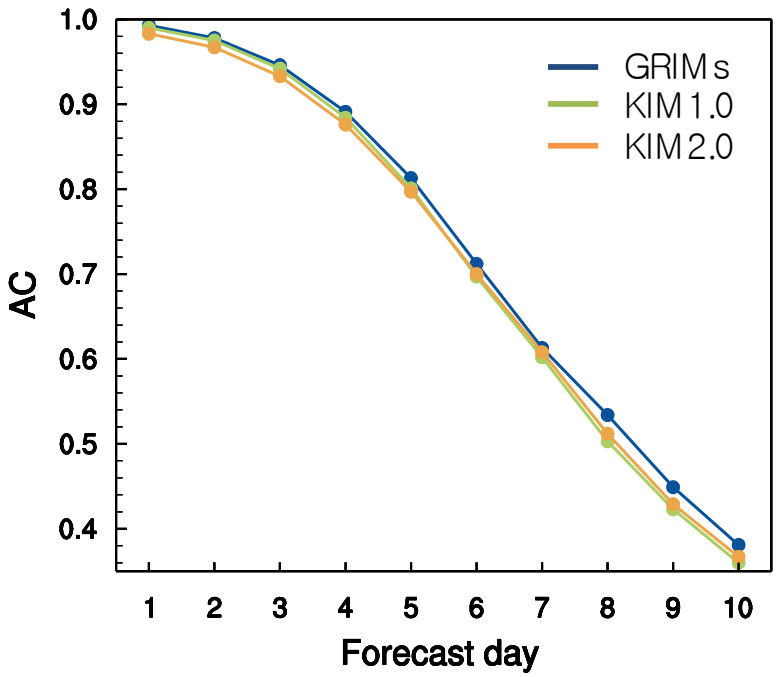
Dynamic core (non-hydrostatic over a cubed sphere)

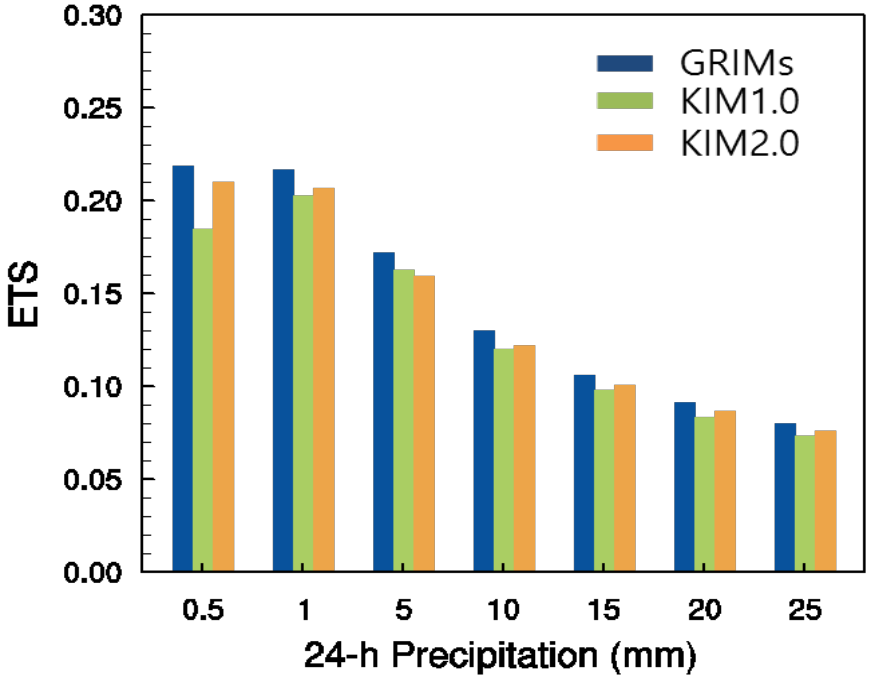
- Cubed sphere, horizontal: Spectral element, vertical: Finite difference
- Flux-type compressible governing equations
- Time-split temporal integration: Slow mode → third-order Runge-Kutta
  Horizontal sound wave and gravity wave → Forward-Backward
  vertical sound wave and buoyancy → implicit



Dynamics improvement (KIM 1.0 versus KIM 2.0)

CAM-SE **KIAPS 2015**



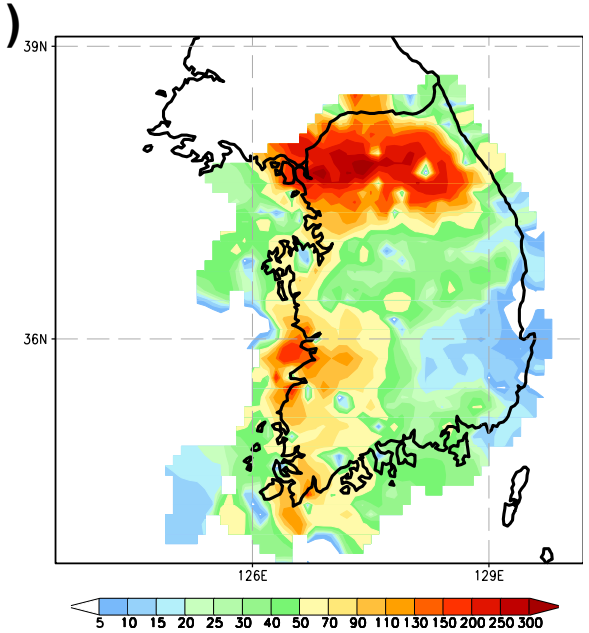


As a reference of GRIMs (spherical harmonics) and CAM-SE (corresponding hydr ostatic model), the KIM 2.0 (nonhydrostatic) core was successfully formulated an d coupled to physics package

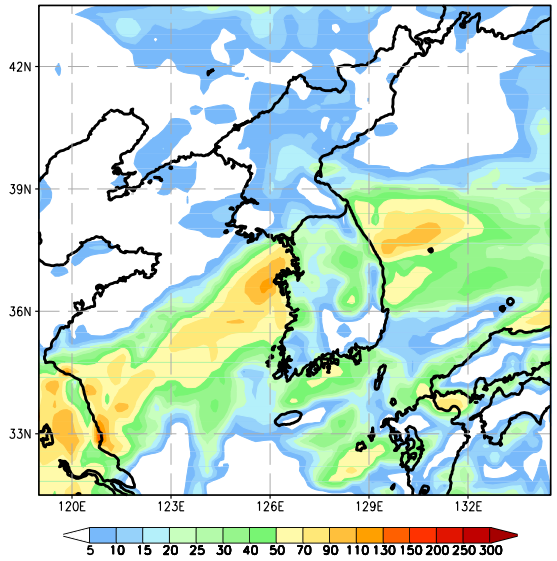
CPS (revision) : Advanced Physics

2006. 7. 13 – Heavy rainfall over Korea : WRF 27 km

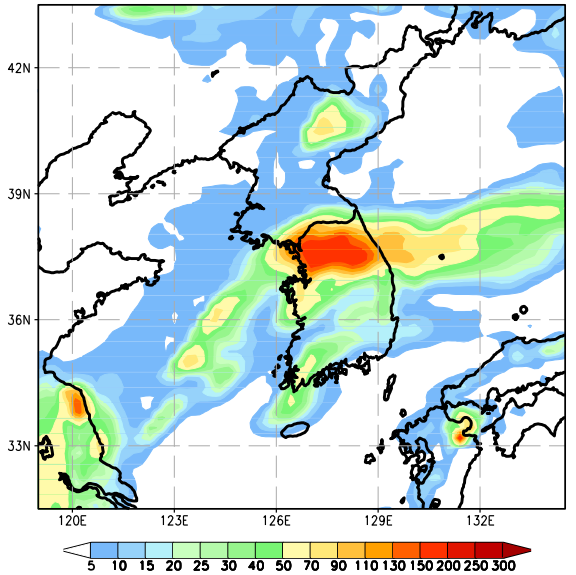
OBS



SAS (phys 1.0)



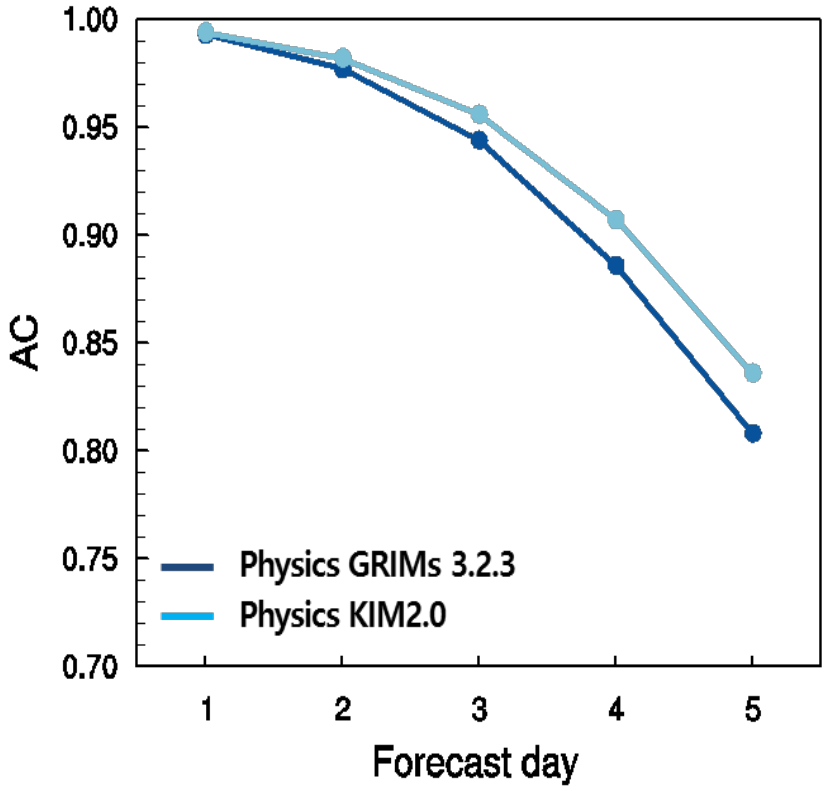
SAS (phys 2.0

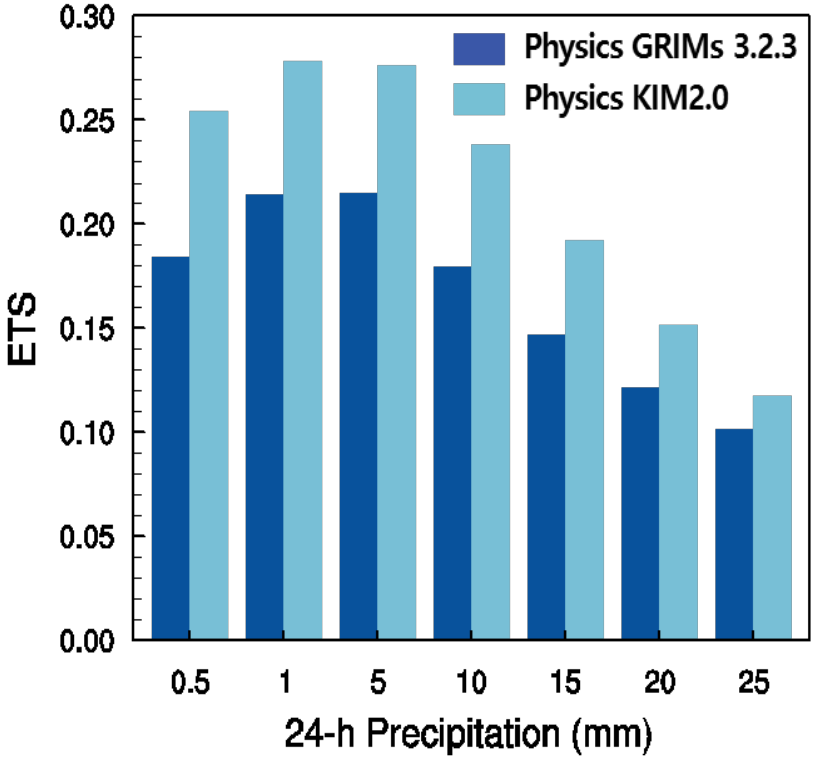


Daily precipitation was significantly improved by revising the triggering function of the simplified Arakawa-Schubert cumulus parameterization scheme (CPS) (Lim et al. 2014)

Physics improvement (GRIMS 3.2.3 versus KIM 2.0)

YSU 2013 KIAPS 2015





While KIM dycore and DA were being developed, physics modules had been improved in WRF and GRIMs platforms

