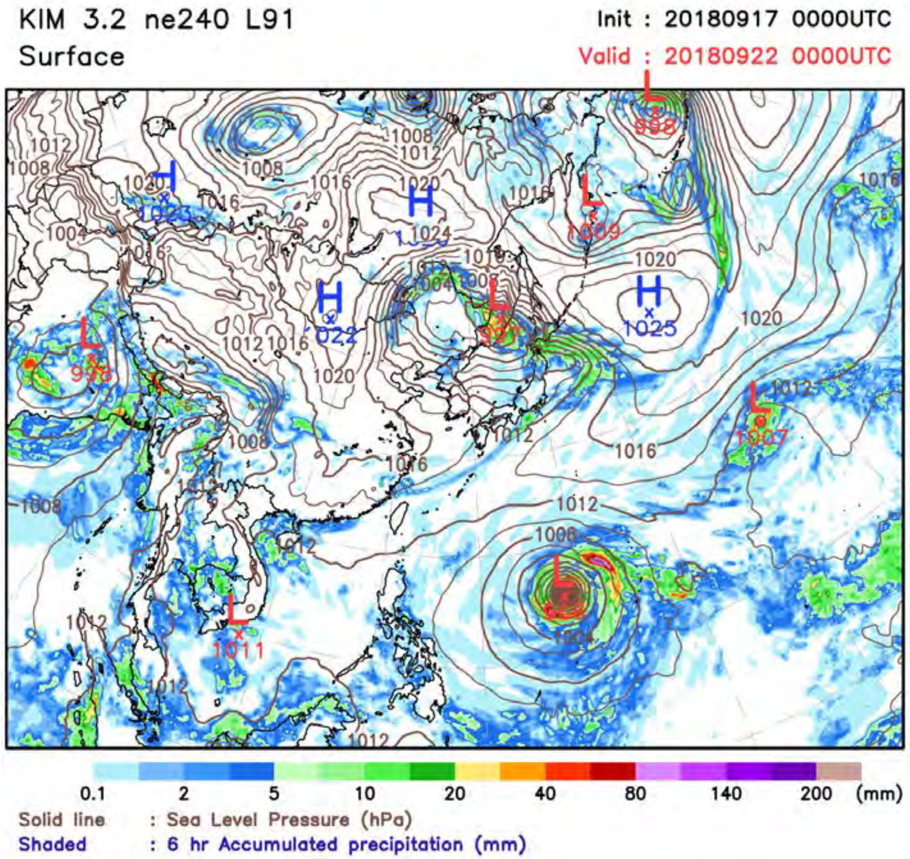
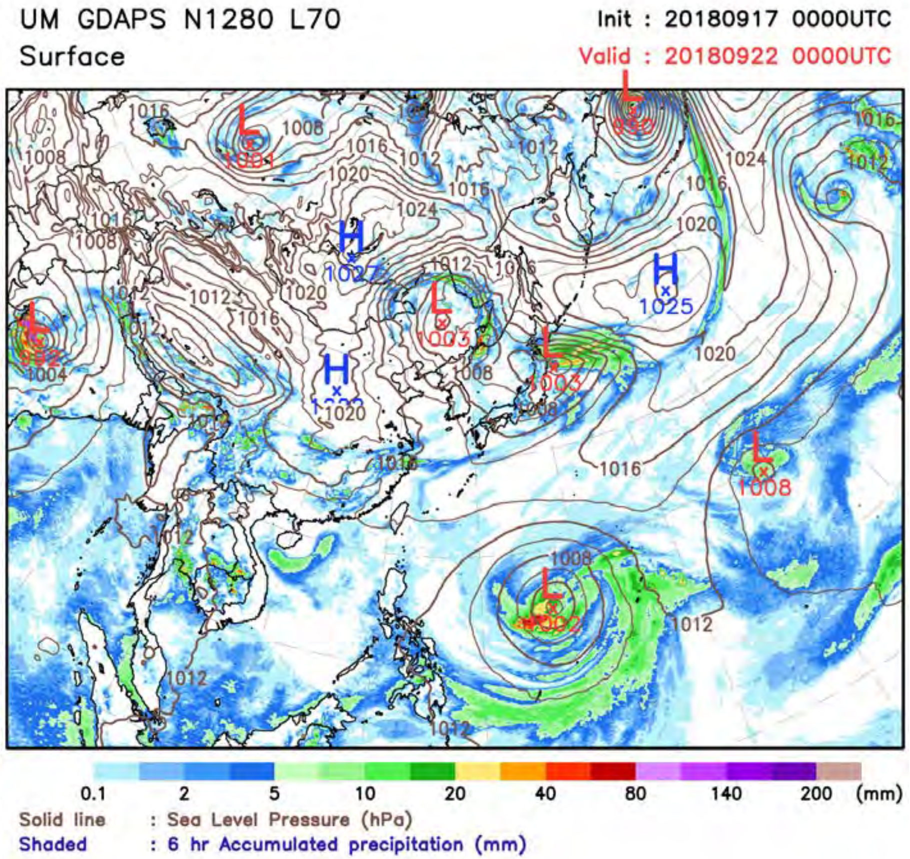
Initial time : 2018. 09. 17. 00UTC

FCST : +120hr

KIM 3.2

KMA UM





Initial time : 2018. 09. 17. 00UTC

FCST : +126hr

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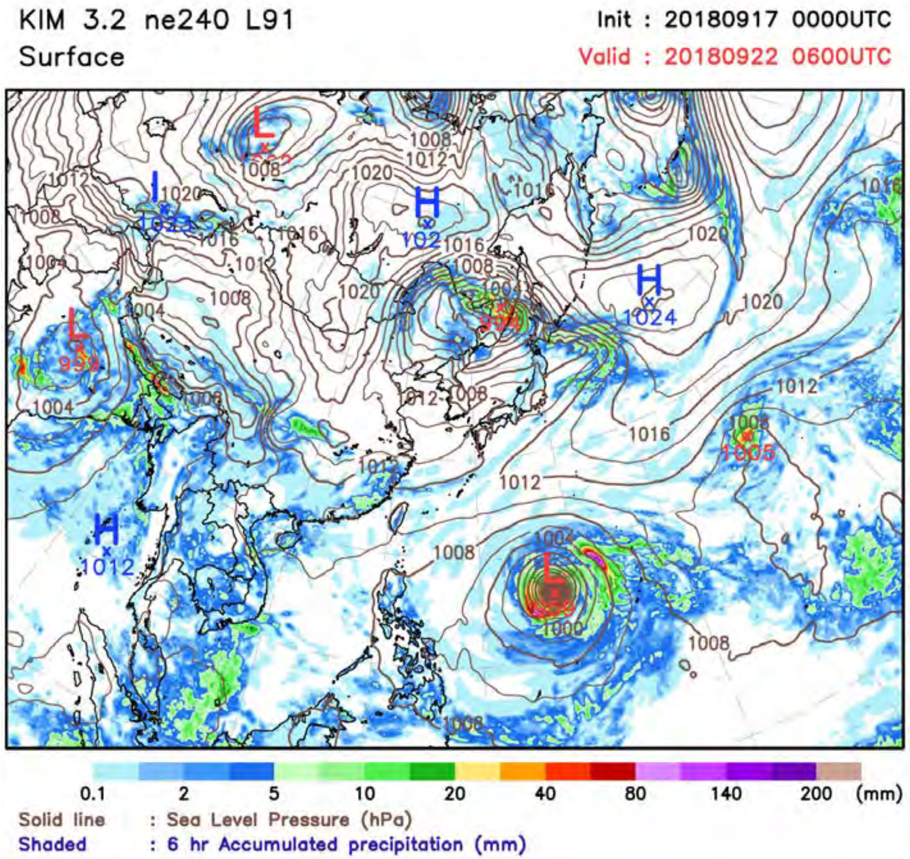

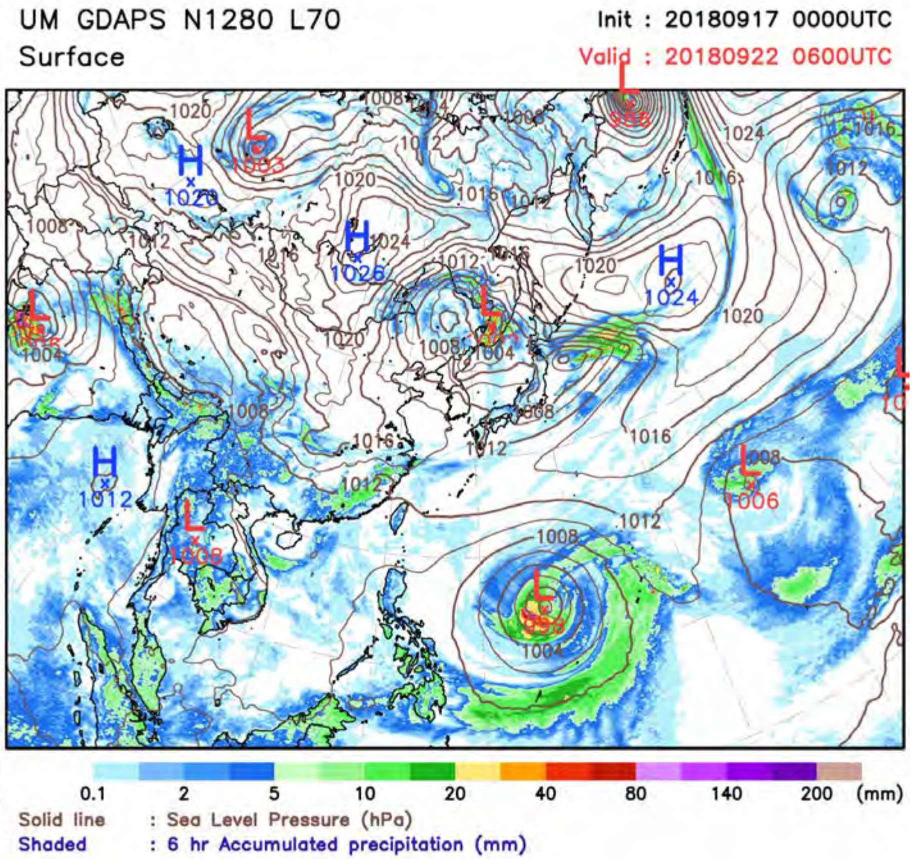

Initial time : 2018. 09. 17. 00UTC

FCST : +132hr

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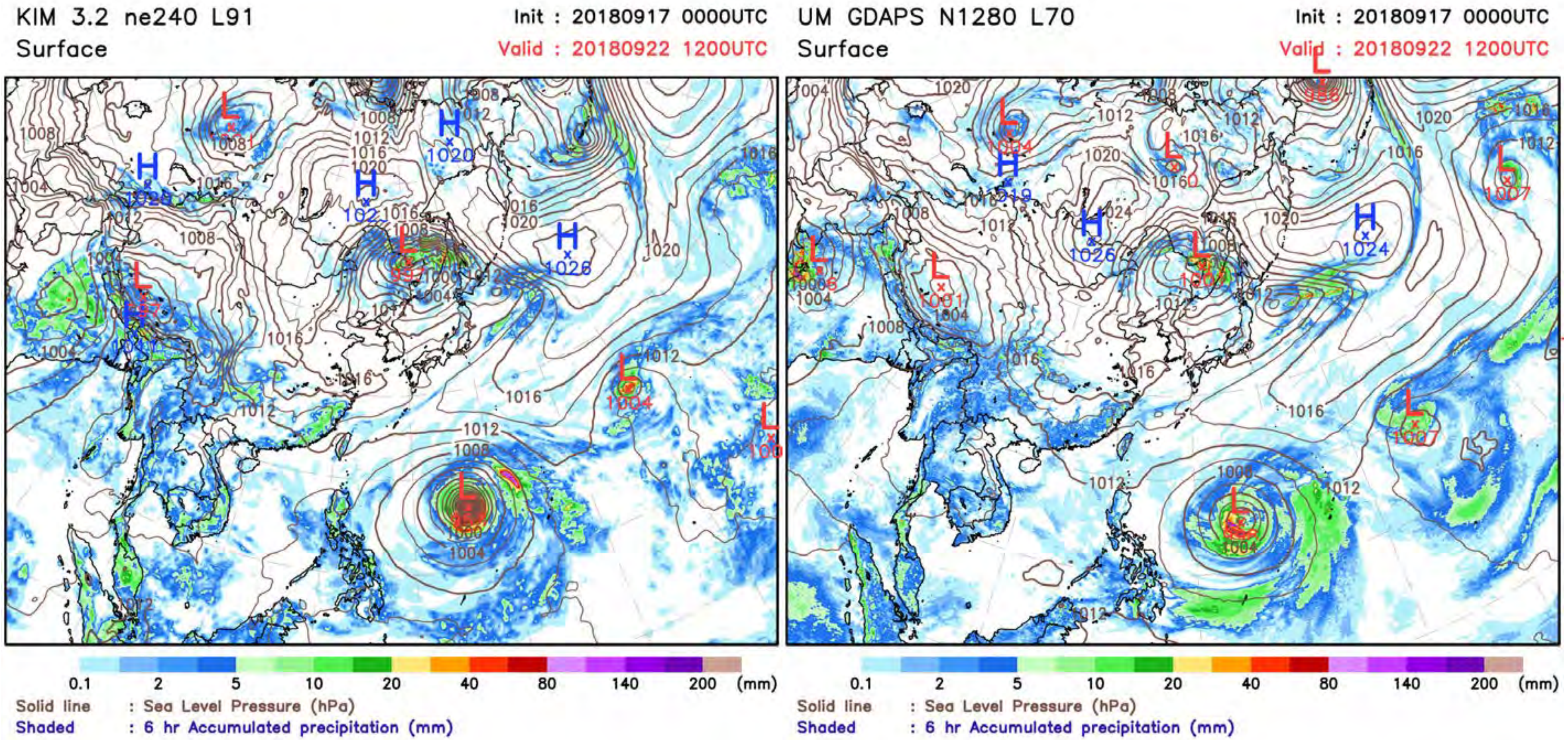
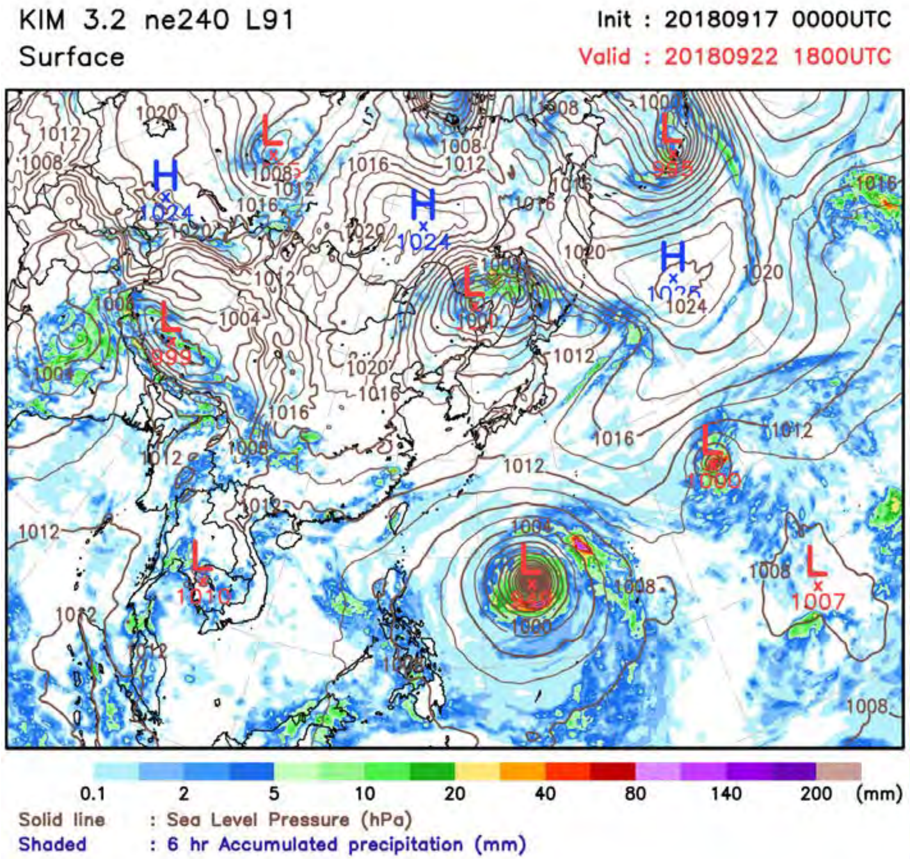