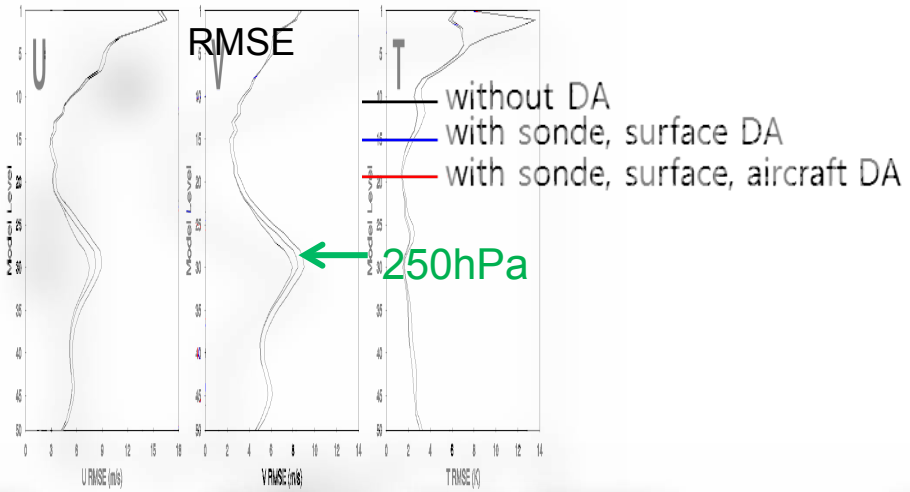
3DVAR over a cubed sphere : Song and Kwon (2015, MWR)

- Construction of Aircraft and AMSU-A data assimilation for 3DVAR system built on KIM (cubed sphere grid using real-observations)

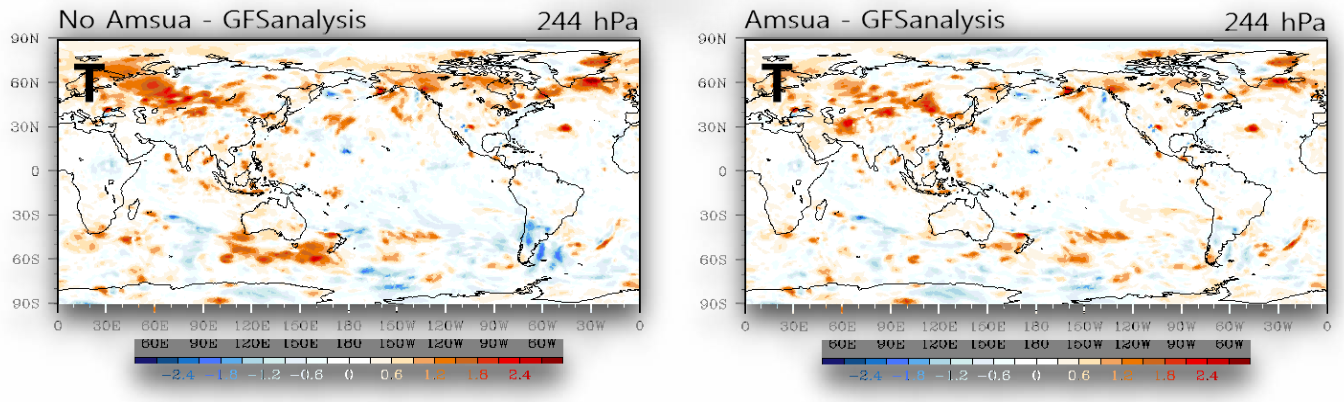
- Aircraft, AMSU-A: including I/O, tangent linear/adjoint observation operator
- For AMSU-A, the Jacobian matrix gained from the KPOP system is used for operator (brightness temperature temperature)

- **Results of 3DVAR system**

Aircraft
data assimilation



AMSU-A
data assimilation



Verification/Analysis : Testbeds

Model

KIM (Korean Integrated Model system)
reference models (GFS, UM, IFS)

Resolution

100 km – 12 km, 50 (0.3 hPa) to 91 (0.01 hPa)

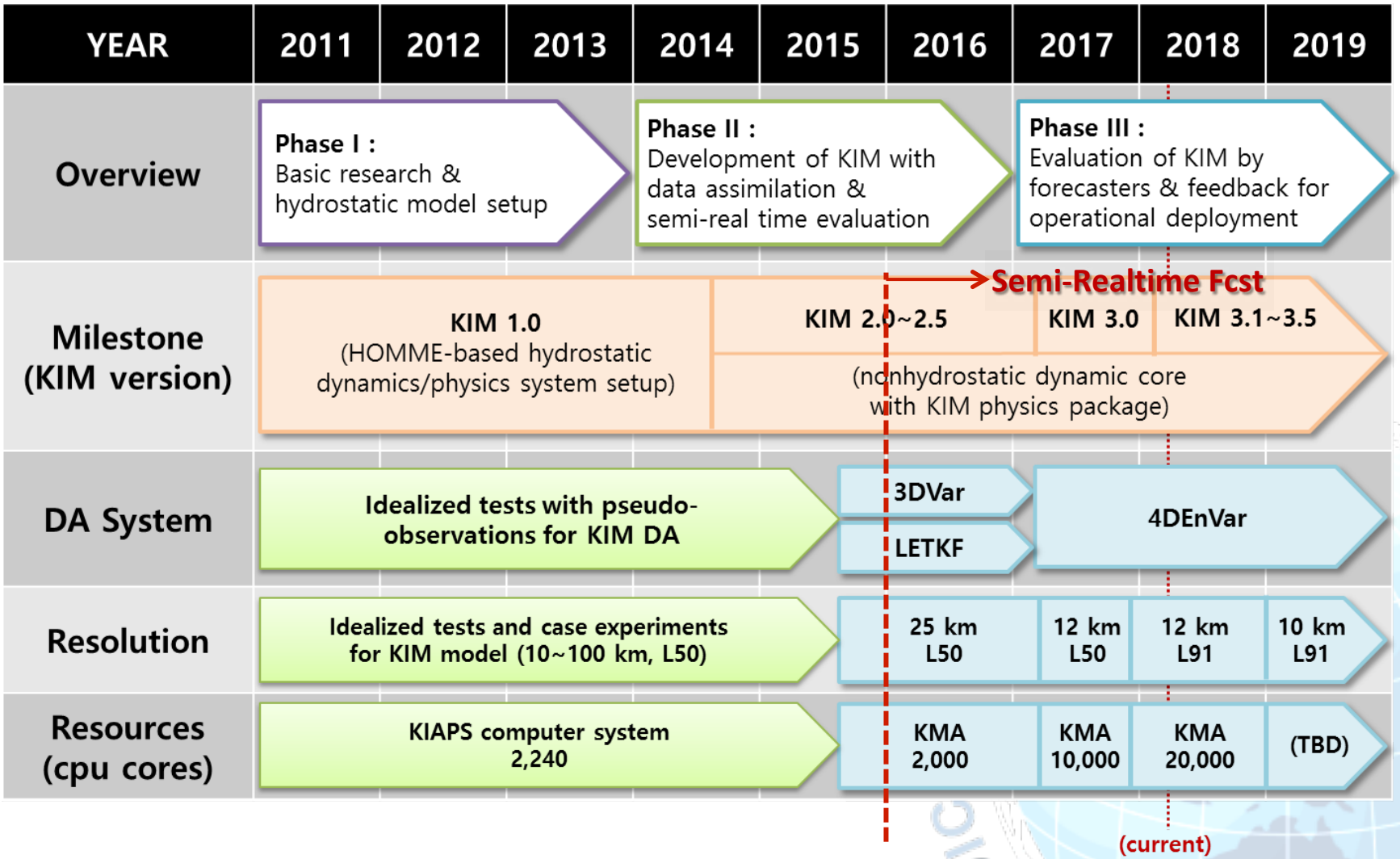
Testbeds

High-impact weather forecast
- Heavy-rainfall event
- Heavy-snowfall event
- Migratory cyclone event
- Typhoon Bolaven and Tembin
- Typhoon Sanba

Seasonal simulation
- 2013 JJA, 2013-2014 DJF
- 5 ensemble members

Medium-range forecast (10-day forecast)
- Skill evaluation : for July 2013, February 2014
  July-Aug-Sep 2017, Jan-Feb-Mar 2017

KIM History

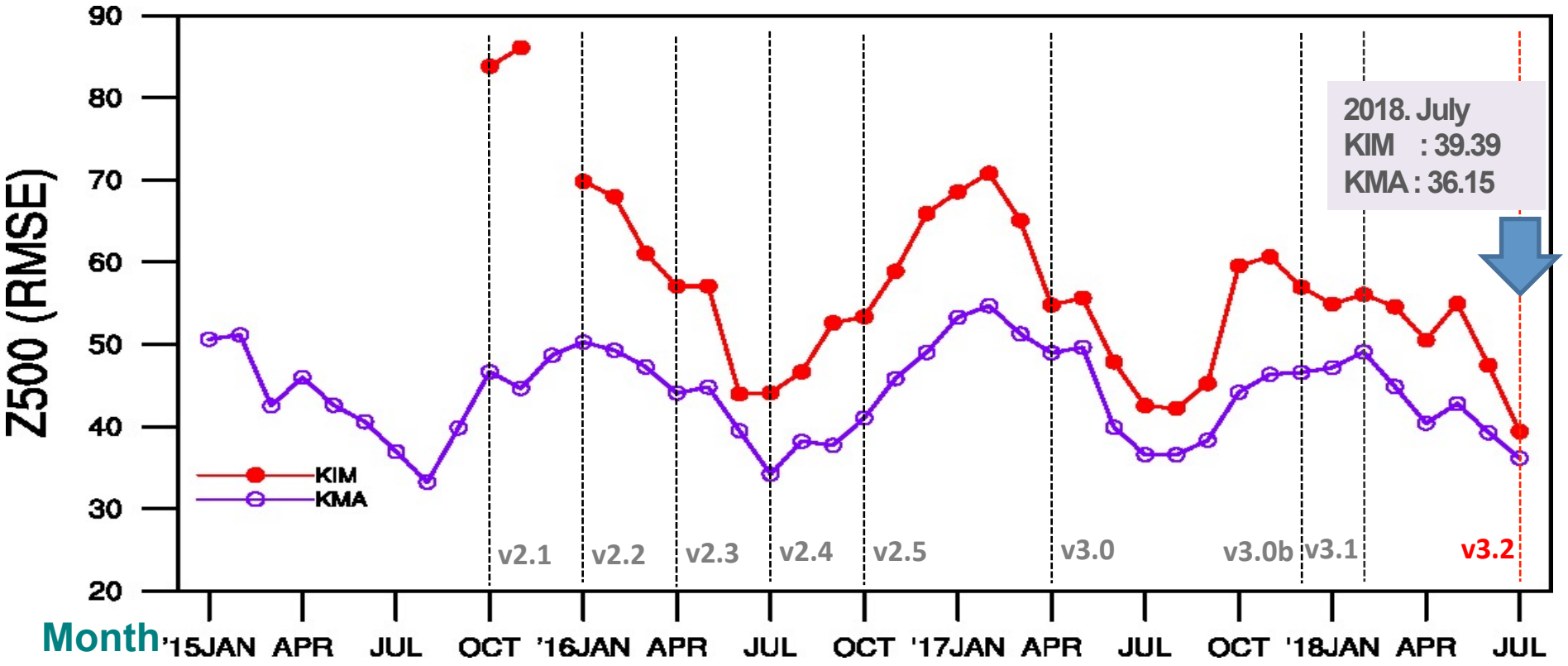

YEAR
2011
2012
2013
2014
2015
2016
2017
2018
2019
Overview
Phase I : Basic research & hydrostatic model setup
Phase II : Development of KIM with data assimilation & semi-real time evaluation
Phase III : Evaluation of KIM by forecasters & feedback for operational deployment
Milestone (KIM version)
KIM 1.0 (HOMME-based hydrostatic dynamics/physics system setup)
Semi-Realtime Fcst
KIM 2.0~2.5
KIM 3.0
KIM 3.1~3.5
(nonhydrostatic dynamic core with KIM physics package)
DA System
Idealized tests with pseudo-observations for KIM DA
3DVar
LETKF
4DEnVar
Resolution
Idealized tests and case experiments for KIM model (10~100 km, L50)
25 km L50
12 km L50
12 km L91
10 km L91
Resources (cpu cores)
KIAPS computer system 2,240
KMA 2,000
KMA 10,000
KMA 20,000
(TBD)
(current)

KIM physics packages (KIM 3.1, Feb. 2018)

Physics schemes		KIM 3.1	Remarks
Cumulus parameterization (CPS)		Han et al. (2016) Kwon and Hong (2017)	Routed in GFS CPS of GRIMs, but with the improved cloud microphysics and the inclusion of scale-aware functi on, names KSAS (gray-zone SAS)
Shallow convection (SCV)		Hong and Jang (2018)	Routed in Tiedtke SCV (Tiedtke 1989) of GRIMs, but with improved diffusivity, and triggering function
Cloud microphysics (MPS)		Hong et al. (2004) Bae et al. (2018)	Routed in WSM5 (Hong et al. 2004) of WRF, but with the inclusion of cloud properties in radiation package (Bae et al. 2016)
Radiation (RAD)		Baek (2017)	Routed in RRTMG (Iacono et al. 2008) of WRF, but with a newly developed unified RAD package
Cloudiness (CLD)		Park et al. (2016)	A newly developed prognostic cloudiness package based on the Tiedtke prognostic cloudiness (Tiedtke 1993)
Vertical diffusion (PBL)		Shin and Hong (2015) Lee et al. (2018)	Routed in YSU PBL (Hong et al. 2006, Hong 2010) of WRF, but with the inclusion of scale-aware function and st ratocumulus mixing
Aerosol chemistry (AER)		Choi et al. (2018)	A newly generated 3D aerosol data, based on IFS MACC 2D aerosol climatology
Orographic gravity wave drag (GWDo)		Choi and Hong (2015)	Routed in GWDo (Kim and Arakawa 1995, Hong et al. 2008) of GRIMs, but with the inclusion of orography block ing and anisotropy of mountains
No-mountain gravity wave drag (noGWDo)		Choi et al. (2018)	A newly developed source-based spectral non-orographic GWD, based on Choi and Chun (2011) and Richter et al. (2010).
Land surface layer (LSM)		Koo et al. (2017, 2018)	Routed in Noah 3.0 of GRIMs (Ek et al., 2002, Chen and Dudhia, 2000), but a revised snow physics and the incl usion of form drag
Ocean surface layer (OSM)		Kim and Hong (2010), Lee and Hong (2018)	Routed in GRIMs, but with the inclusion of salinity effect in latent heat flux computation

KIM Real time forecasts skill

NH 500 hPa geopotential height RMSE (+120h forecasts)

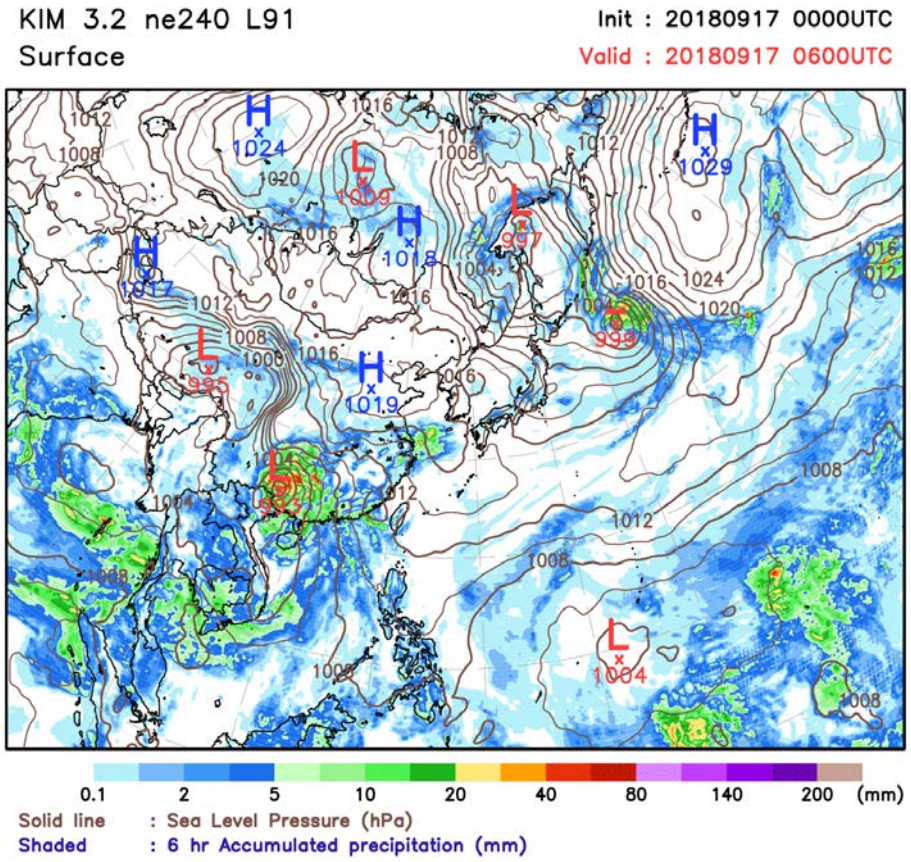


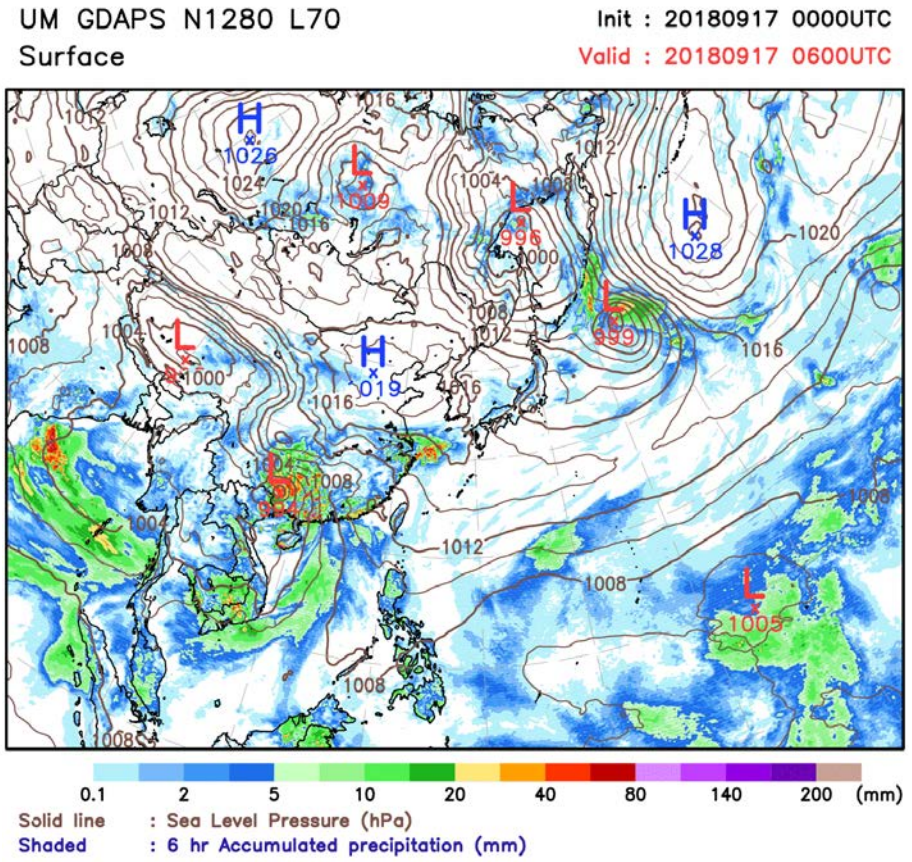
KIM: with own DA KMA: KMA-UM

Initial time : 2018. 09. 17. 00UTC

FCST : +6hr

KIM 3.2	KMA UM

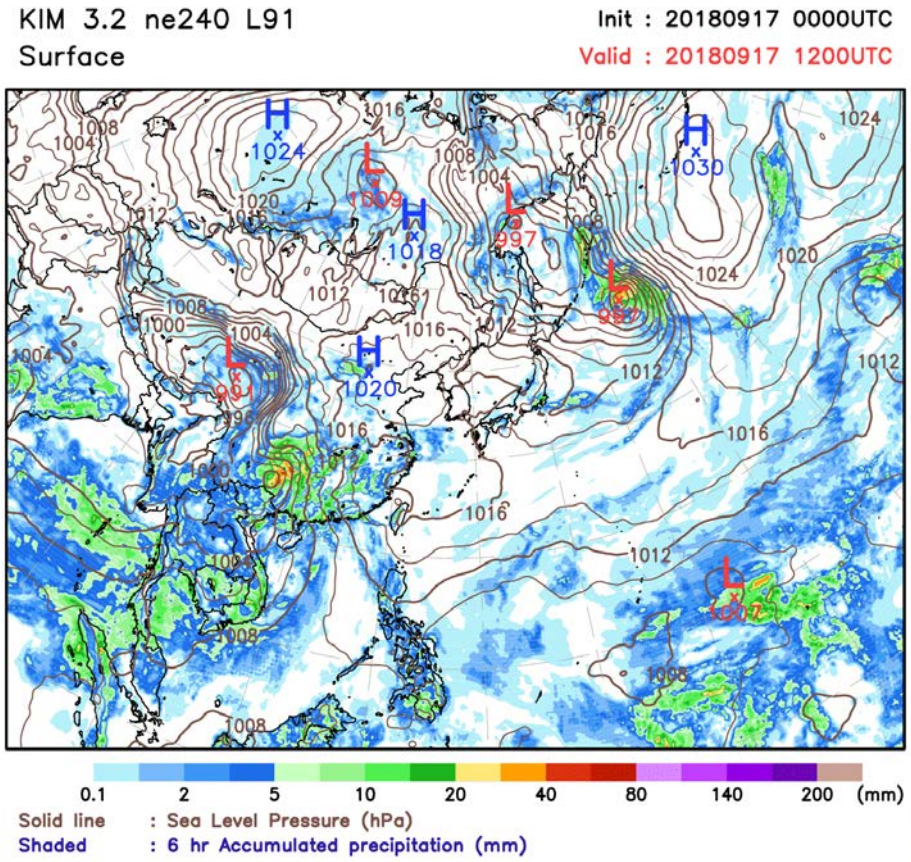


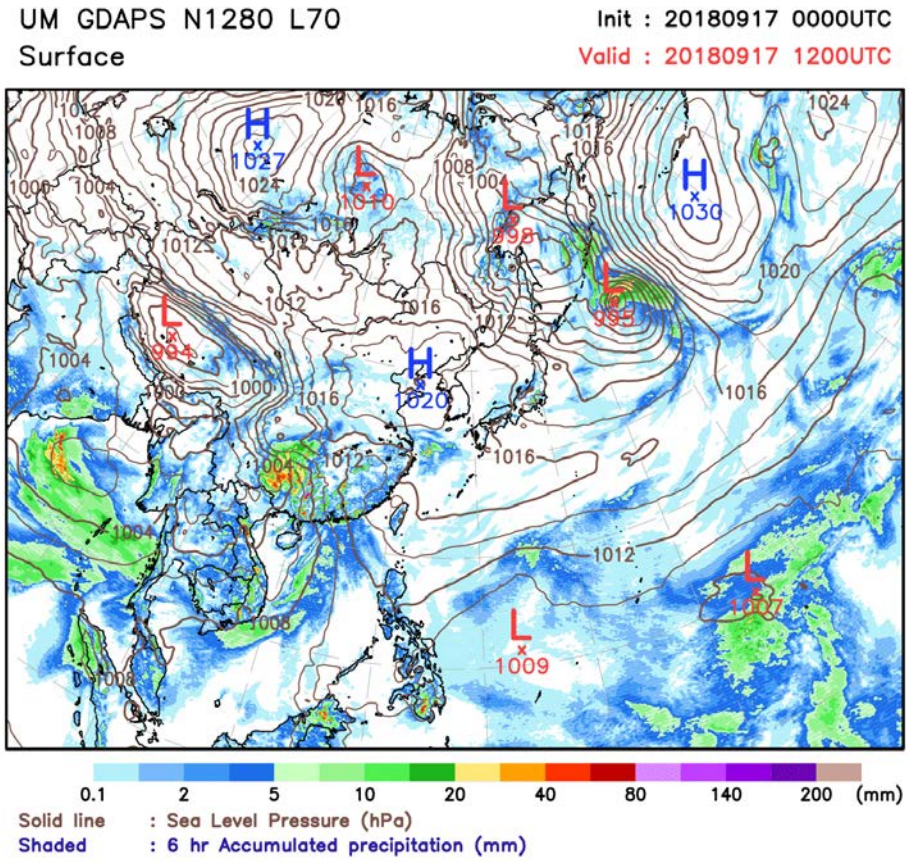


Initial time : 2018. 09. 17. 00UTC

FCST : +12hr

KIM 3.2	KMA UM

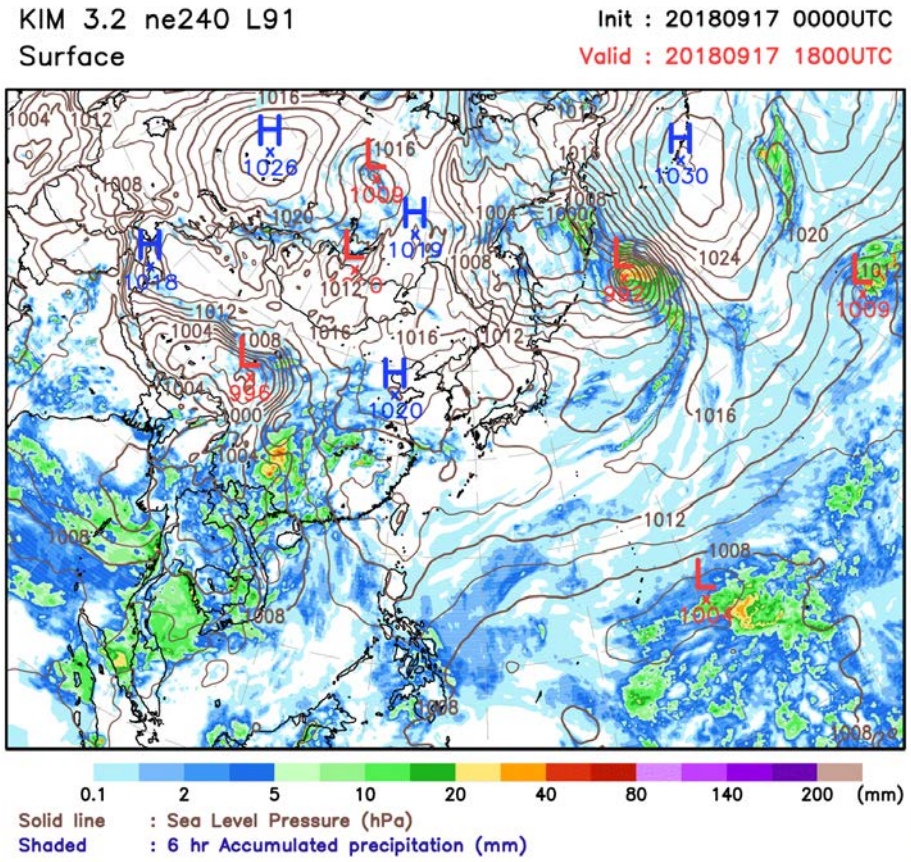


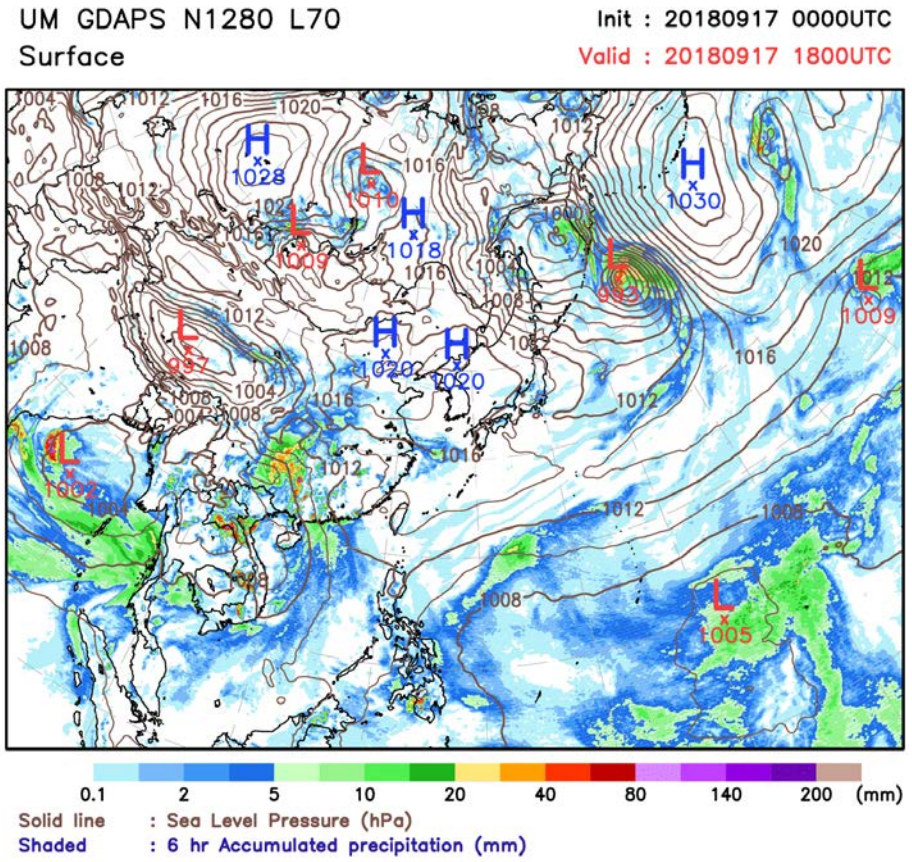


Initial time : 2018. 09. 17. 00UTC

FCST : +18hr

KIM 3.2	KMA UM

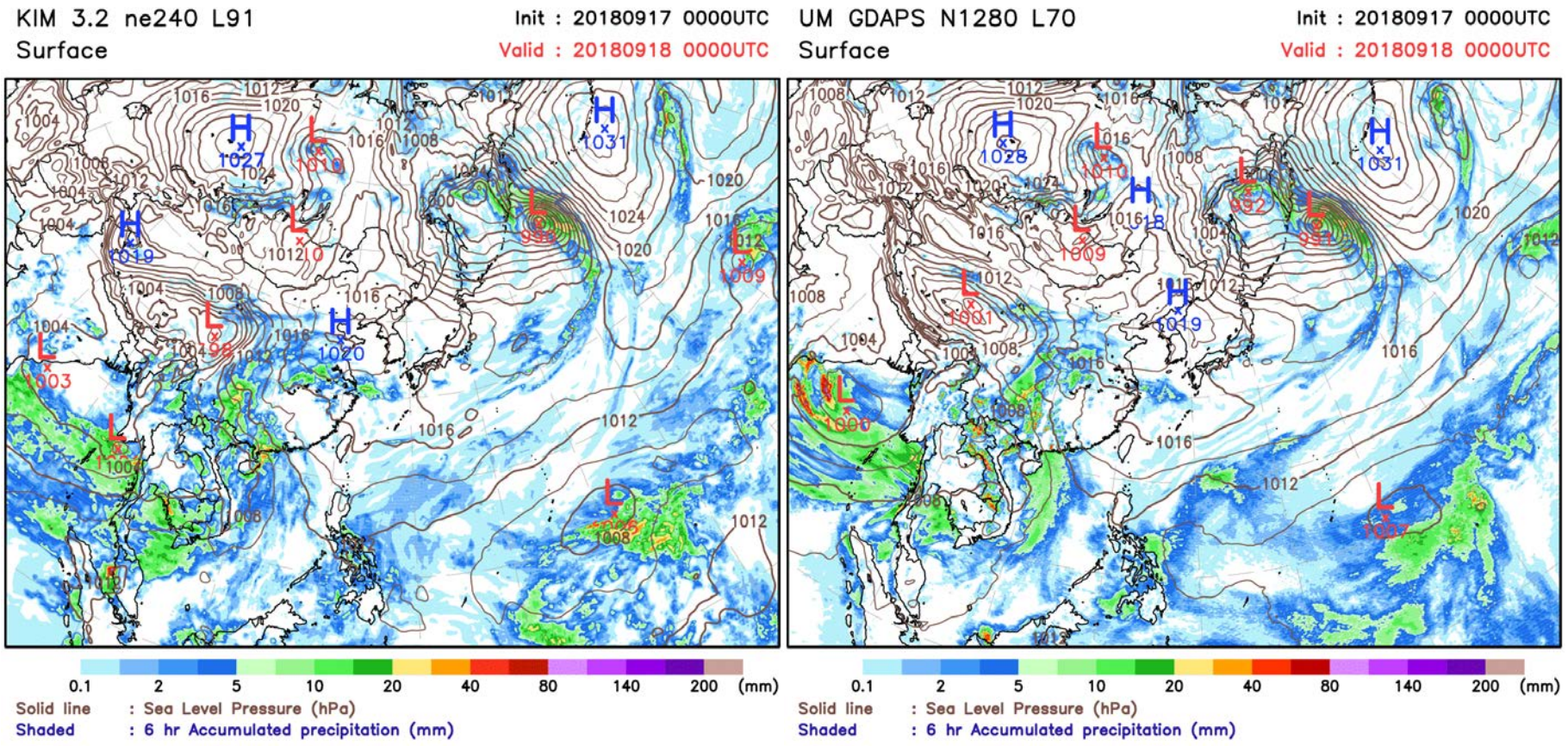