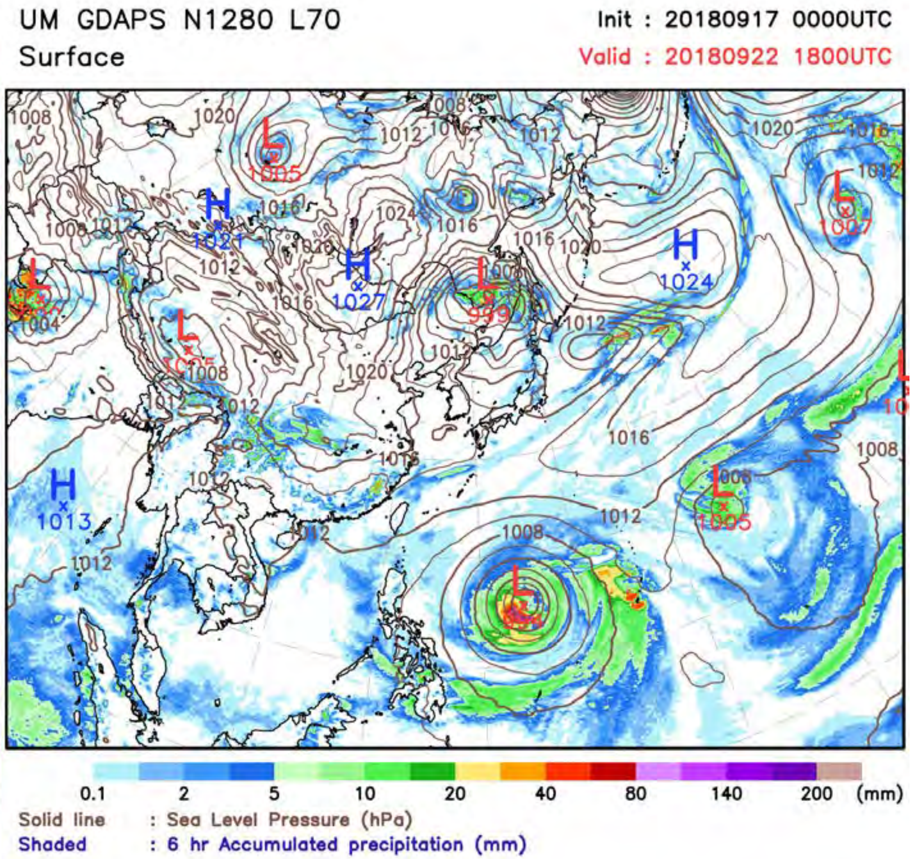
Initial time : 2018. 09. 17. 00UTC

FCST : +138hr

KIM 3.2

KMA UM





Initial time : 2018. 09. 17. 00UTC

FCST : +144hr

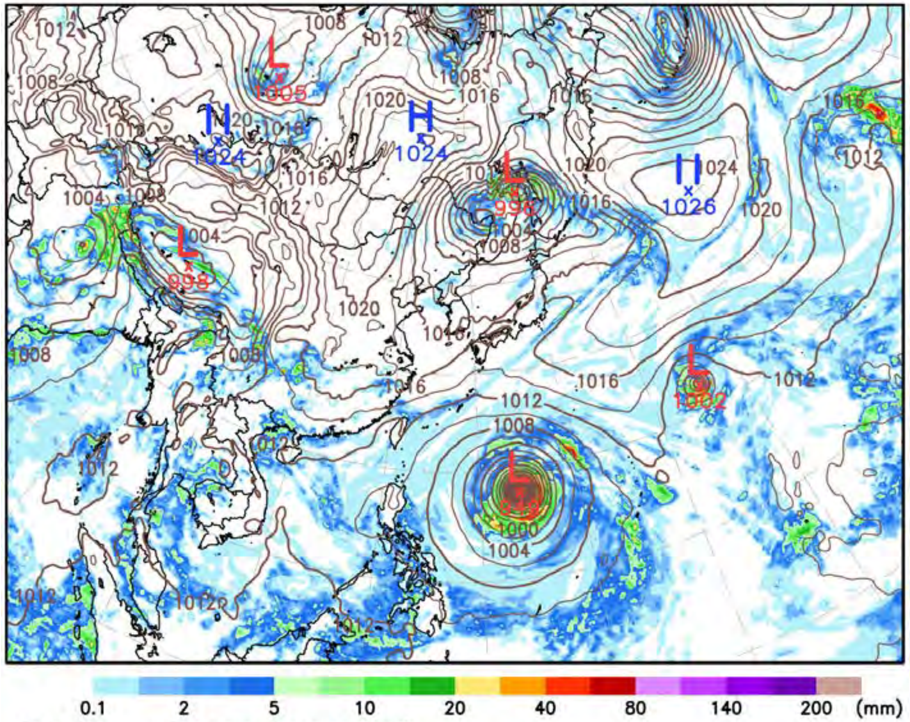
KIM 3.2

KMA UM

KIM 3.2 ne240 L91 Surface

Init : 20180917 0000UTC

Valid : 20180923 0000UTC



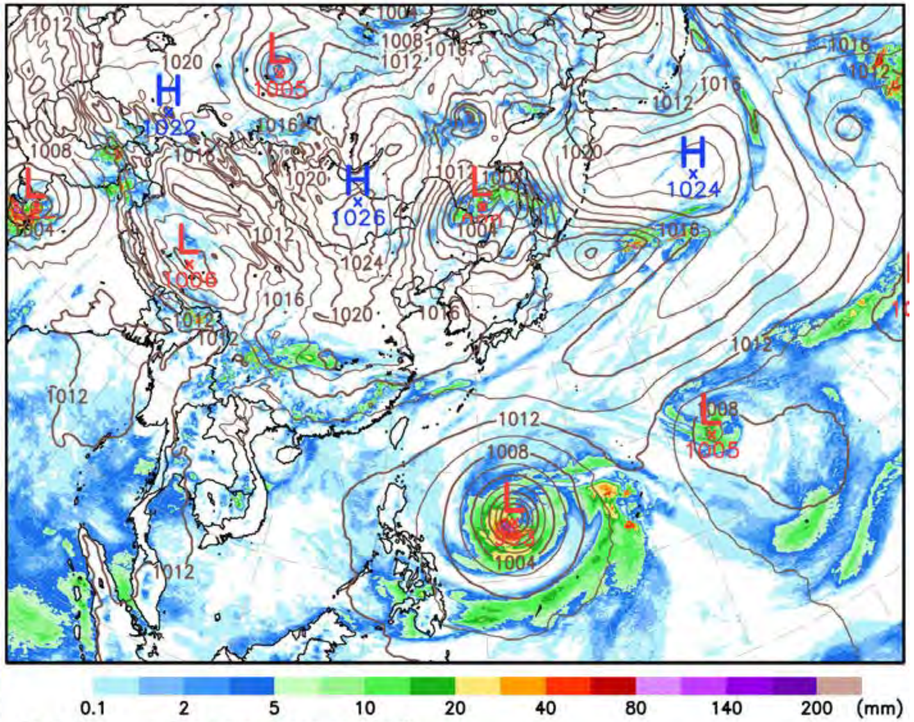
Solid line : Sea Level Pressure (hPa)

Shaded : 6 hr Accumulated precipitation (mm)

UM GDAPS N1280 L70 Surface

Init : 20180917 0000UTC

Valid : 20180923 0000UTC



Solid line : Sea Level Pressure (hPa)

Shaded : 6 hr Accumulated precipitation (mm)

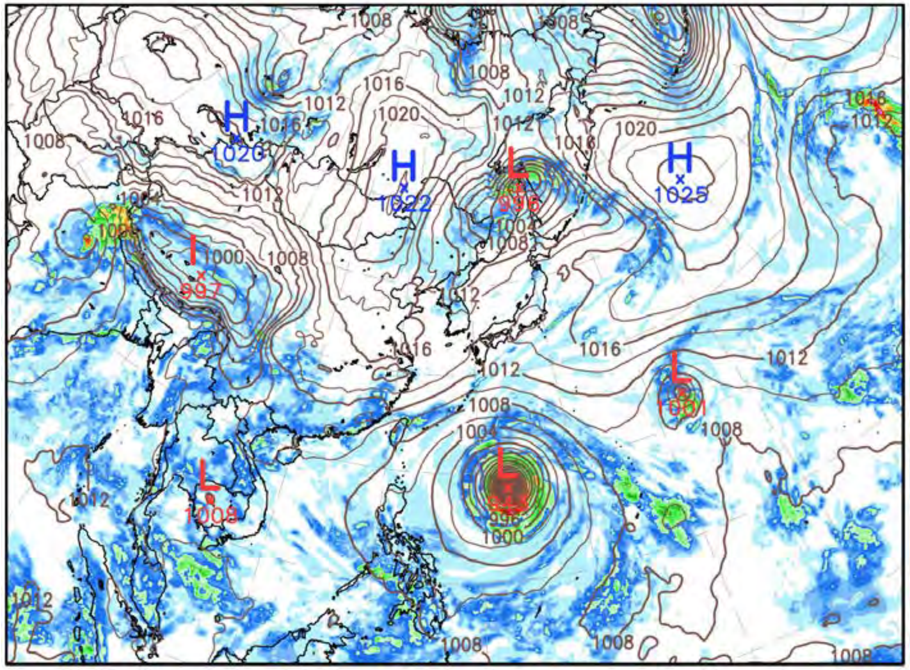
Initial time : 2018. 09. 17. 00UTC

FCST : +150hr

KIM 3.2	KMA UM

KIM 3.2 ne240 L91 Init : 20180917 0000UTC

Surface Valid : 20180923 0600UTC



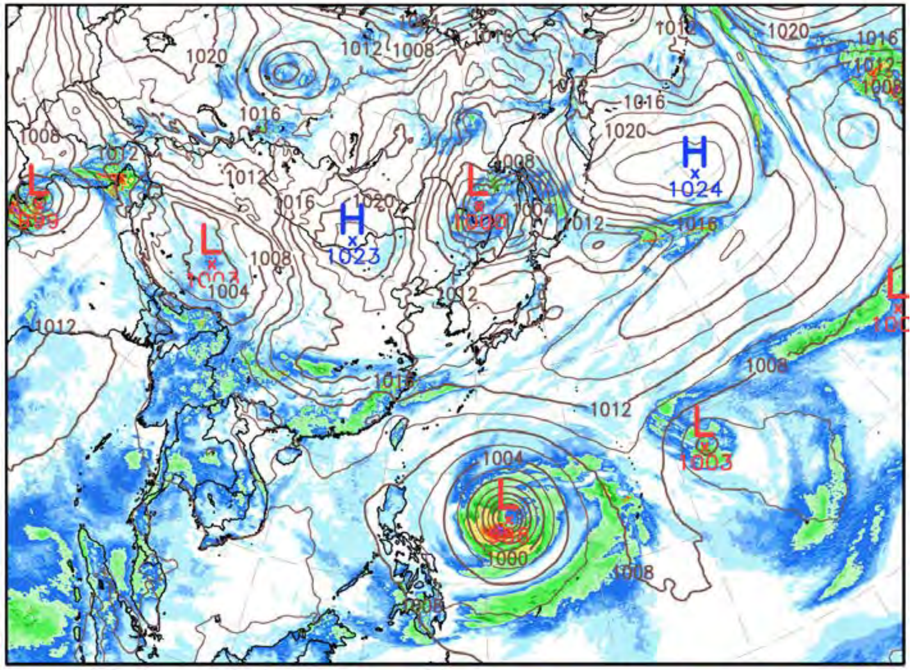
0.1 2 5 10 20 40 80 140 200 (mm)

Solid line : Sea Level Pressure (hPa)

Shaded : 6 hr Accumulated precipitation (mm)

UM GDAPS N1280 L70 Init : 20180917 0000UTC

Surface Valid : 20180923 0600UTC



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

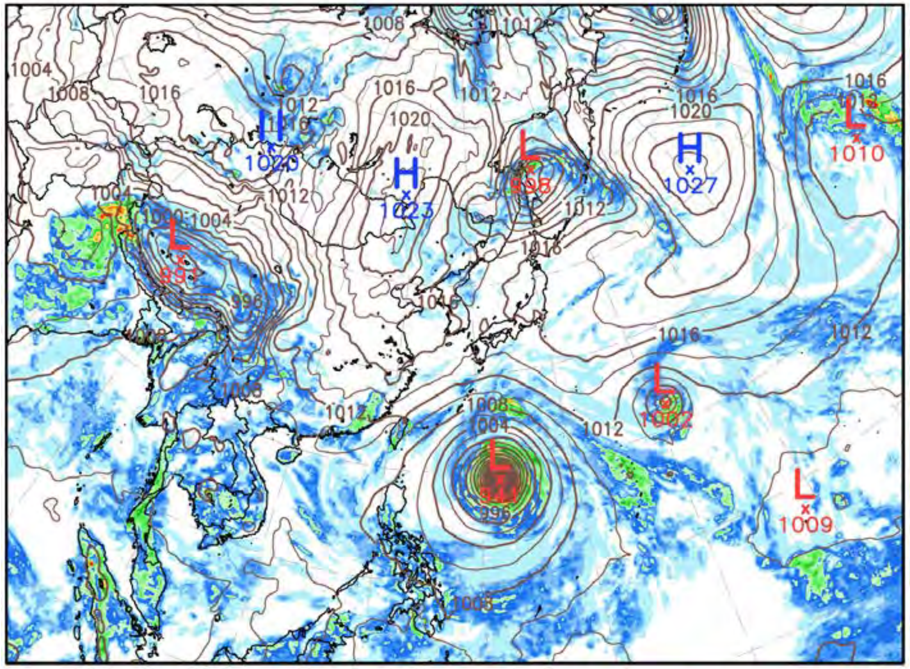
FCST : +156hr

KIM 3.2

KMA UM

KIM 3.2 ne240 L91 Init : 20180917 0000UTC

Surface Valid : 20180923 1200UTC



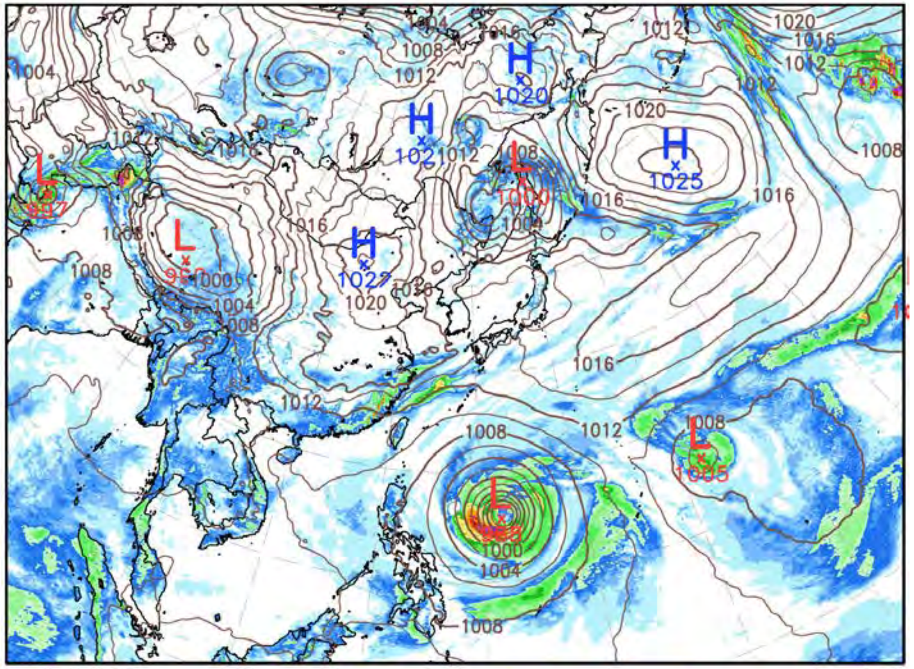
0.1 2 5 10 20 40 80 140 200 (mm)

Solid line : Sea Level Pressure (hPa)

Shaded : 6 hr Accumulated precipitation (mm)

UM GDAPS N1280 L70 Init : 20180917 0000UTC

Surface Valid : 20180923 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

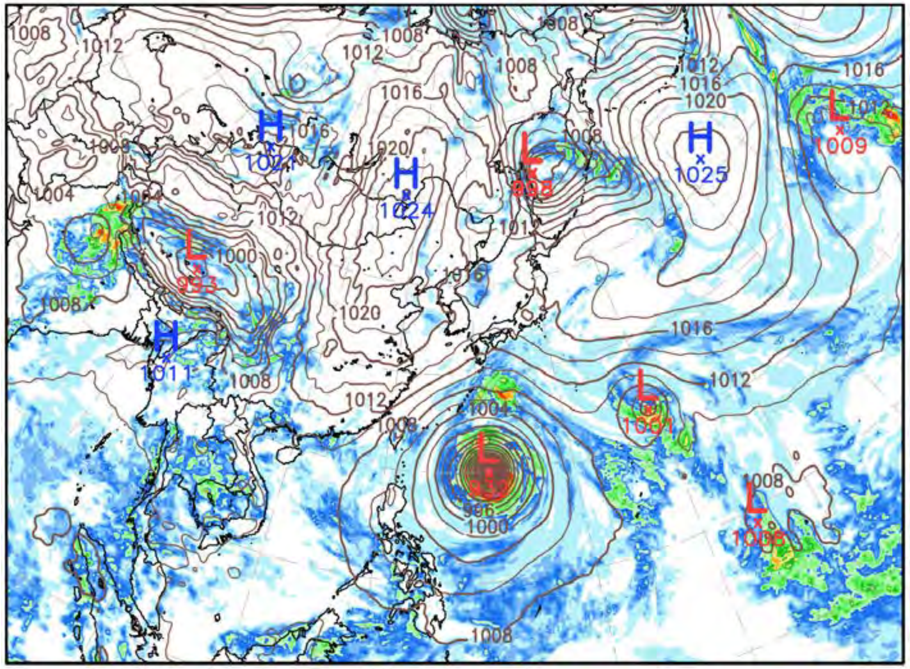
FCST : +162hr

KIM 3.2

KMA UM

KIM 3.2 ne240 L91 Init : 20180917 0000UTC

Surface Valid : 20180923 1800UTC



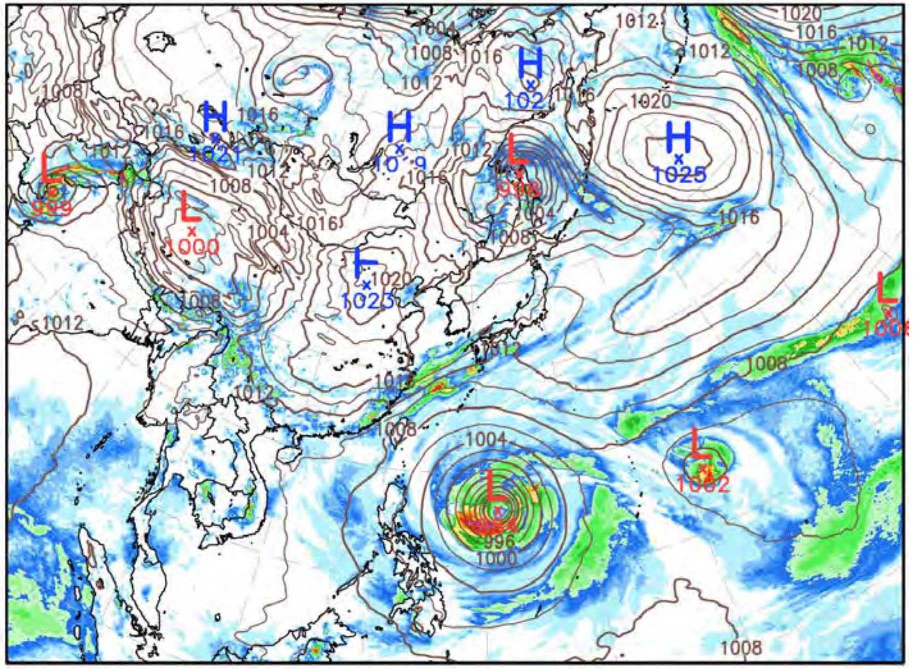
0.1 2 5 10 20 40 80 140 200 (mm)

Solid line : Sea Level Pressure (hPa)

Shaded : 6 hr Accumulated precipitation (mm)

UM GDAPS N1280 L70 Init : 20180917 0000UTC

Surface Valid : 20180923 1800UTC



0.1 2 5 10 20 40 80 140 200 (mm)

Solid line : Sea Level Pressure (hPa)

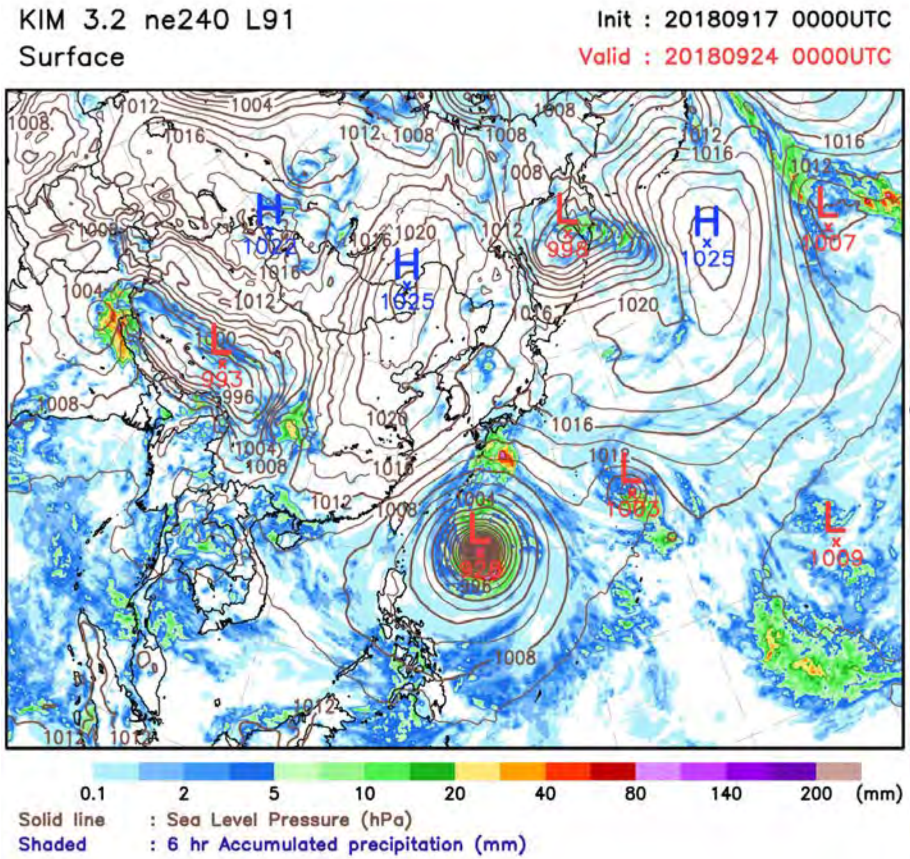
Shaded : 6 hr Accumulated precipitation (mm)