Initial time : 2018. 09. 17. 00UTC

FCST : +24hr

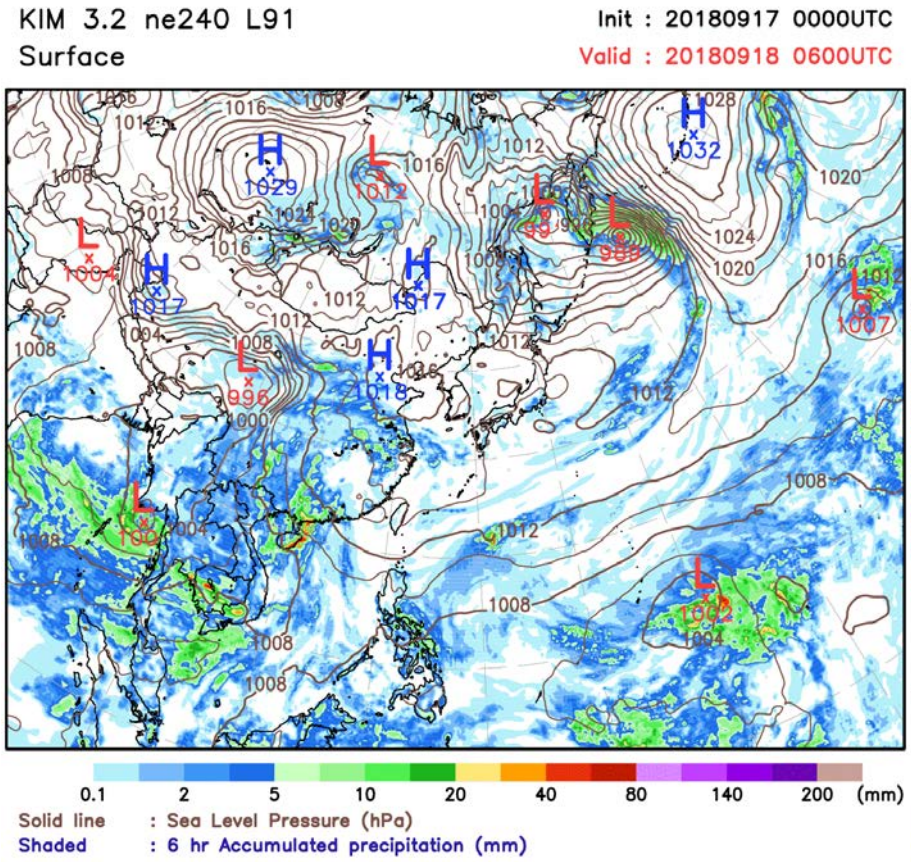
KIM 3.2	KMA UM

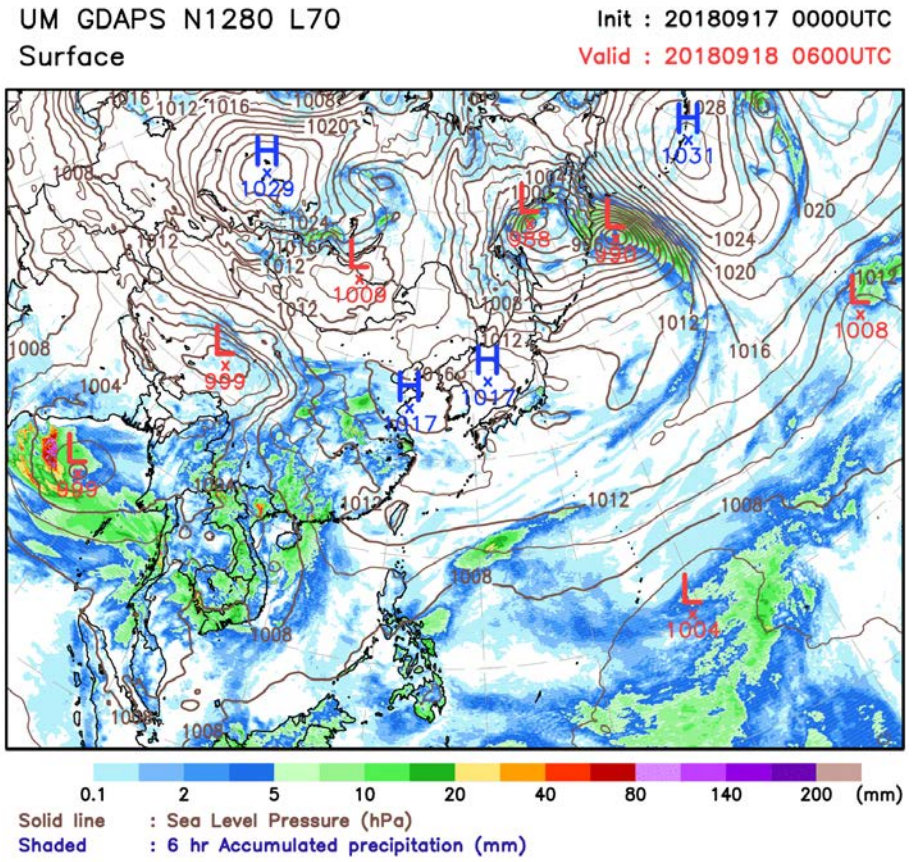


Initial time : 2018. 09. 17. 00UTC

FCST : +30hr

KIM 3.2	KMA UM



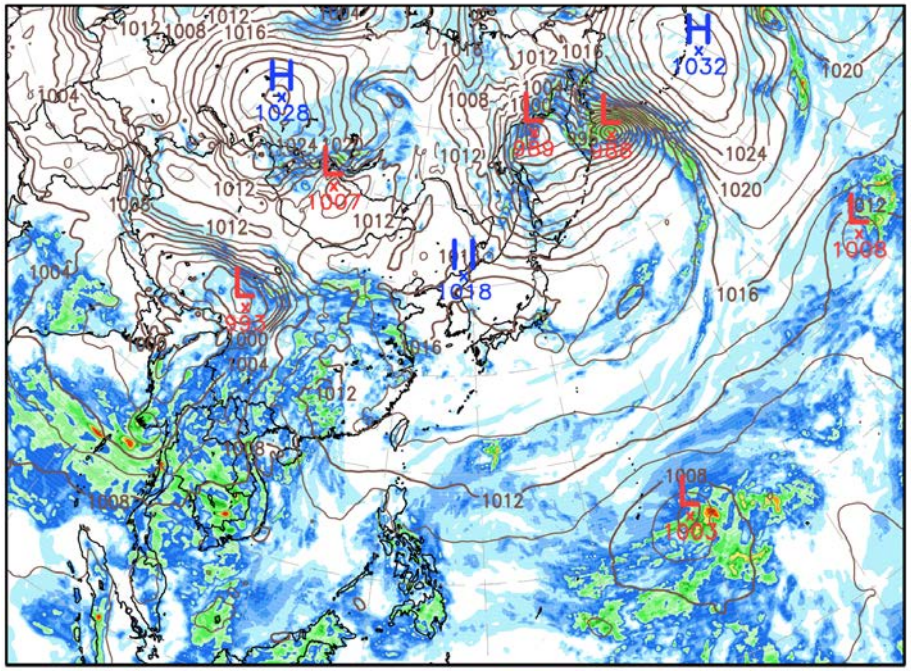


Initial time : 2018. 09. 17. 00UTC

FCST : +36hr

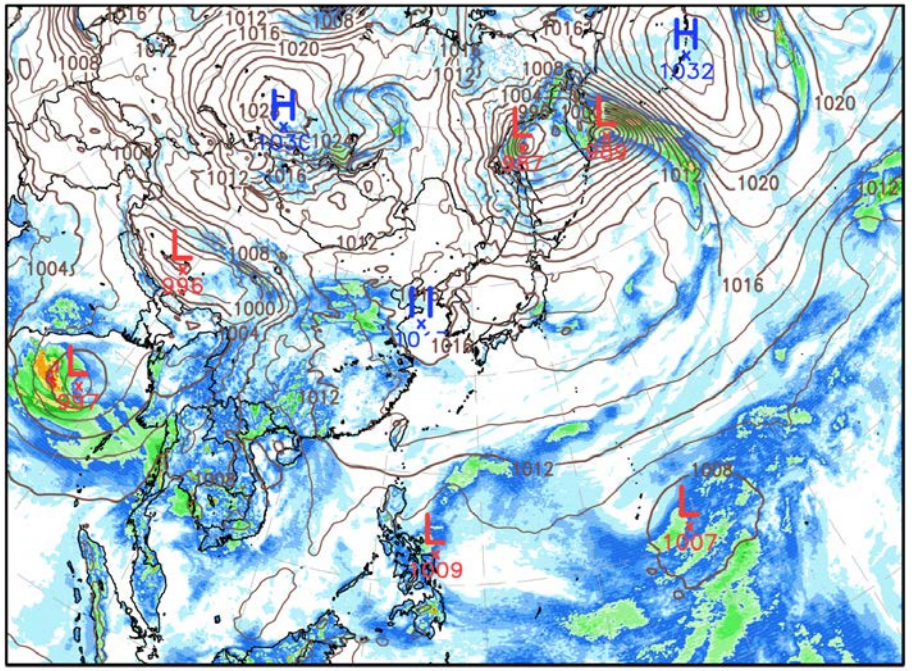
KIM 3.2	KMA UM

KIM 3.2 ne240 L91 Init : 20180917 0000UTC
Surface Valid : 20180918 1200UTC



0.1 2 5 10 20 40 80 140 200 (mm)
Solid line : Sea Level Pressure (hPa)
Shaded : 6 hr Accumulated precipitation (mm)

UM GDAPS N1280 L70 Init : 20180917 0000UTC