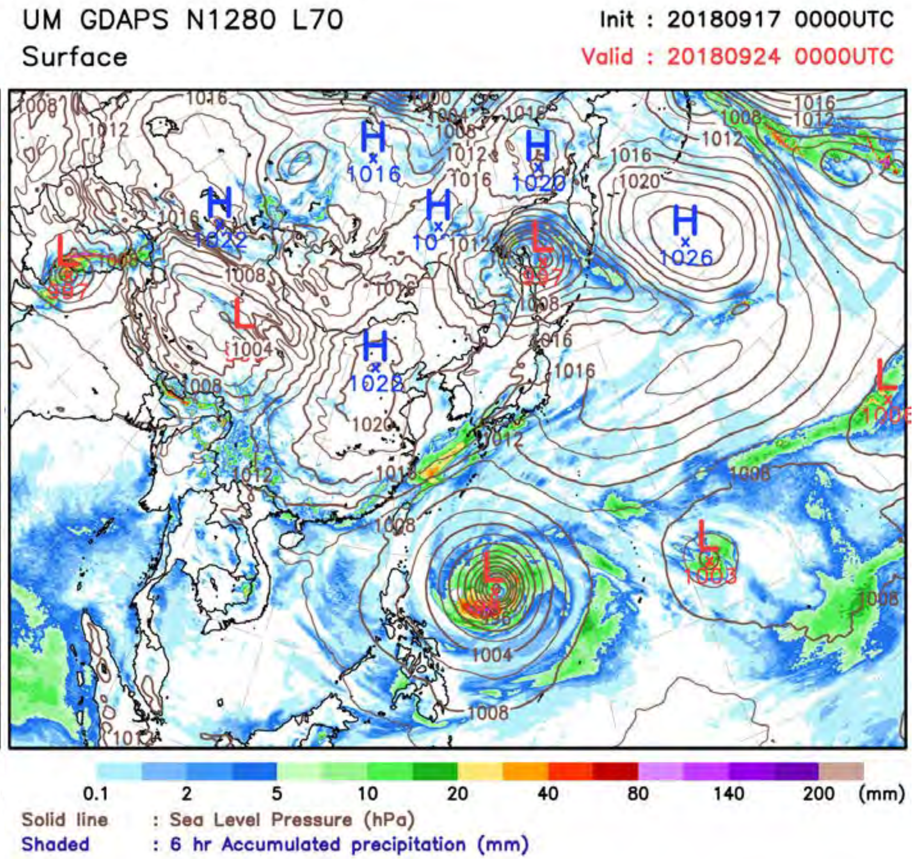
Initial time : 2018. 09. 17. 00UTC

FCST : +168hr

KIM 3.2

KMA UM



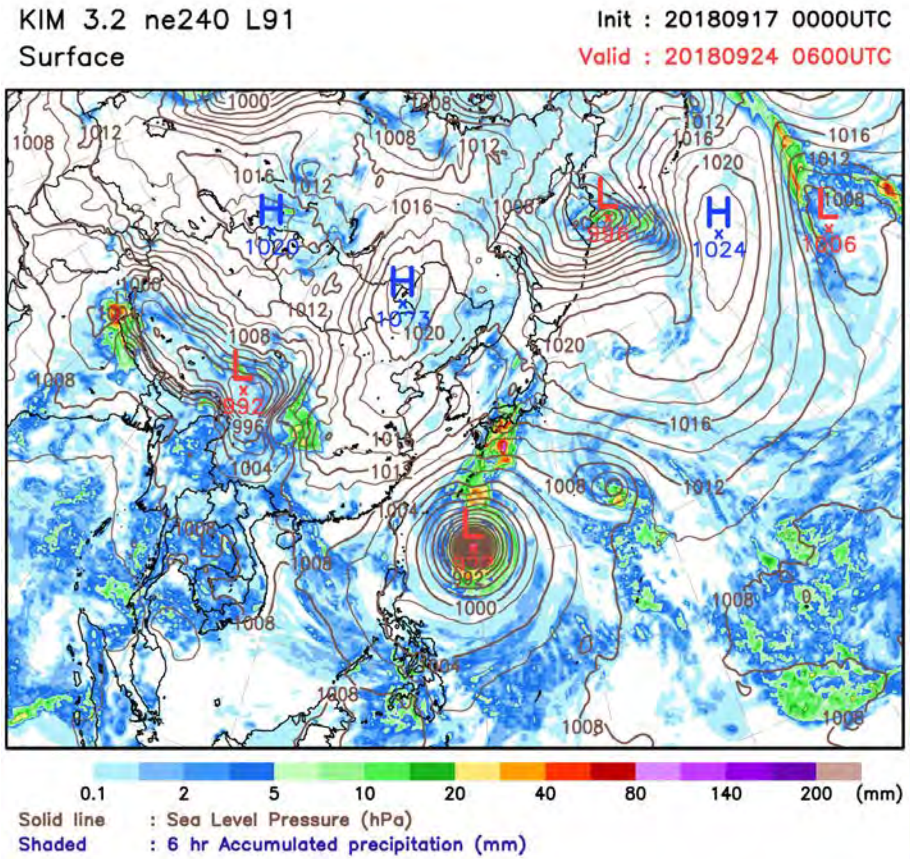


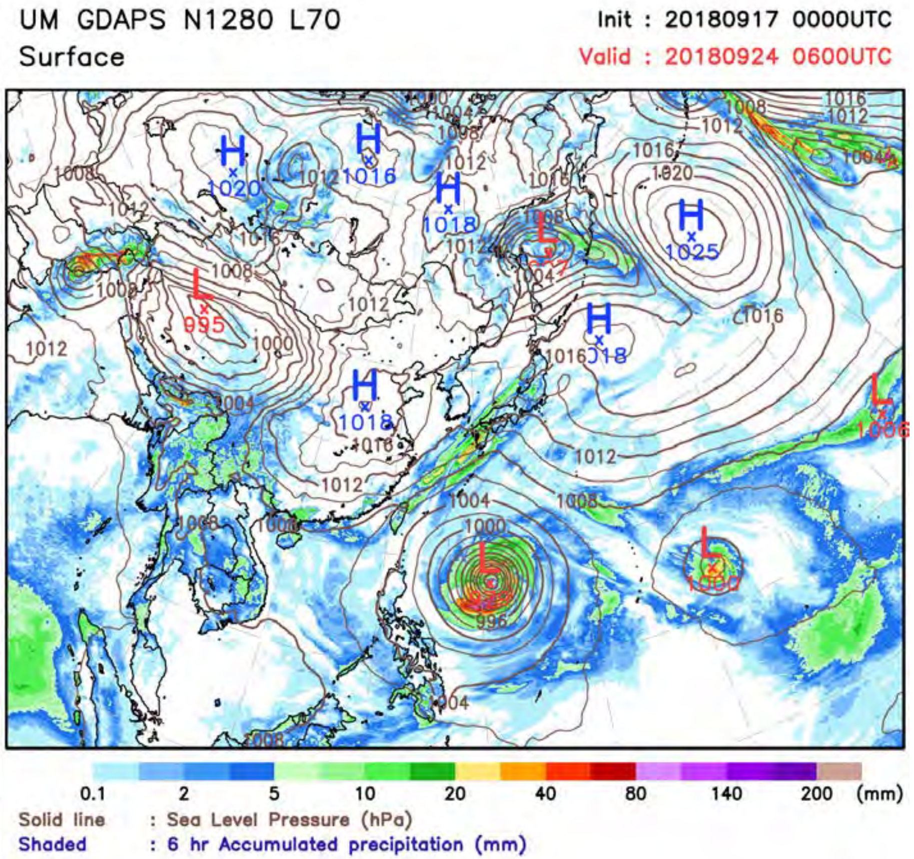
Initial time : 2018. 09. 17. 00UTC

FCST : +174hr

KIM 3.2

KMA UM



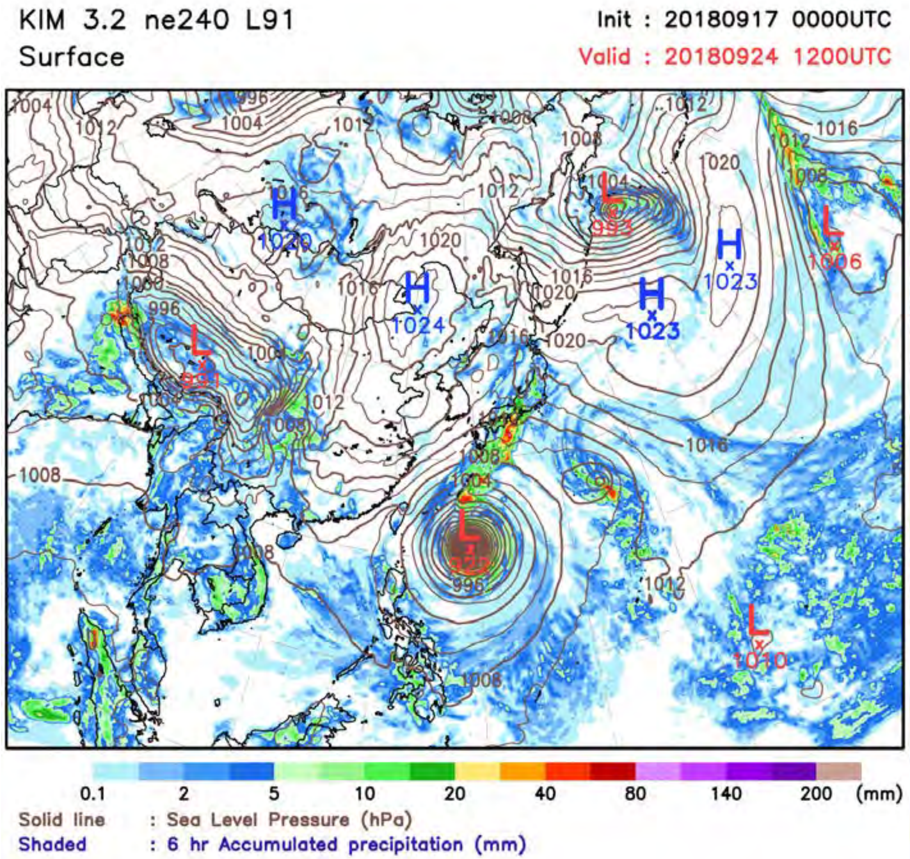


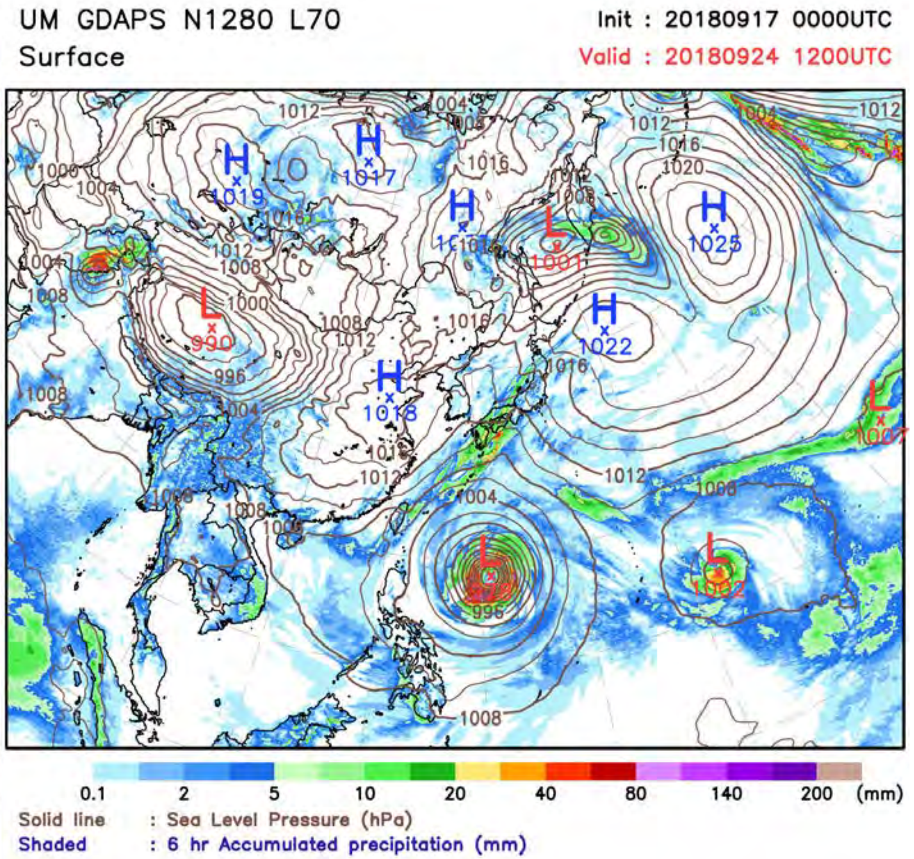
Initial time : 2018. 09. 17. 00UTC

FCST : +180hr

KIM 3.2

KMA UM





Initial time : 2018. 09. 17. 00UTC

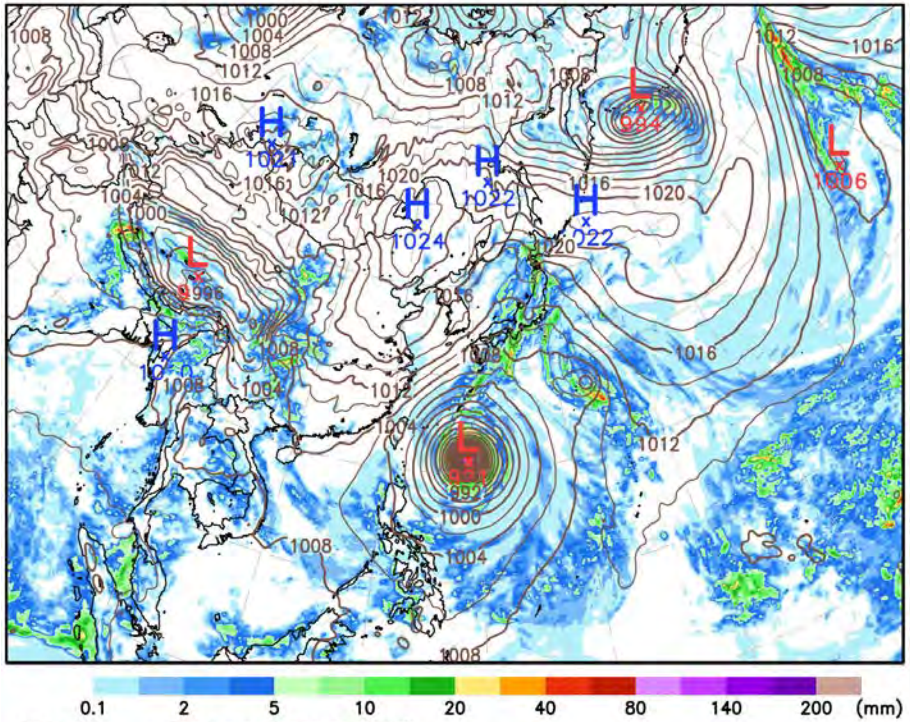
FCST : +186hr

KIM 3.2

KMA UM

KIM 3.2 ne240 L91 Init : 20180917 0000UTC

Surface Valid : 20180924 1800UTC

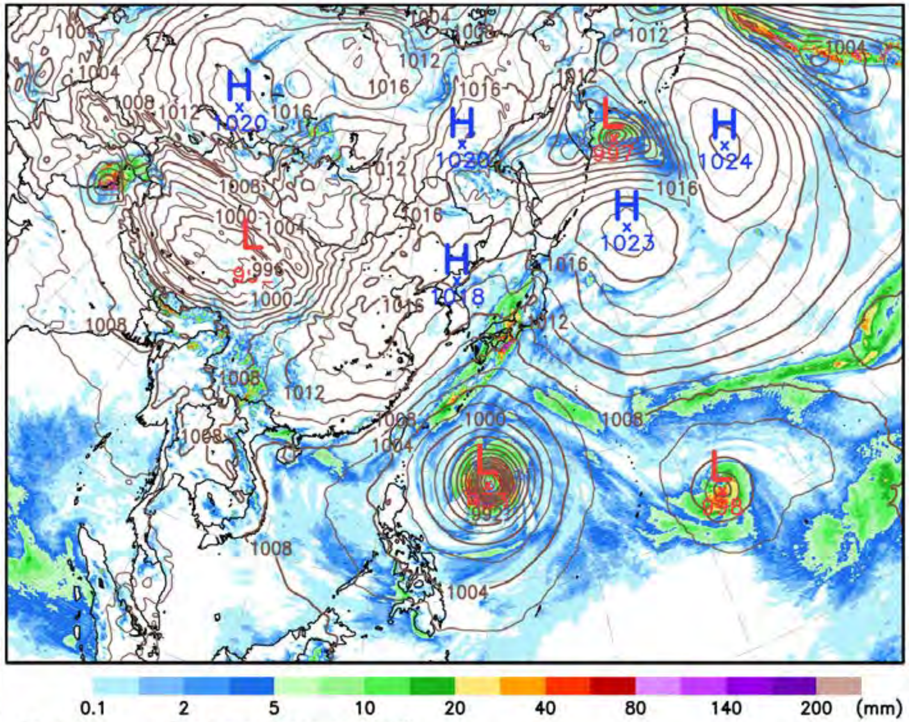


Solid line : Sea Level Pressure (hPa)

Shaded : 6 hr Accumulated precipitation (mm)