Surface Valid : 20180918 1200UTC

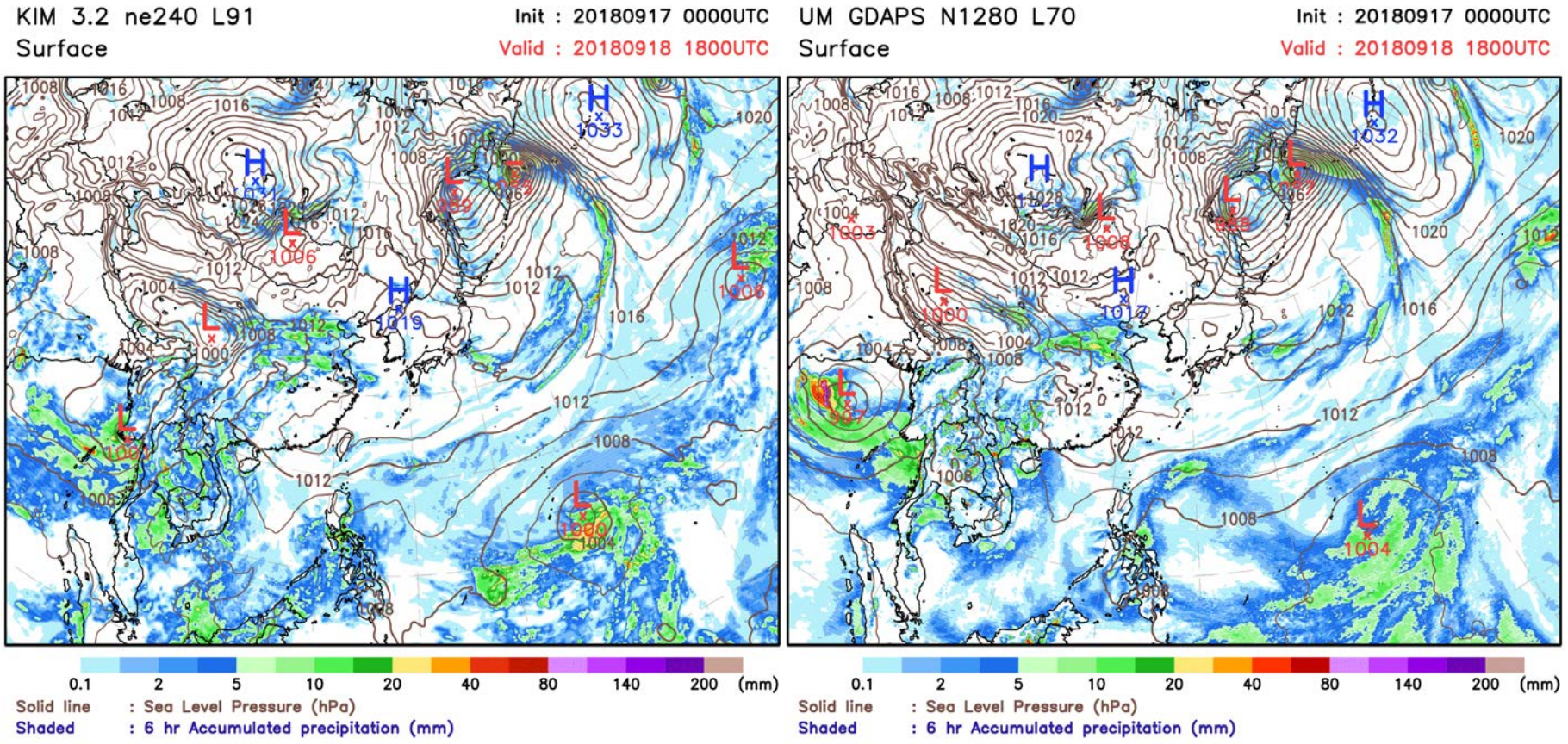


0.1 2 5 10 20 40 80 140 200 (mm)
Solid line : Sea Level Pressure (hPa)
Shaded : 6 hr Accumulated precipitation (mm)

Initial time : 2018. 09. 17. 00UTC

FCST : +42hr

KIM 3.2	KMA UM

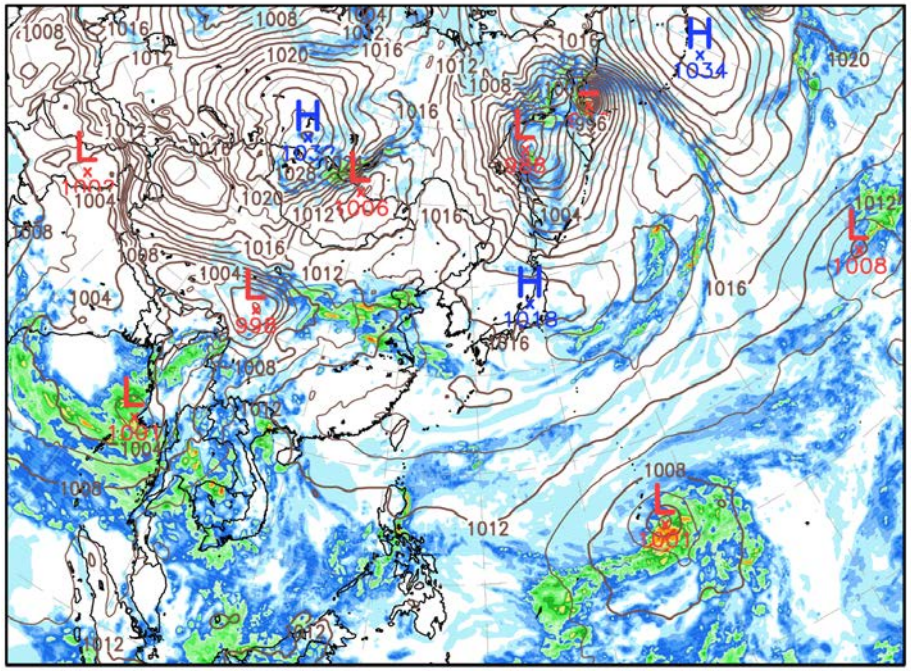


Initial time : 2018. 09. 17. 00UTC

FCST : +48hr

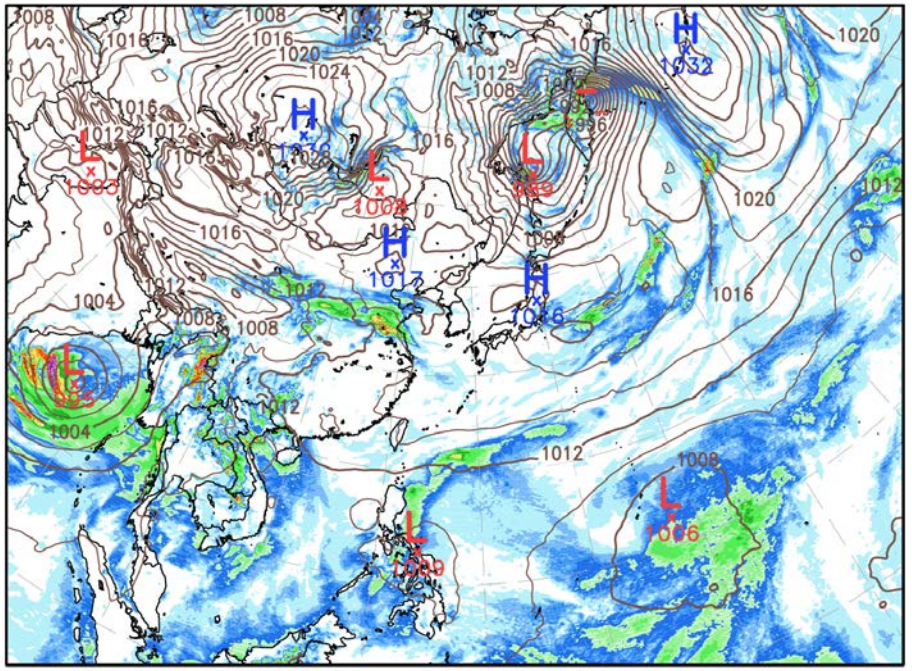
KIM 3.2	KMA UM

KIM 3.2 ne240 L91 Init : 20180917 0000UTC
Surface Valid : 20180919 0000UTC



0.1 2 5 10 20 40 80 140 200 (mm)
Solid line : Sea Level Pressure (hPa)
Shaded : 6 hr Accumulated precipitation (mm)

UM GDAPS N1280 L70 Init : 20180917 0000UTC
Surface Valid : 20180919 0000UTC

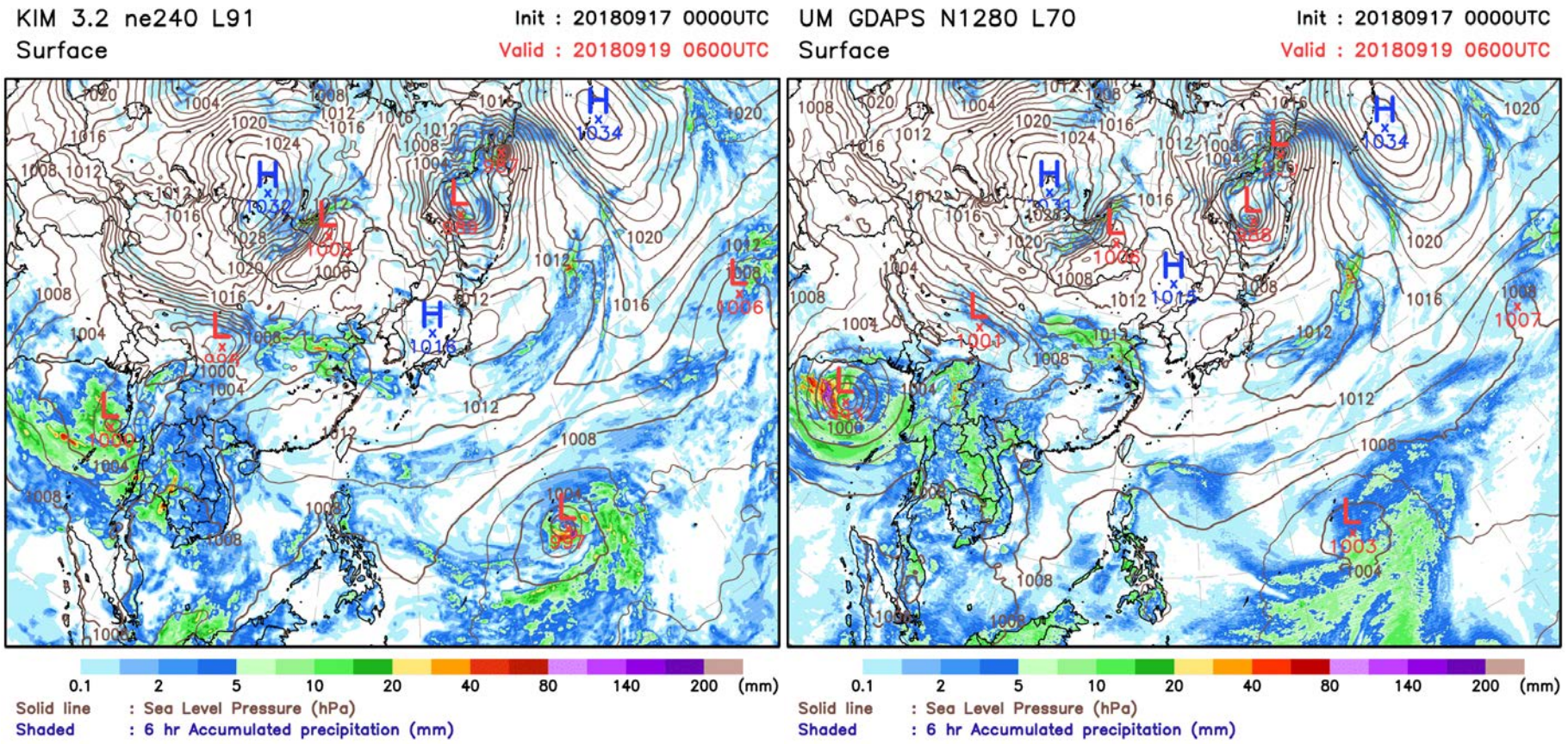


0.1 2 5 10 20 40 80 140 200 (mm)
Solid line : Sea Level Pressure (hPa)
Shaded : 6 hr Accumulated precipitation (mm)

Initial time : 2018. 09. 17. 00UTC

FCST : +54hr

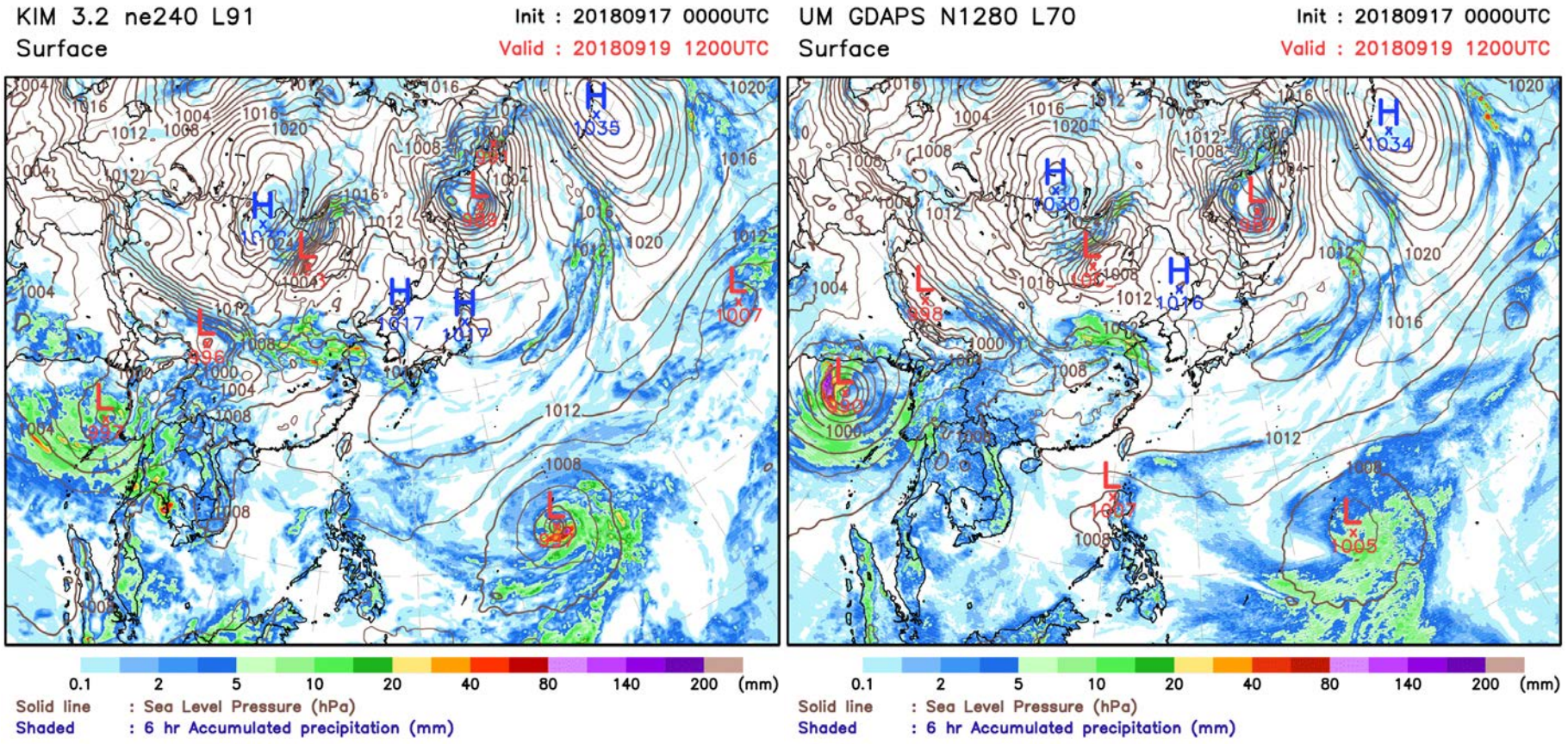
KIM 3.2	KMA UM



Initial time : 2018. 09. 17. 00UTC

FCST : +60hr

KIM 3.2	KMA UM

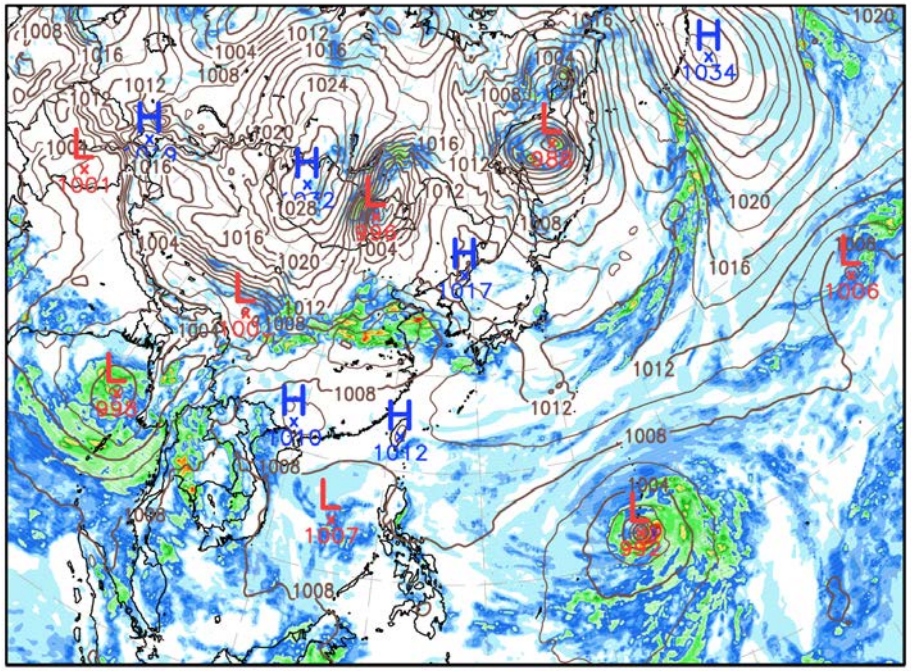


Initial time : 2018. 09. 17. 00UTC

FCST : +66hr

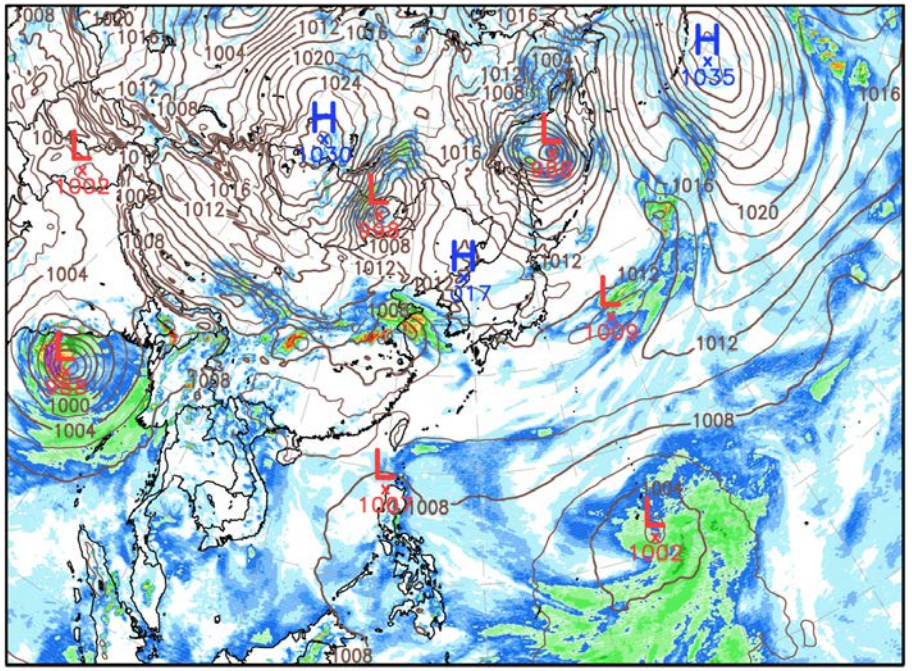
KIM 3.2	KMA UM

KIM 3.2 ne240 L91 Init : 20180917 0000UTC
Surface Valid : 20180919 1800UTC



0.1 2 5 10 20 40 80 140 200 (mm)
Solid line : Sea Level Pressure (hPa)
Shaded : 6 hr Accumulated precipitation (mm)

UM GDAPS N1280 L70 Init : 20180917 0000UTC
Surface Valid : 20180919 1800UTC

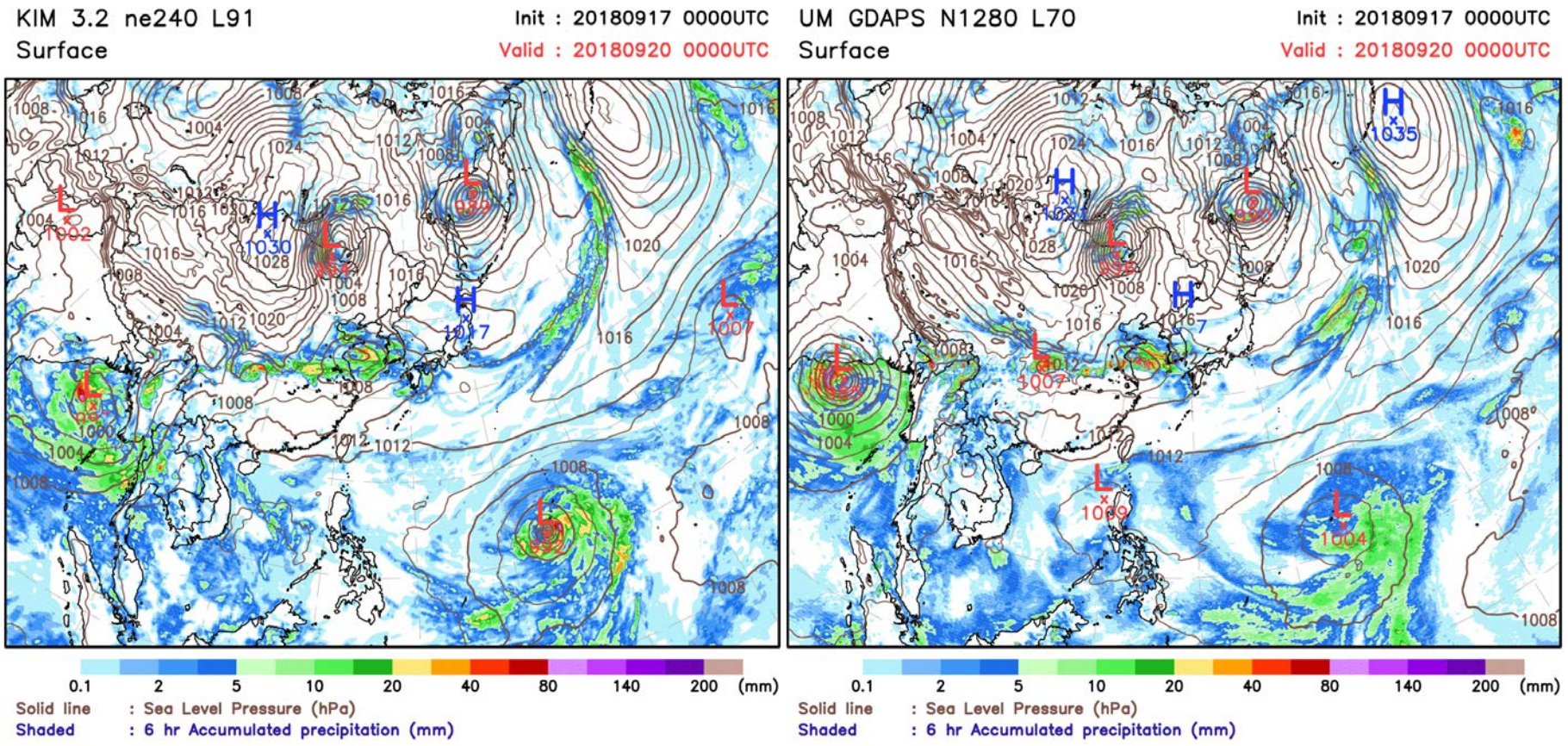


0.1 2 5 10 20 40 80 140 200 (mm)
Solid line : Sea Level Pressure (hPa)
Shaded : 6 hr Accumulated precipitation (mm)