UM GDAPS N1280 L70 Init : 20180917 0000UTC

Surface Valid : 20180924 1800UTC



Solid line : Sea Level Pressure (hPa)

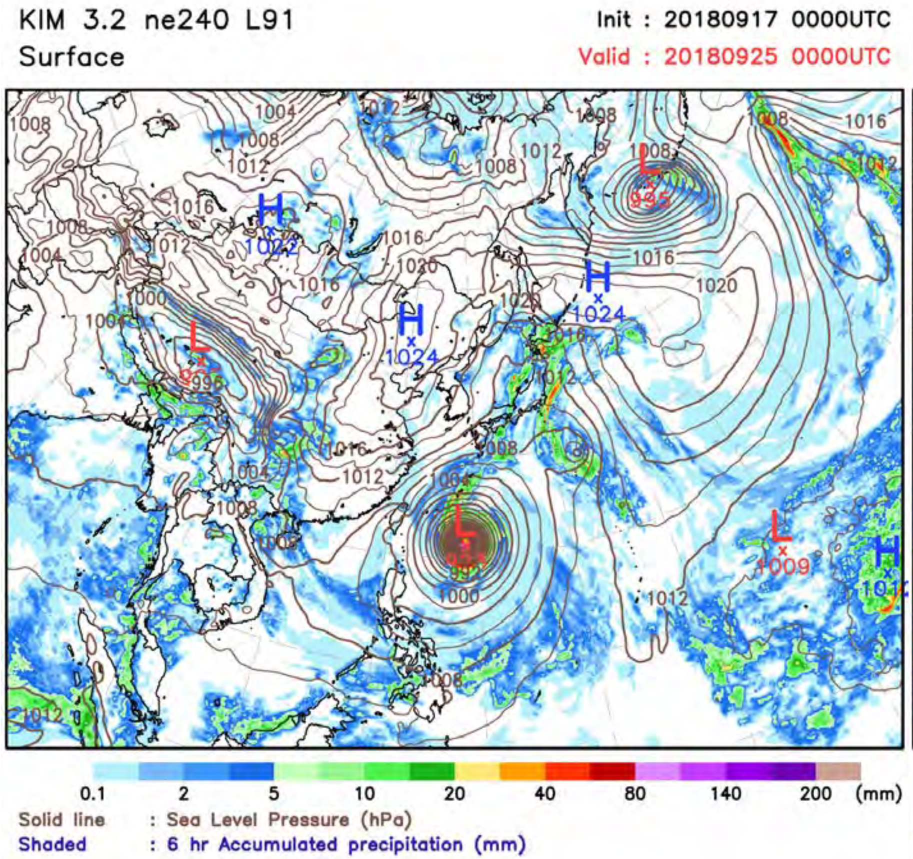
Shaded : 6 hr Accumulated precipitation (mm)

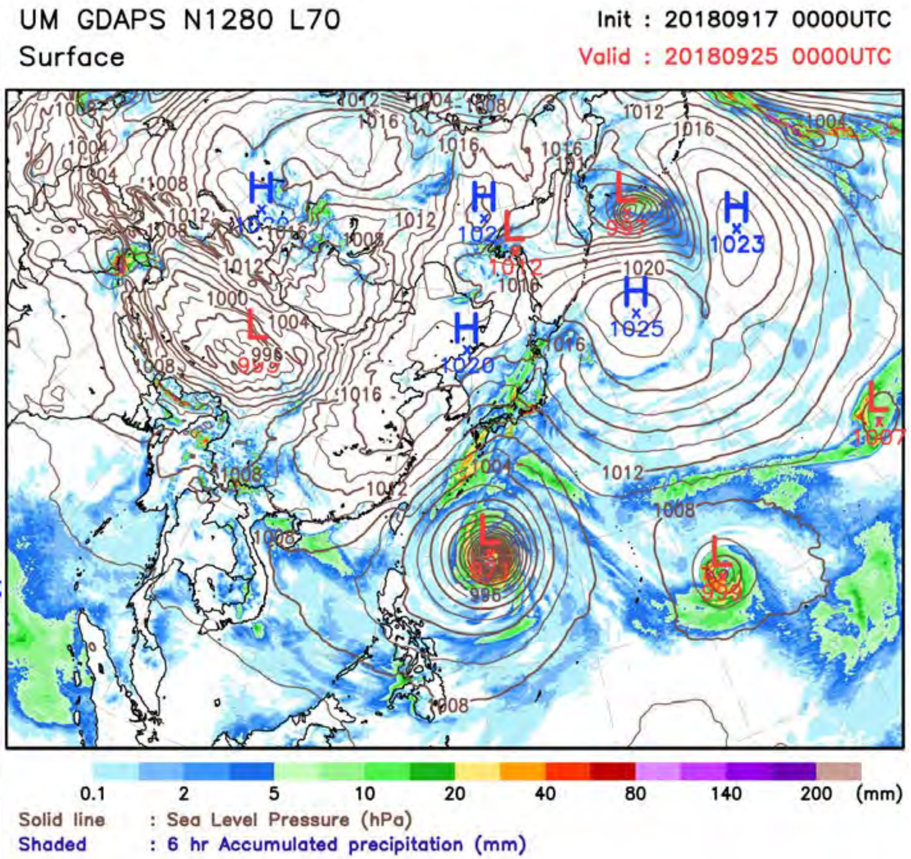
Initial time : 2018. 09. 17. 00UTC

FCST : +192hr

KIM 3.2

KMA UM





Initial time : 2018. 09. 17. 00UTC

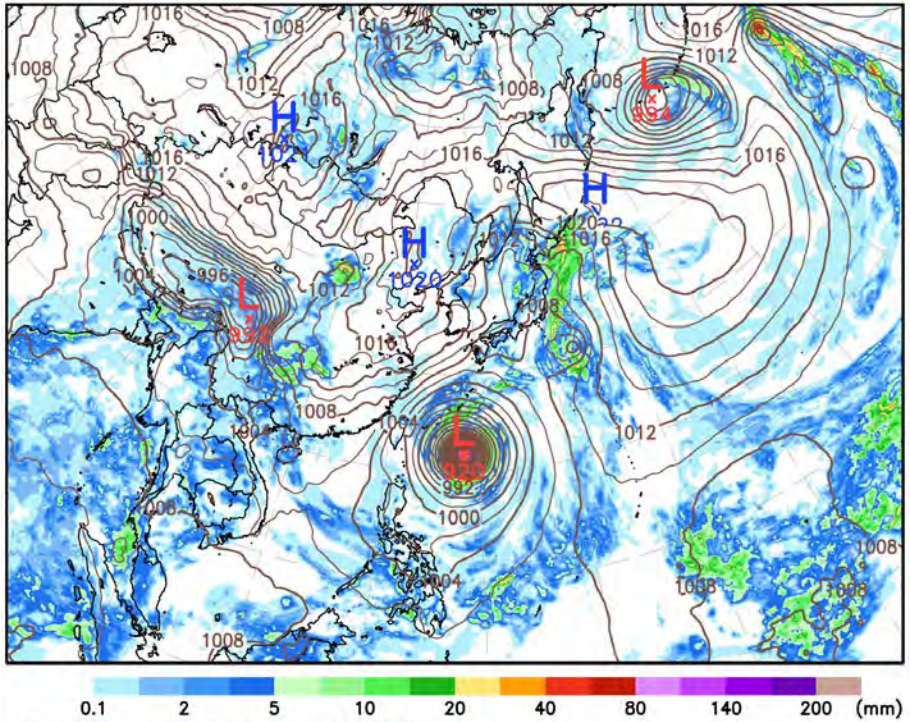
FCST : +198hr

KIM 3.2

KMA UM

KIM 3.2 ne240 L91 Init : 20180917 0000UTC

Surface Valid : 20180925 0600UTC

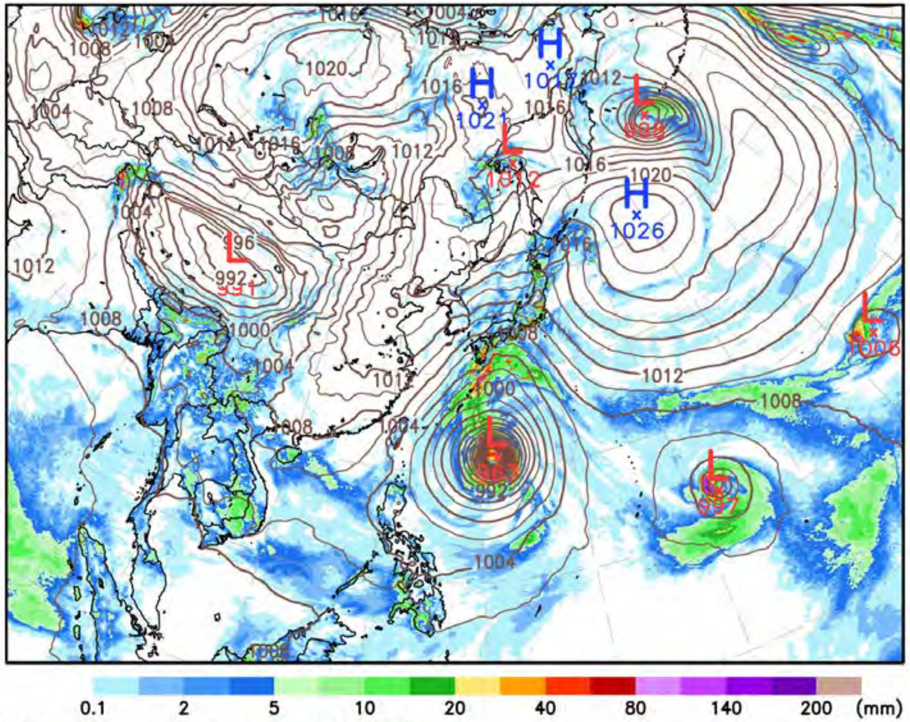


Solid line : Sea Level Pressure (hPa)

Shaded : 6 hr Accumulated precipitation (mm)

UM GDAPS N1280 L70 Init : 20180917 0000UTC

Surface Valid : 20180925 0600UTC



Solid line : Sea Level Pressure (hPa)