Initial time : 2018. 09. 17. 00UTC

FCST : +72hr

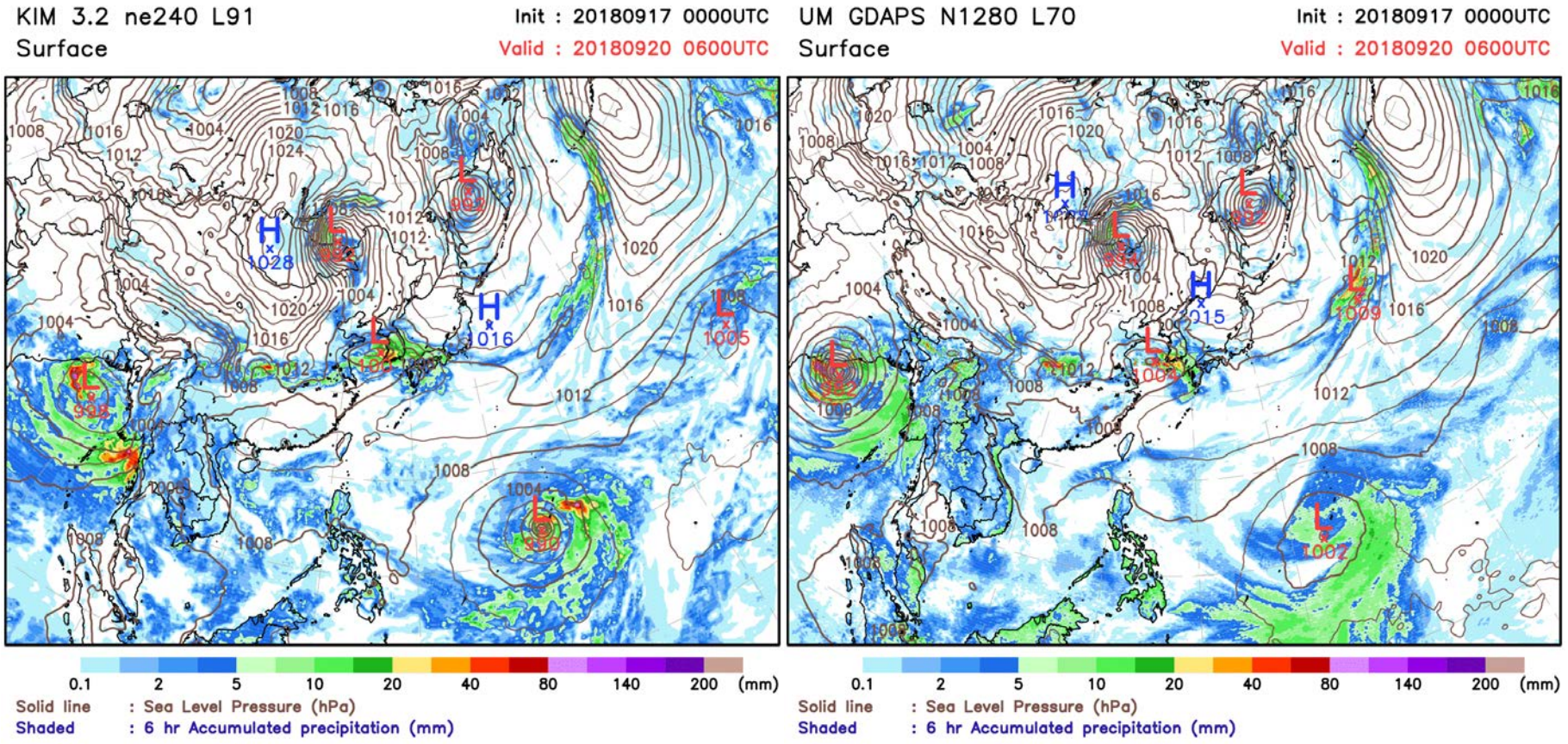
KIM 3.2	KMA UM



Initial time : 2018. 09. 17. 00UTC

FCST : +78hr

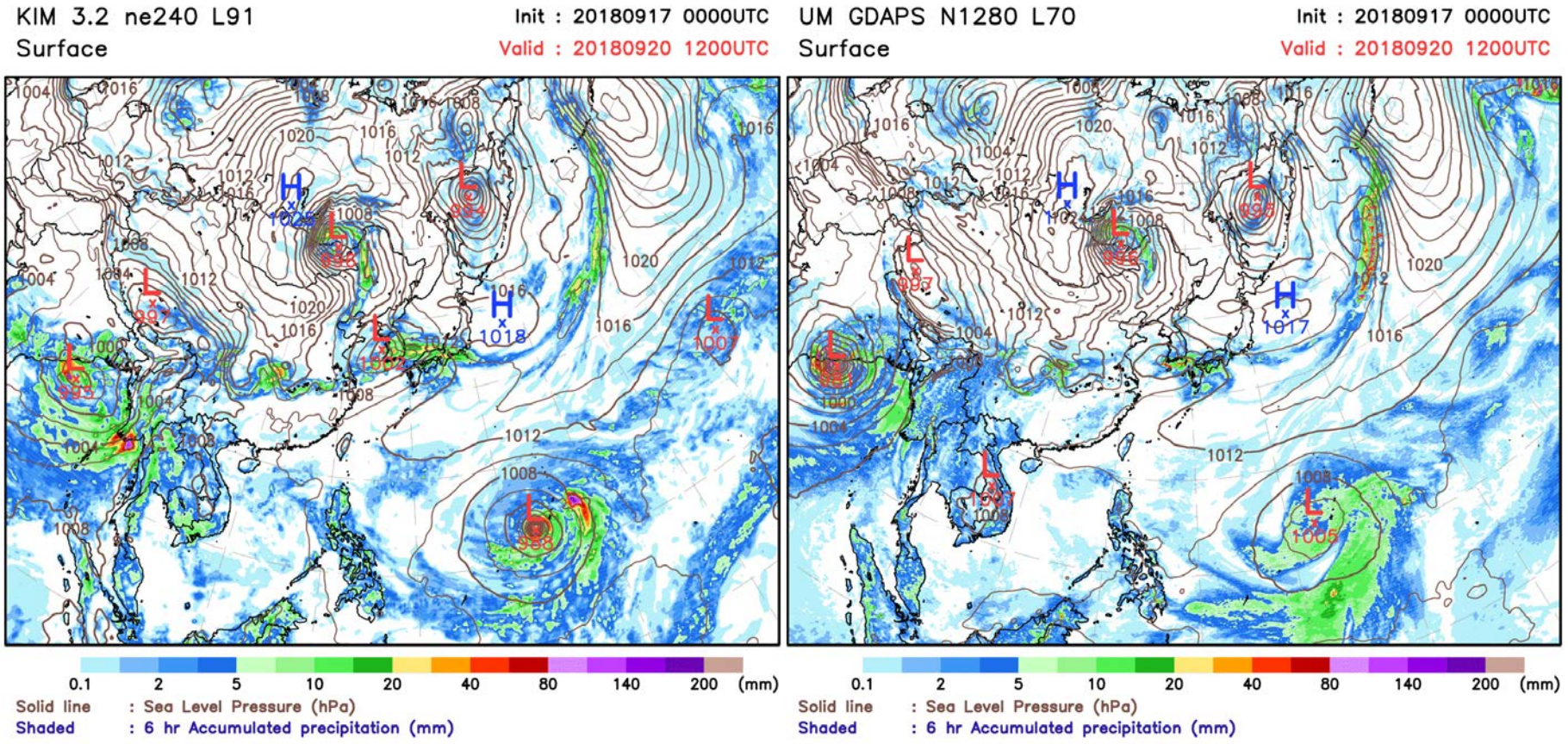
KIM 3.2	KMA UM



Initial time : 2018. 09. 17. 00UTC

FCST : +84hr

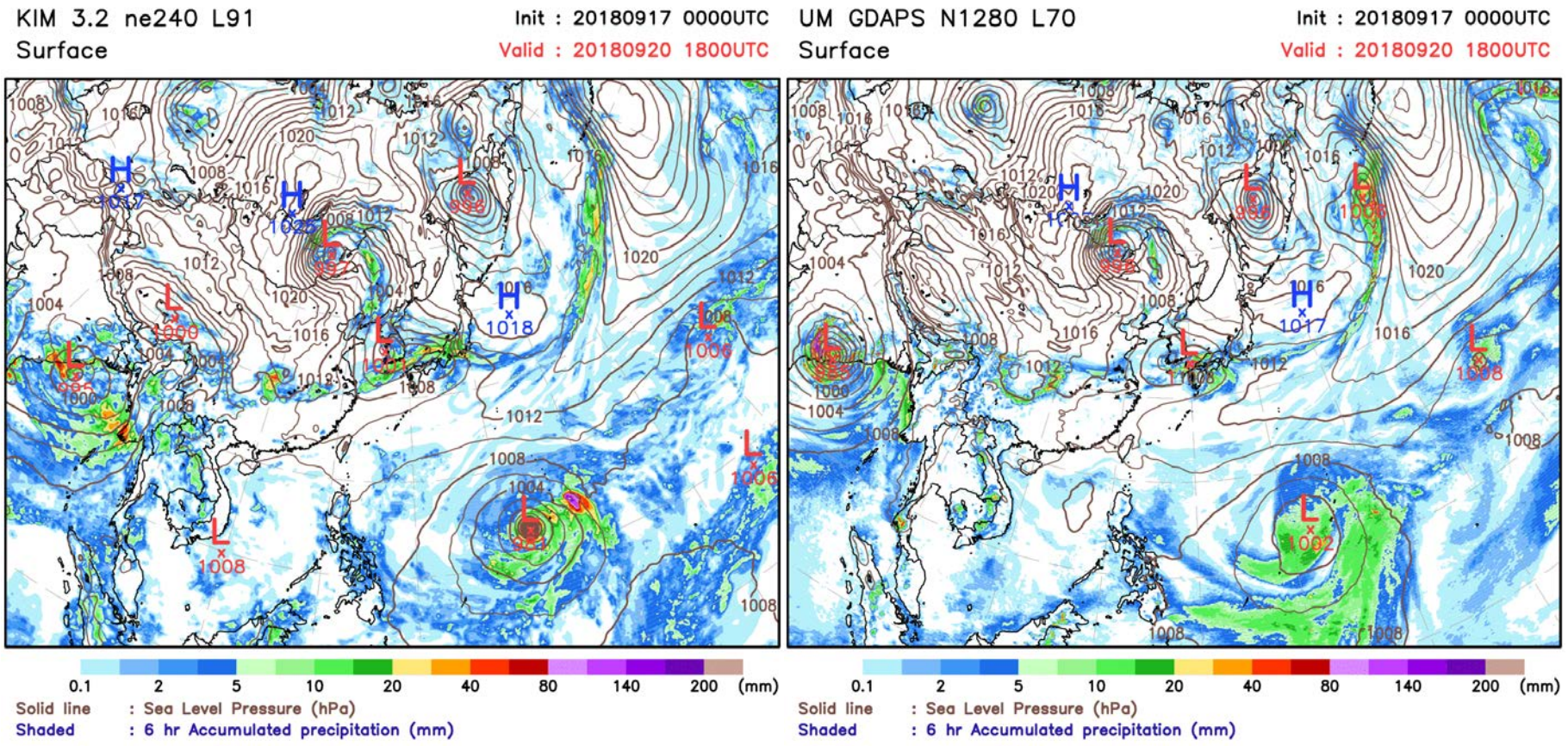
KIM 3.2	KMA UM



Initial time : 2018. 09. 17. 00UTC

FCST : +90hr

KIM 3.2	KMA UM

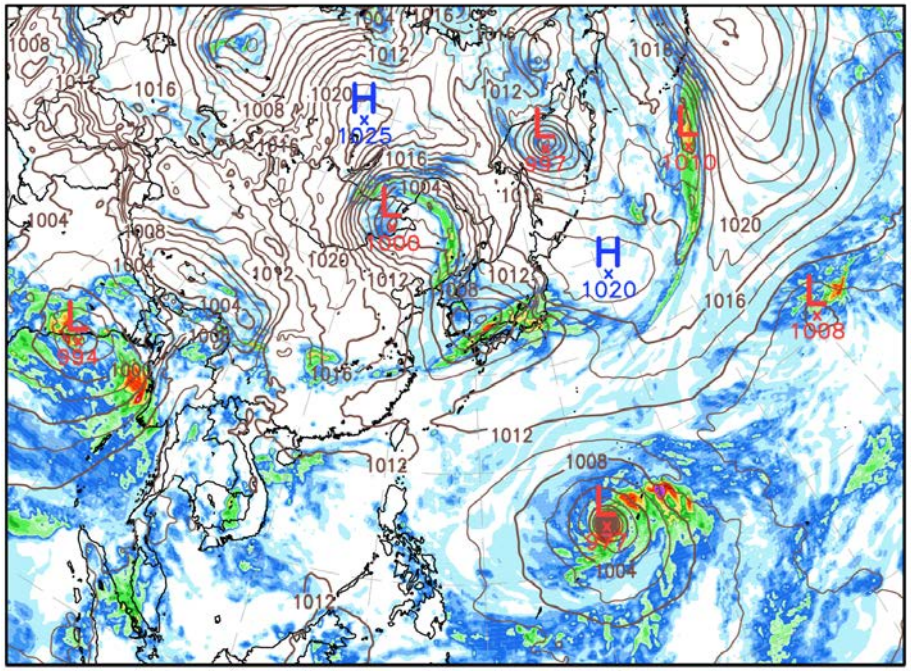


Initial time : 2018. 09. 17. 00UTC

FCST : +96hr

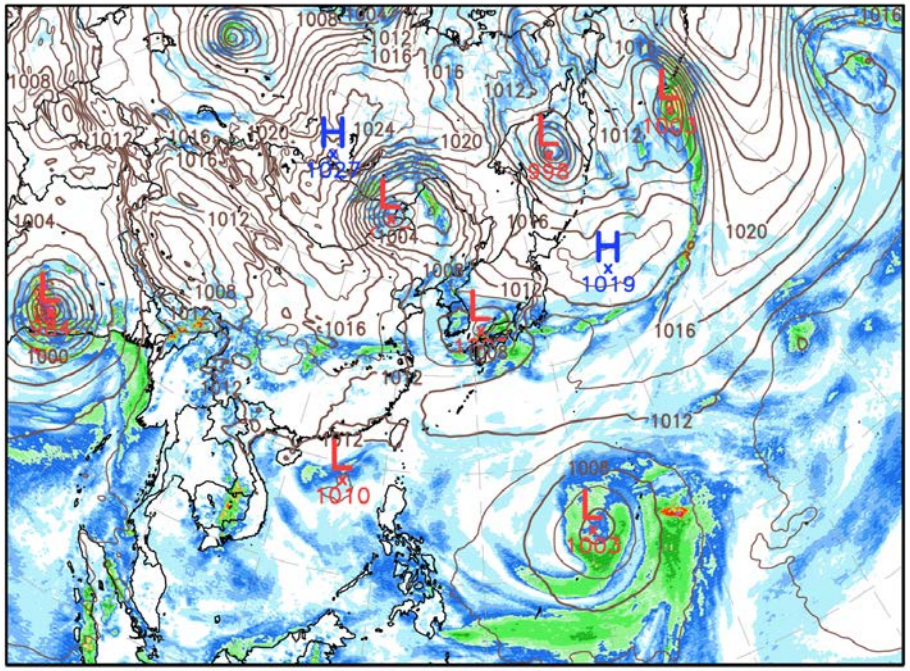
KIM 3.2	KMA UM

KIM 3.2 ne240 L91 — Init : 20180917 0000UTC
Surface — Valid : 20180921 0000UTC



0.1 2 5 10 20 40 80 140 200 (mm)
Solid line : Sea Level Pressure (hPa)
Shaded : 6 hr Accumulated precipitation (mm)

UM GDAPS N1280 L70 — Init : 20180917 0000UTC
Surface — Valid : 20180921 0000UTC

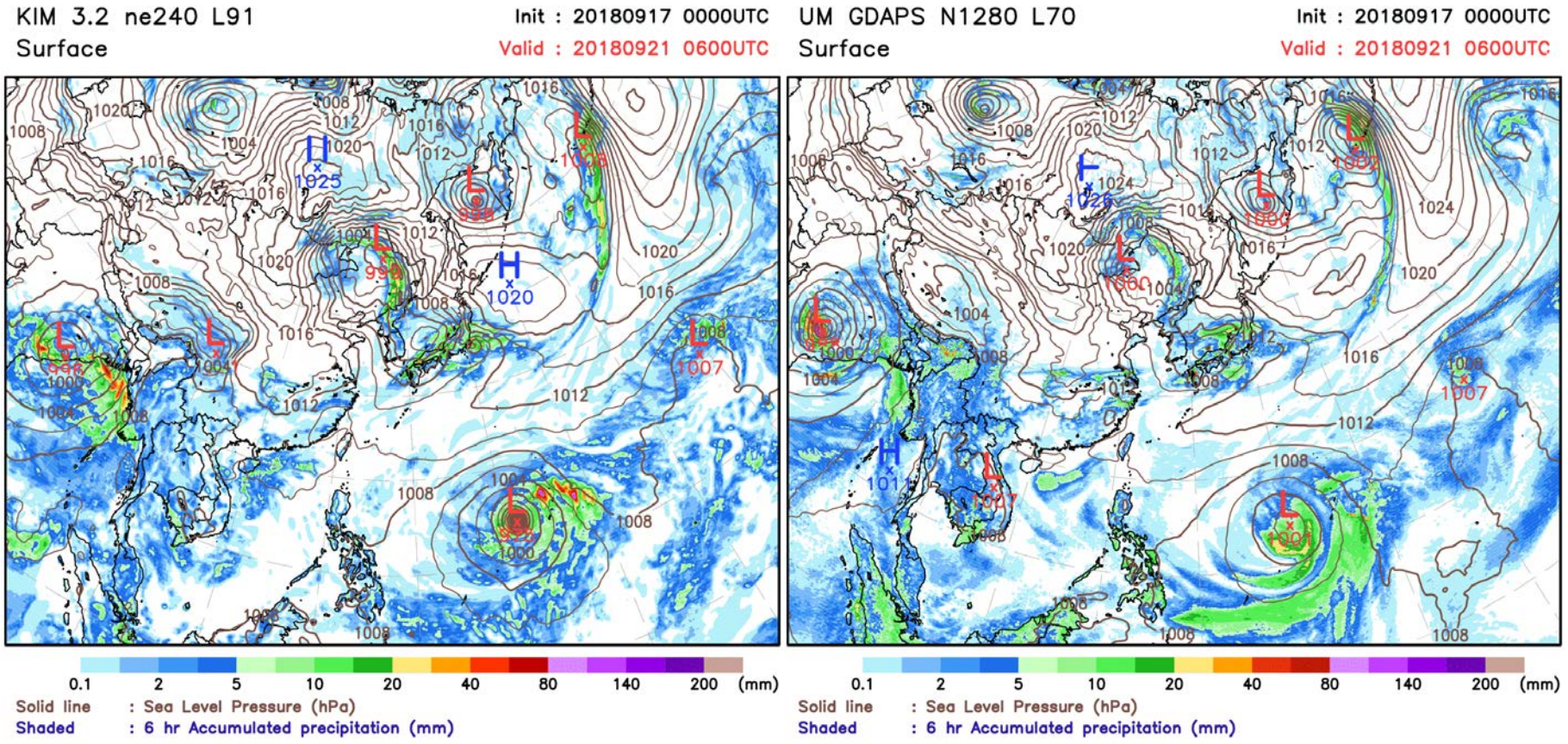


0.1 2 5 10 20 40 80 140 200 (mm)
Solid line : Sea Level Pressure (hPa)
Shaded : 6 hr Accumulated precipitation (mm)

Initial time : 2018. 09. 17. 00UTC

FCST : +102hr

KIM 3.2	KMA UM

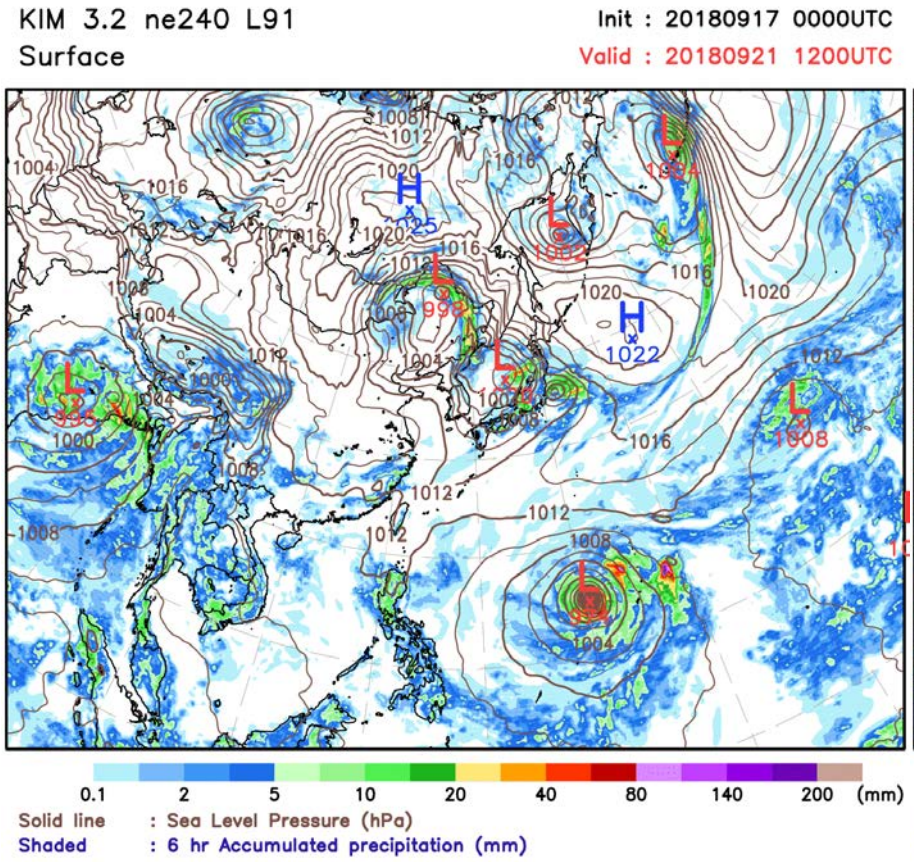


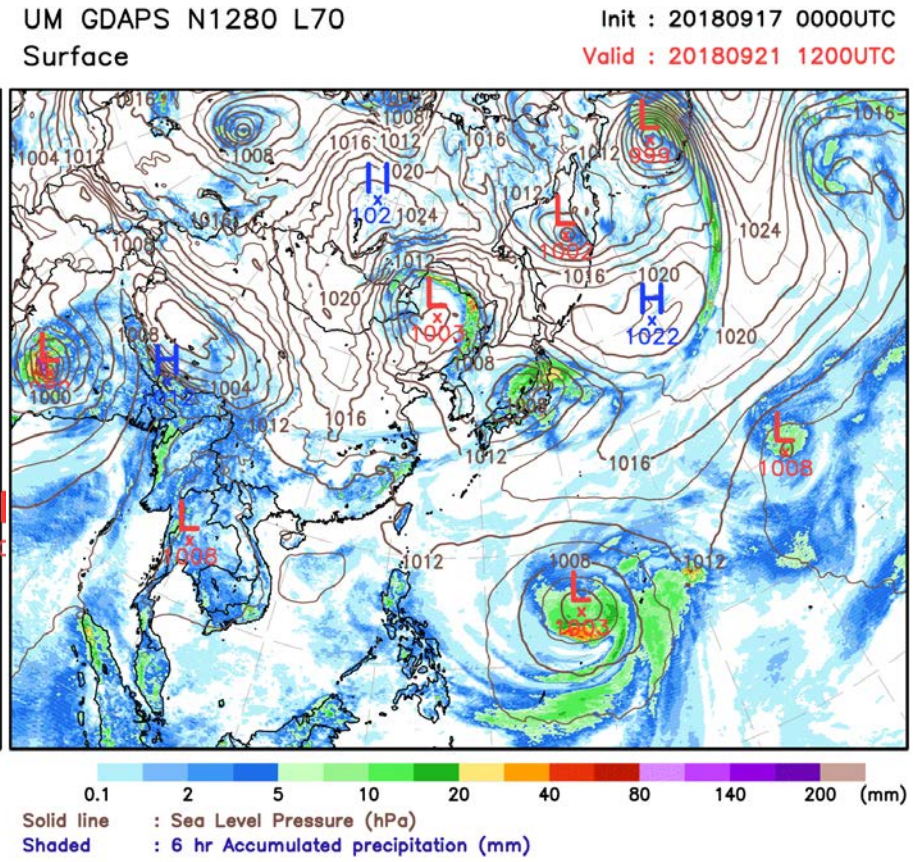
Initial time : 2018. 09. 17. 00UTC

FCST : +108hr

KIM 3.2

KMA
UM





Initial time : 2018. 09. 17. 00UTC

FCST : +114hr

KIM 3.2	KMA UM