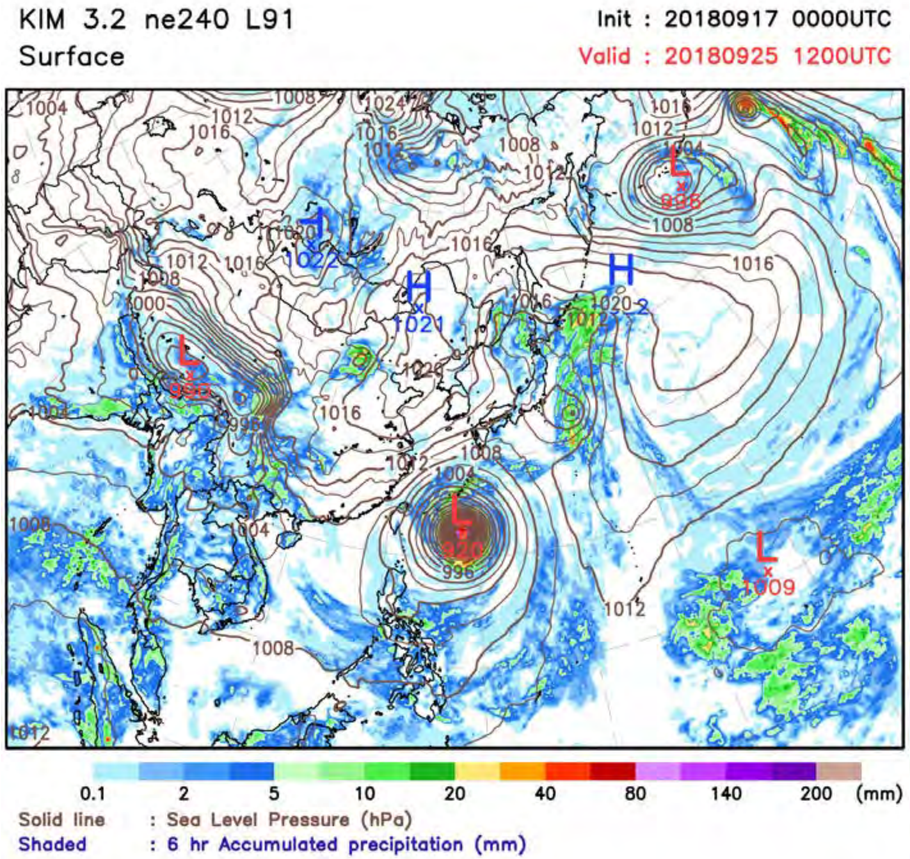
Shaded : 6 hr Accumulated precipitation (mm)

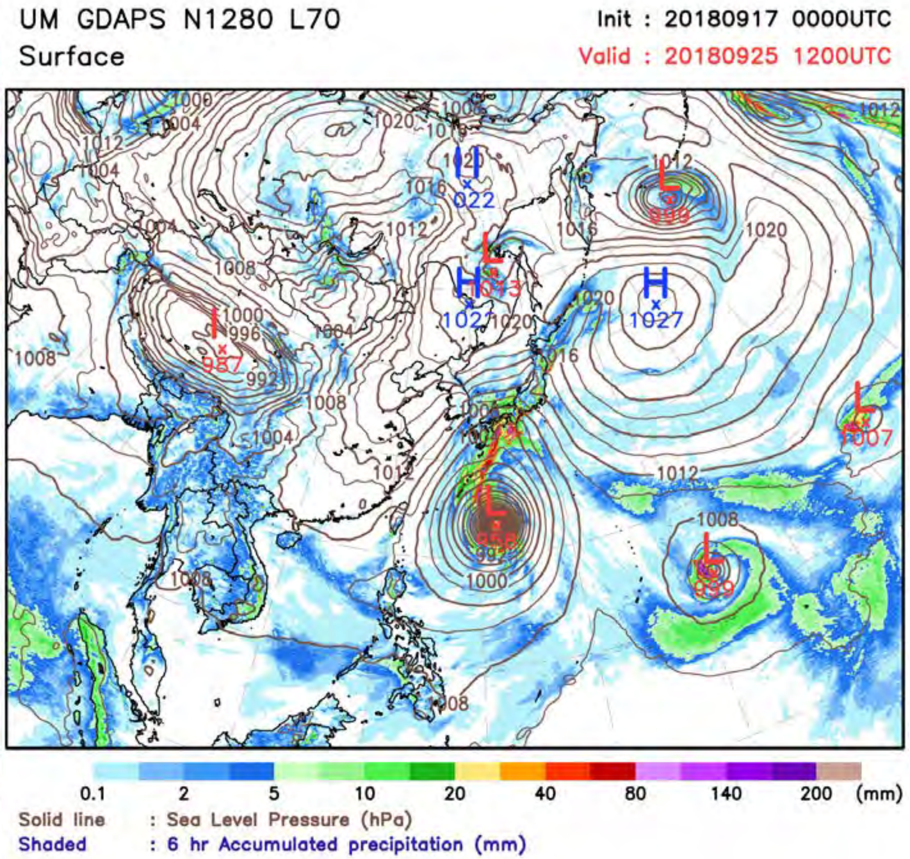
Initial time : 2018. 09. 17. 00UTC

FCST : +204hr

KIM 3.2

KMA UM



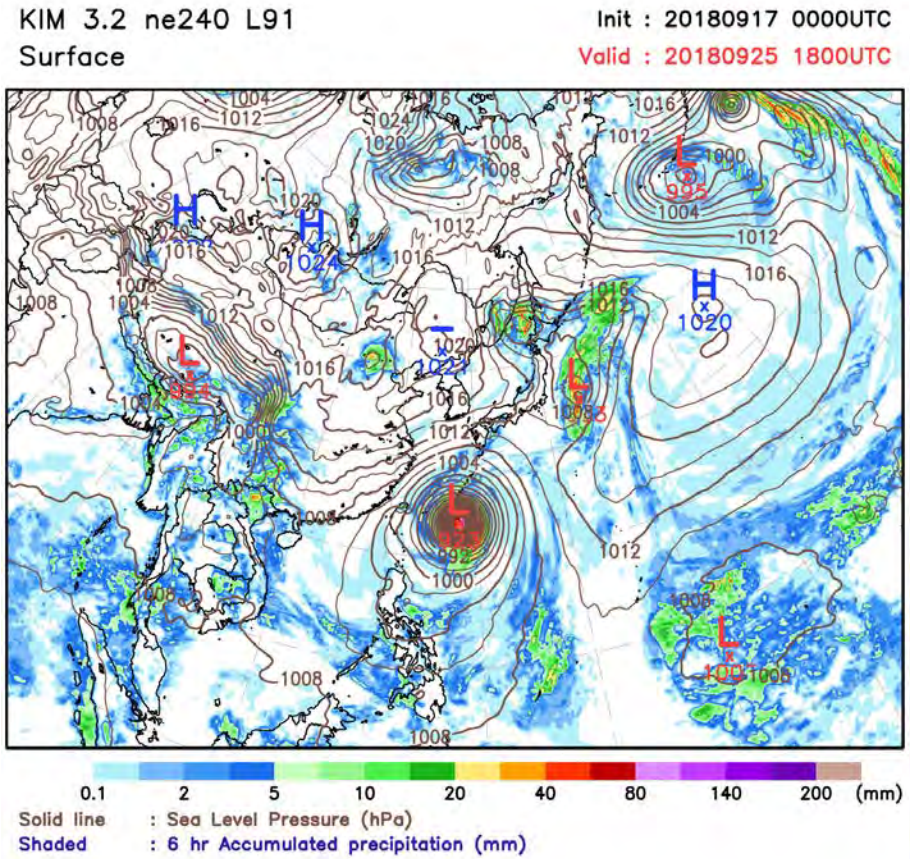


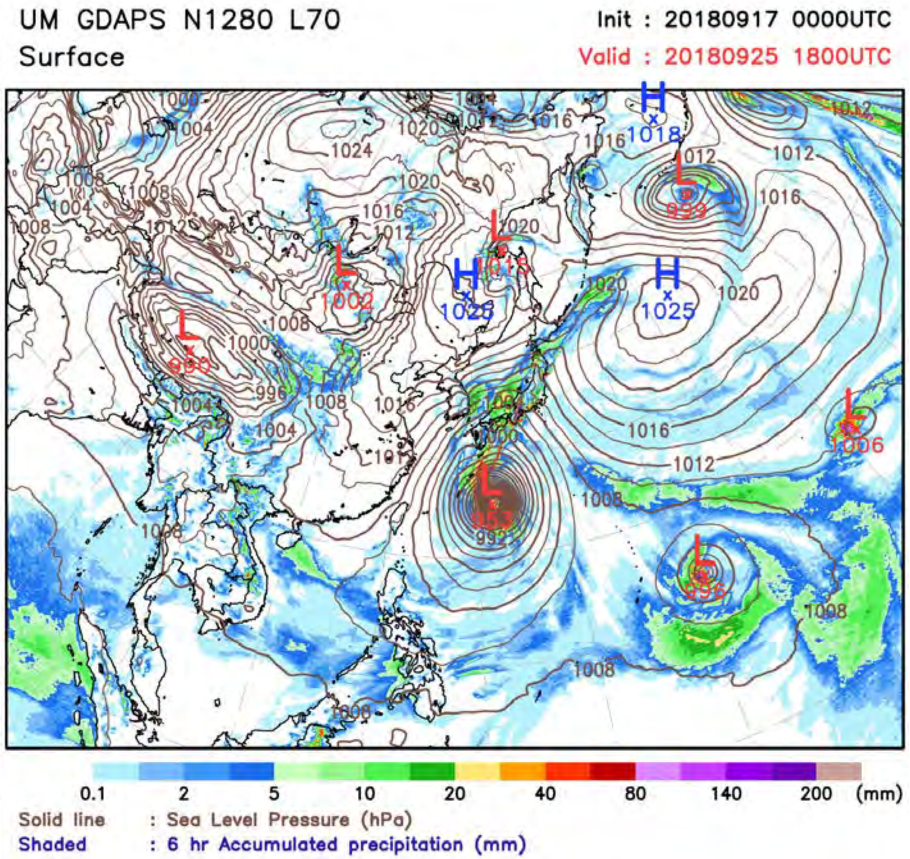
Initial time : 2018. 09. 17. 00UTC

FCST : +210hr

KIM 3.2

KMA UM



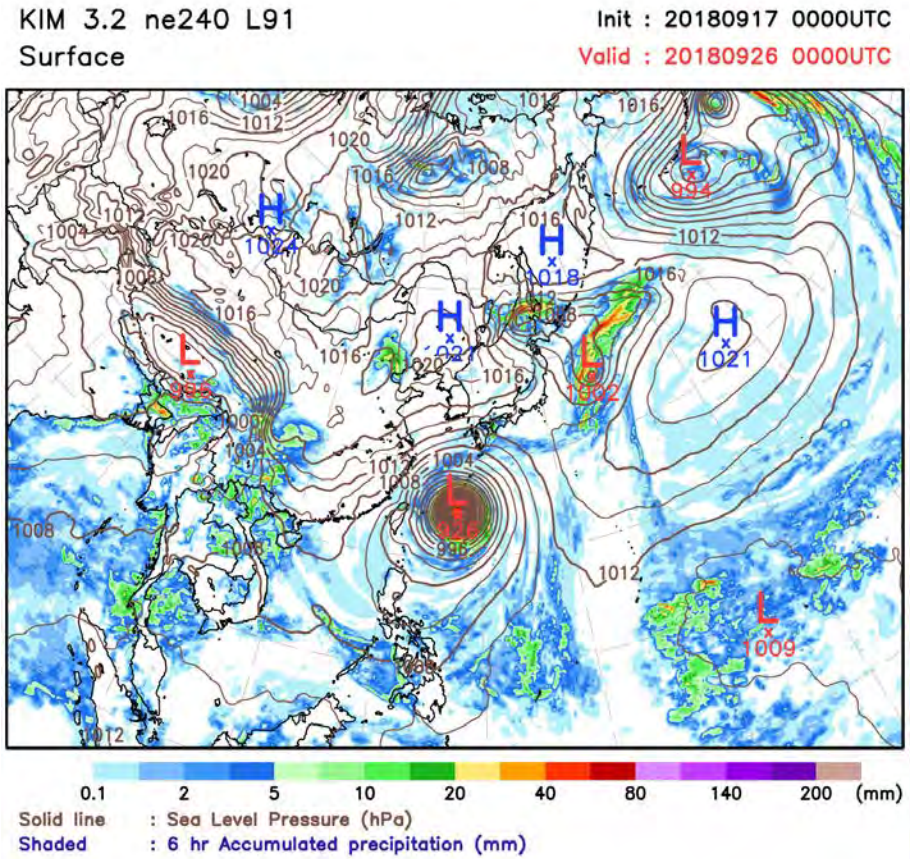


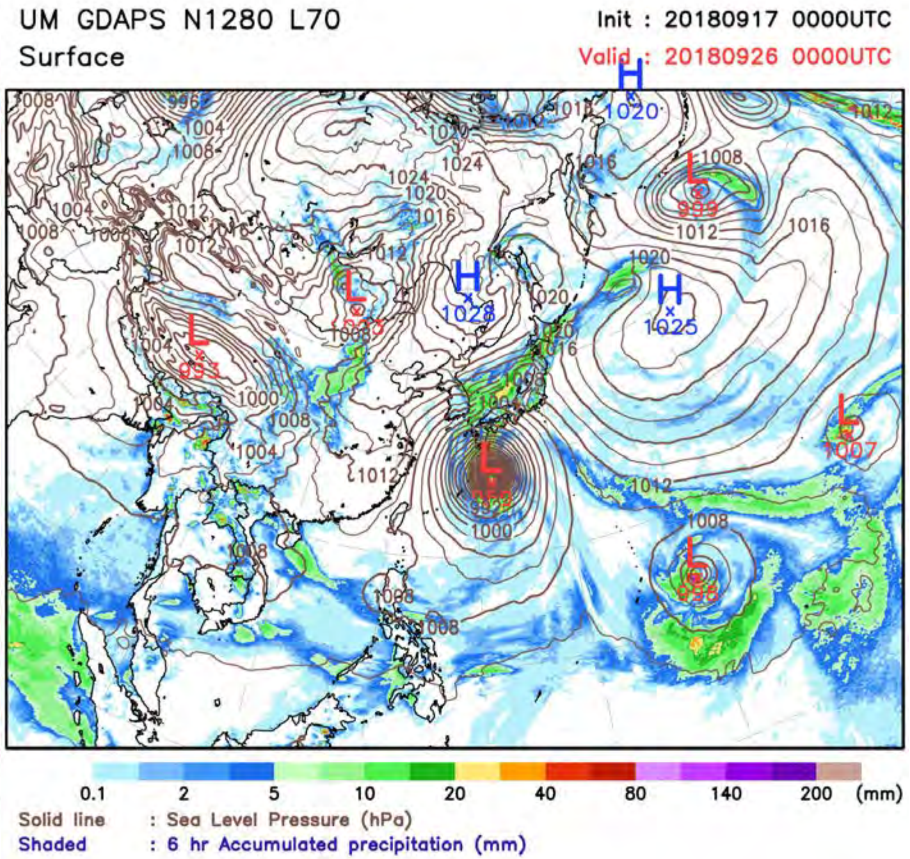
Initial time : 2018. 09. 17. 00UTC

FCST : +216hr

KIM 3.2

KMA UM





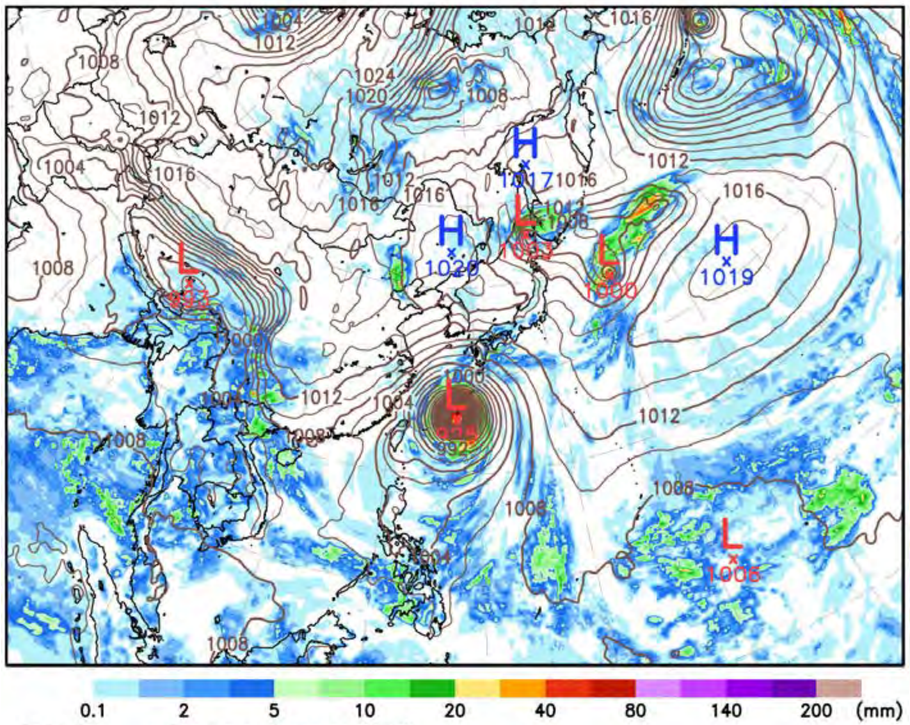
Initial time : 2018. 09. 17. 00UTC

FCST : +222hr

KIM 3.2

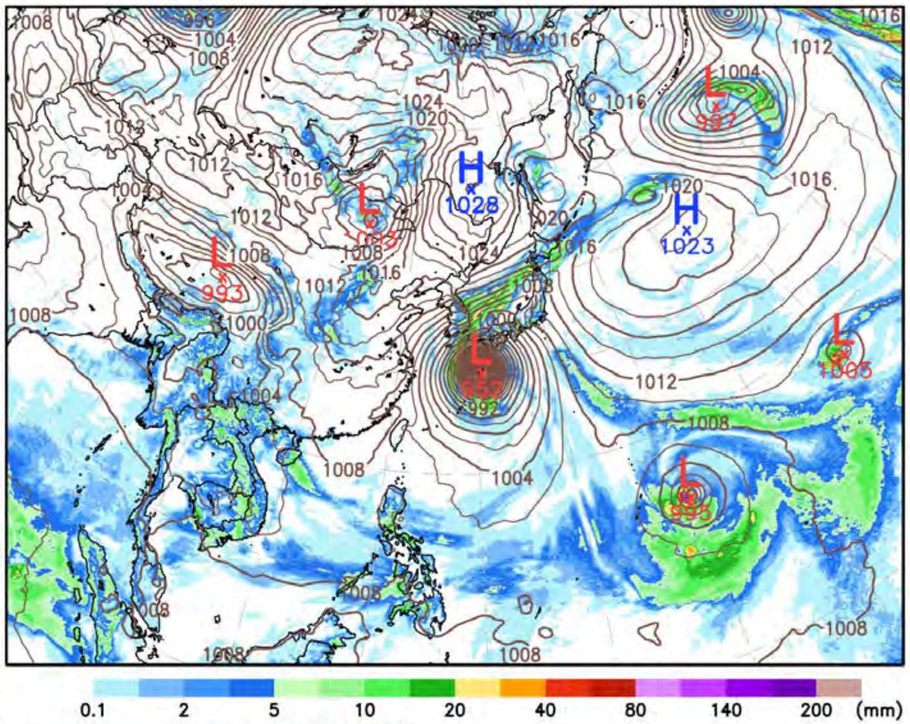
KMA UM

KIM 3.2 ne240 L91 Init : 20180917 0000UTC
Surface Valid : 20180926 0600UTC



Solid line : Sea Level Pressure (hPa)
Shaded : 6 hr Accumulated precipitation (mm)

UM GDAPS N1280 L70 Init : 20180917 0000UTC
Surface Valid : 20180926 0600UTC



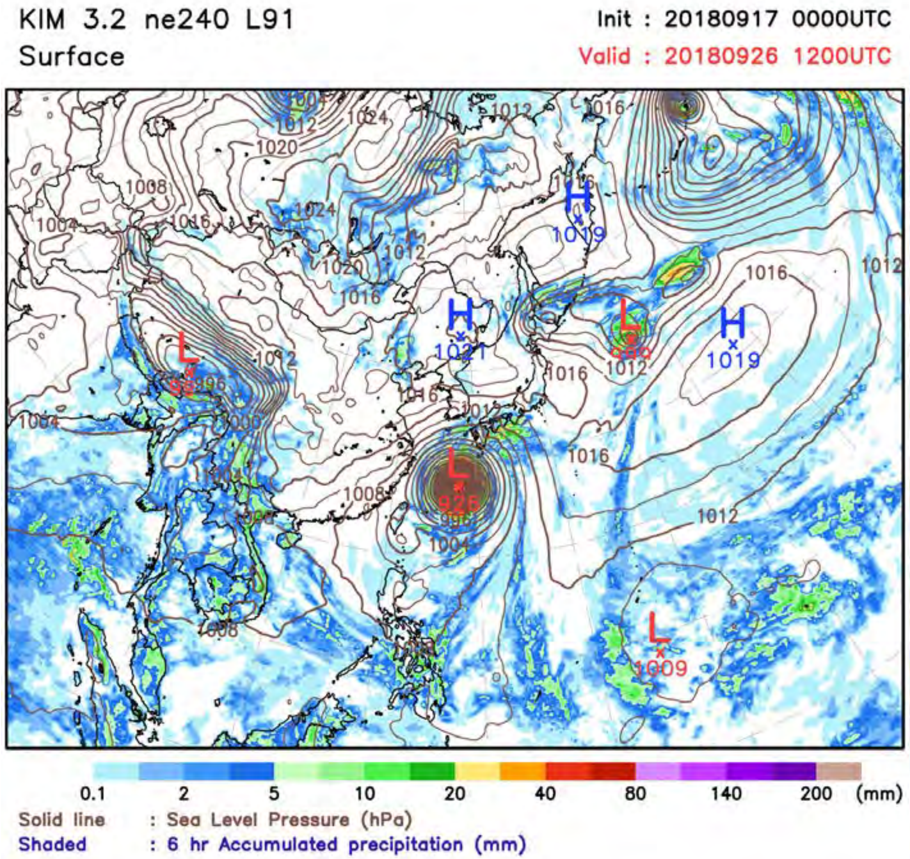
Solid line : Sea Level Pressure (hPa)
Shaded : 6 hr Accumulated precipitation (mm)

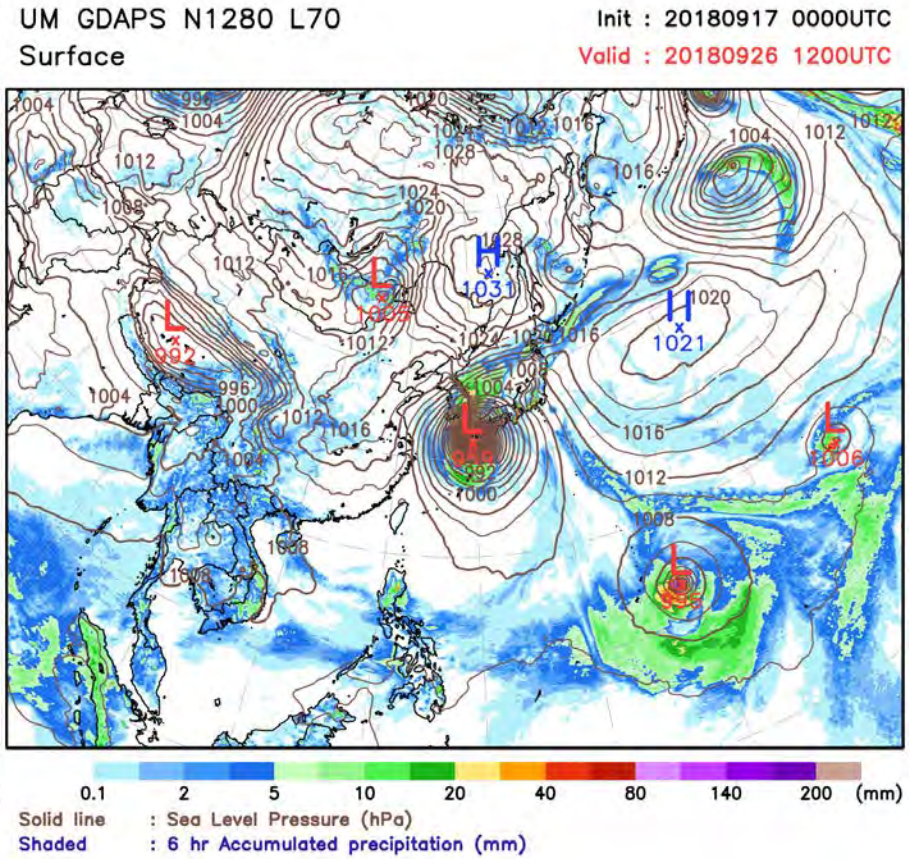
Initial time : 2018. 09. 17. 00UTC

FCST : +228hr

KIM 3.2

KMA UM



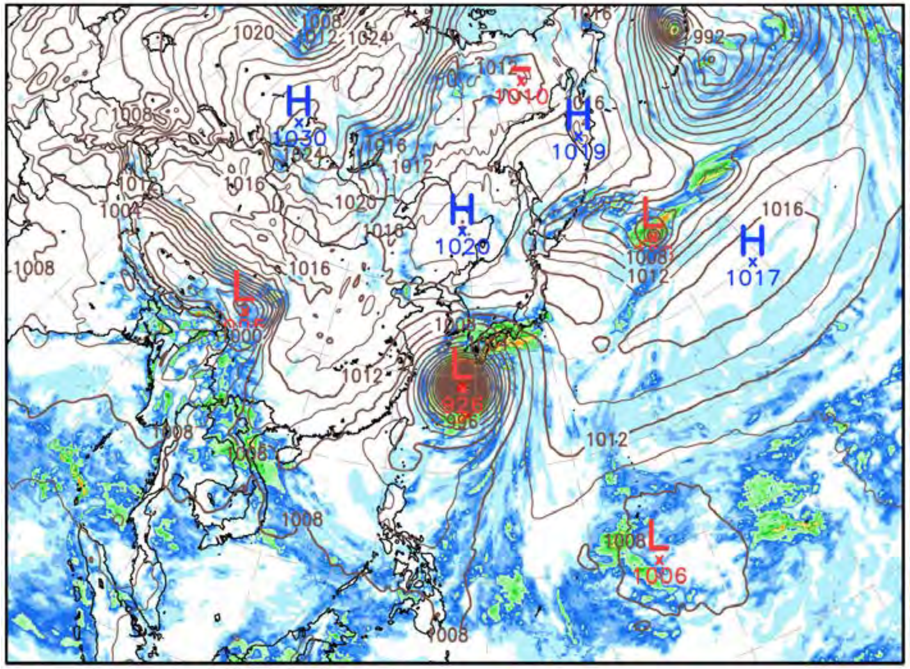


Initial time : 2018. 09. 17. 00UTC

FCST : +234hr

KIM 3.2	KMA UM

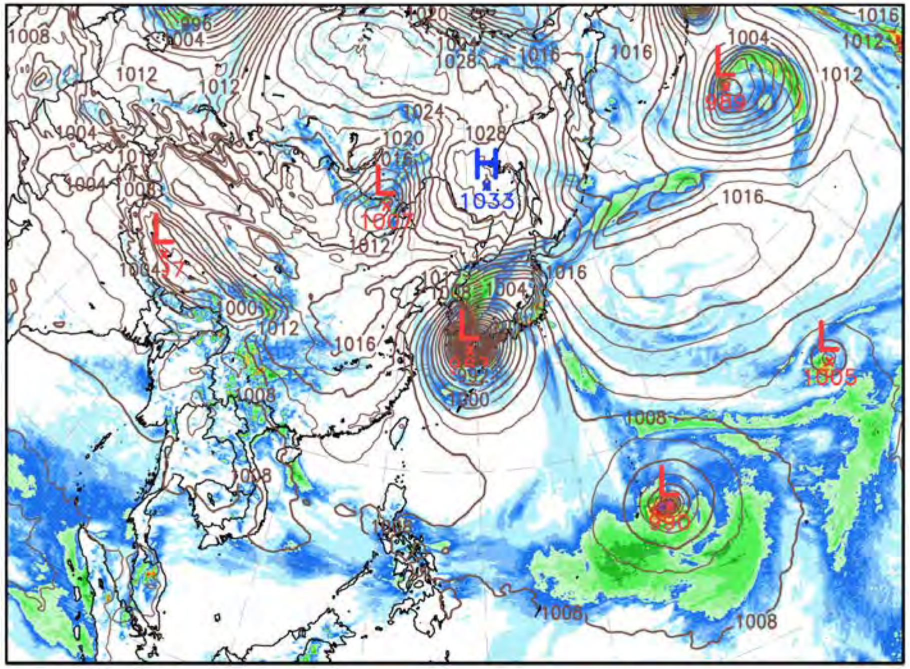
KIM 3.2 ne240 L91 Init : 20180917 0000UTC
Surface Valid : 20180926 1800UTC



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 : 20180926 1800UTC



0.1 2 5 10 20 40 80 140 200 (mm)

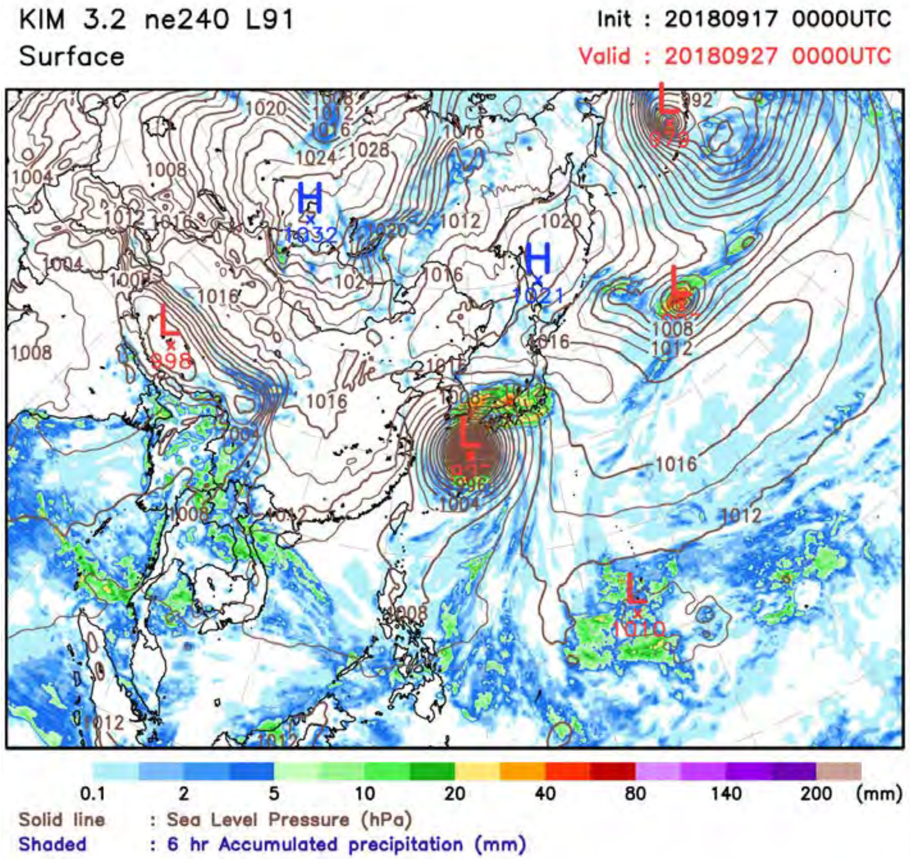
Solid line : Sea Level Pressure (hPa)
Shaded : 6 hr Accumulated precipitation (mm)

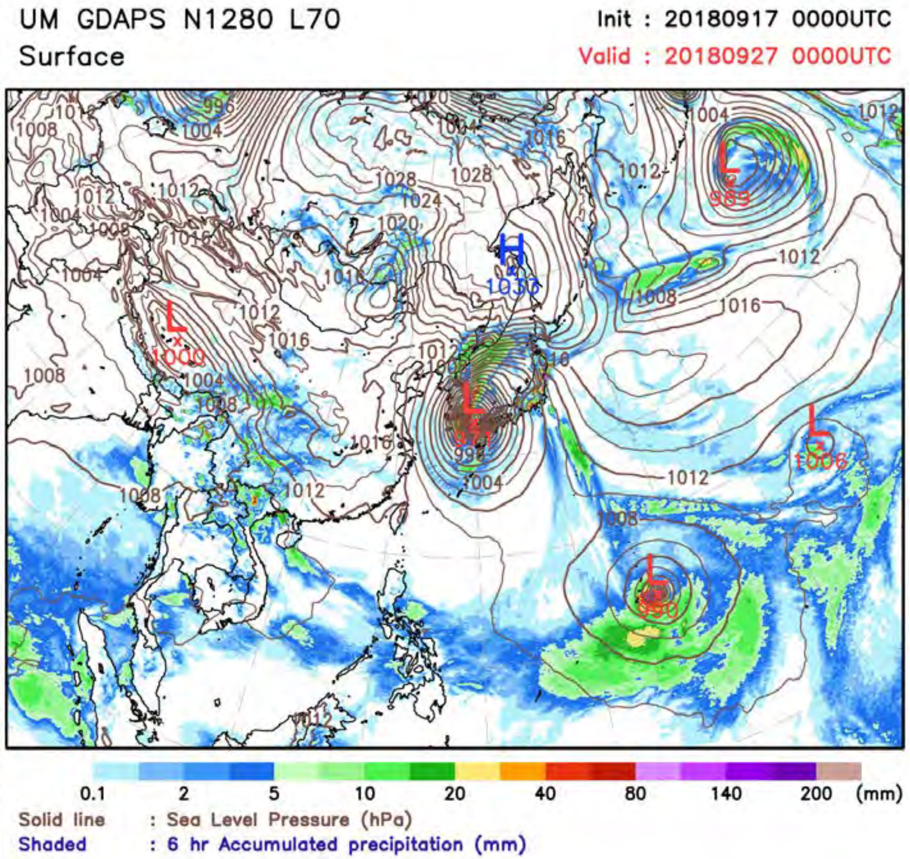
Initial time : 2018. 09. 17. 00UTC

FCST : +240hr

KIM 3.2

KMA UM





Lessons….

From the updates in KIM since July 2015, revisions in DA, physics a nd dynamic cores have proven the reduction of errors in NWP skill

Two model system differ in all aspects of the components
but the synoptic features are quite similar up to day 7 (deterministic)

Recognizing the fact that error in sub-seasonal and seasonal is the a ccumulation of error in NWP,
it would be interesting to apply the stochastic effects with time

Why stochastic physics?

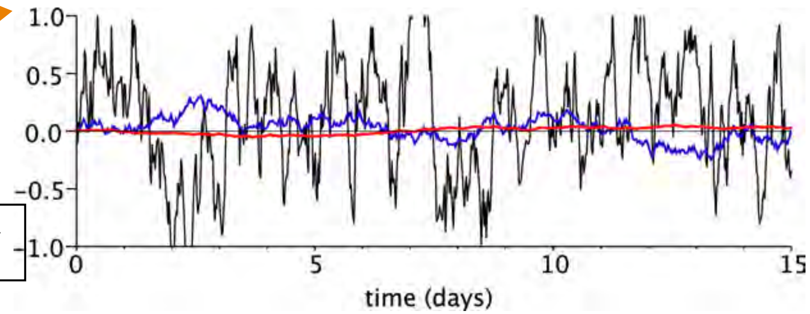
- Model error might arise from a misrepresentation of physical processes on unresolved subgrid-scales.

- Lorenz (1975) : *the ultimate climate models will be stochastic, i.e., random numbers will appear somewhere in the time derivatives.*

<u>Stochastically perturbed physical tendency</u>

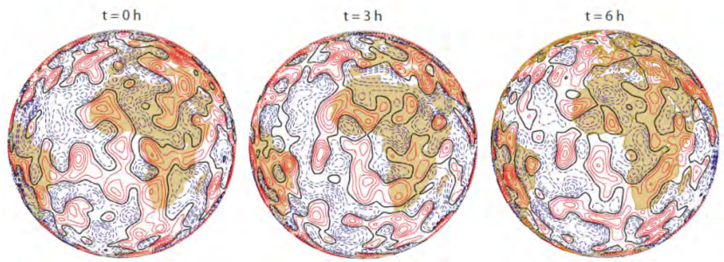
$$X_p = (1 + r_X)X_c$$

Random number



Total parameterized tendency

➔ In medium-range and seasonal prediction,
1) broad ensemble spread
2) reduced outlier



From Buizza et al. (1999) and Palmer et al. (2009)

Why stochastic dynamics?

- Approximation in governing equation
- Computational representation of governing equations, (i. e. spatial and temporal truncation)
- Heterogeneous momentum forcing at a given grid
- Physics : "*unknowns*" dynamics: "*Uncertain*"

↓

Stochastically perturbed dynamical tendency

Koo and Hong (APJAS, 2014)

Perturbed model tendencies

Nonlinear tendency

Linear tendency (spectral)

$$\frac{\partial \chi}{\partial t} = \underbrace{[N + L]}_{D} + P$$

Dynamical tendency Physical tendenc y

T

Total tendency

Random number

$$N_j' \equiv \langle r_j \rangle_\chi N(\chi^n)$$

$$D_j' \equiv \langle r_j \rangle_\chi \left[\frac{\chi_j^{+} - \chi_j^{n-1}}{2\Delta t} \right]$$

$$P_j' \equiv \langle r_j \rangle_\chi \left[\frac{\chi_j^{n+1} - \chi_j^{+}}{2\Delta t} \right]$$

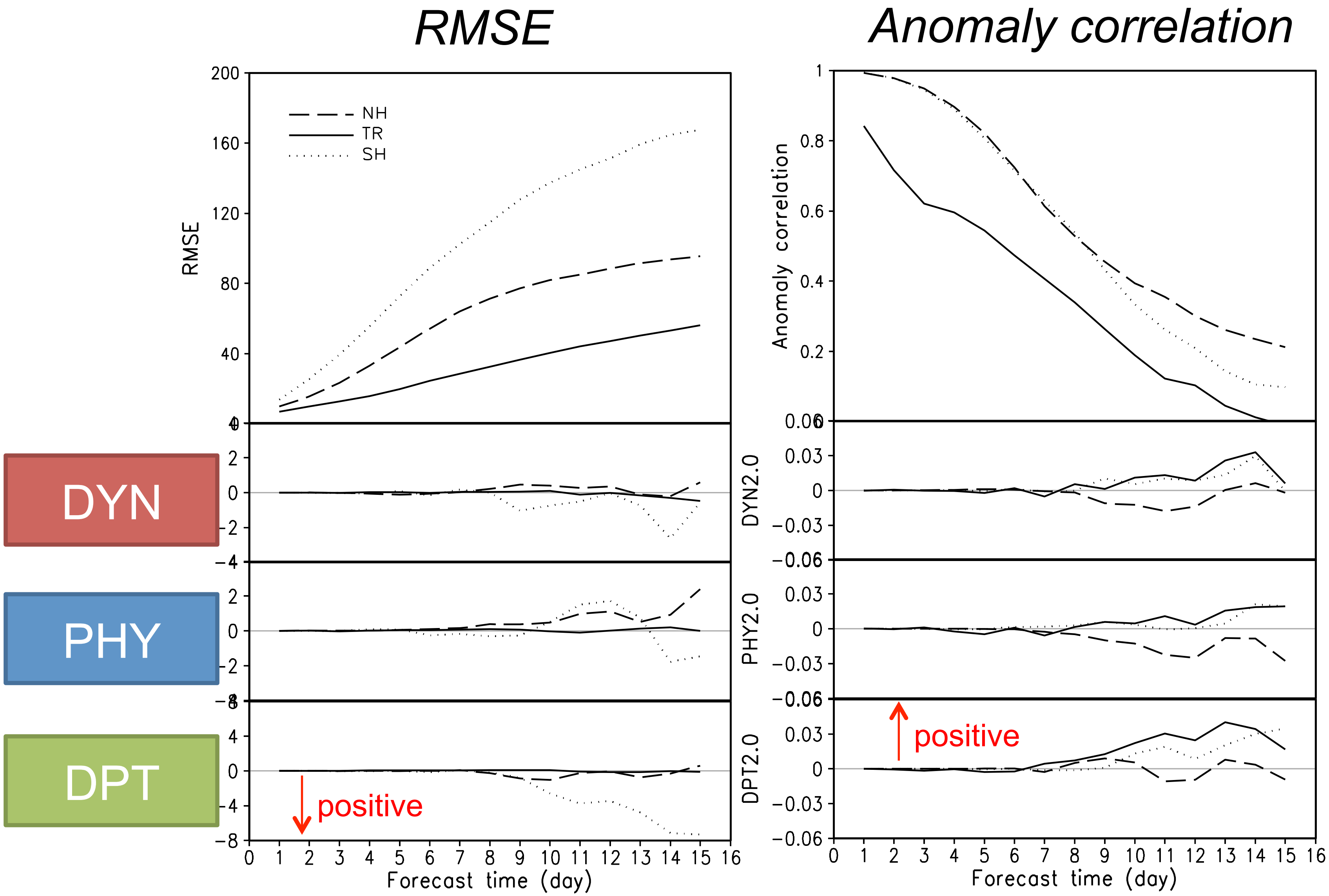
$$T_j' \equiv \langle r_j \rangle_\chi \left[\frac{\chi_j^{n+1} - \chi_j^{n-1}}{2\Delta t} \right]$$

*** Forcing strength is controlled by random int erval (I=0.1, 0.2, 0.5, 1.0, and 2.0)**

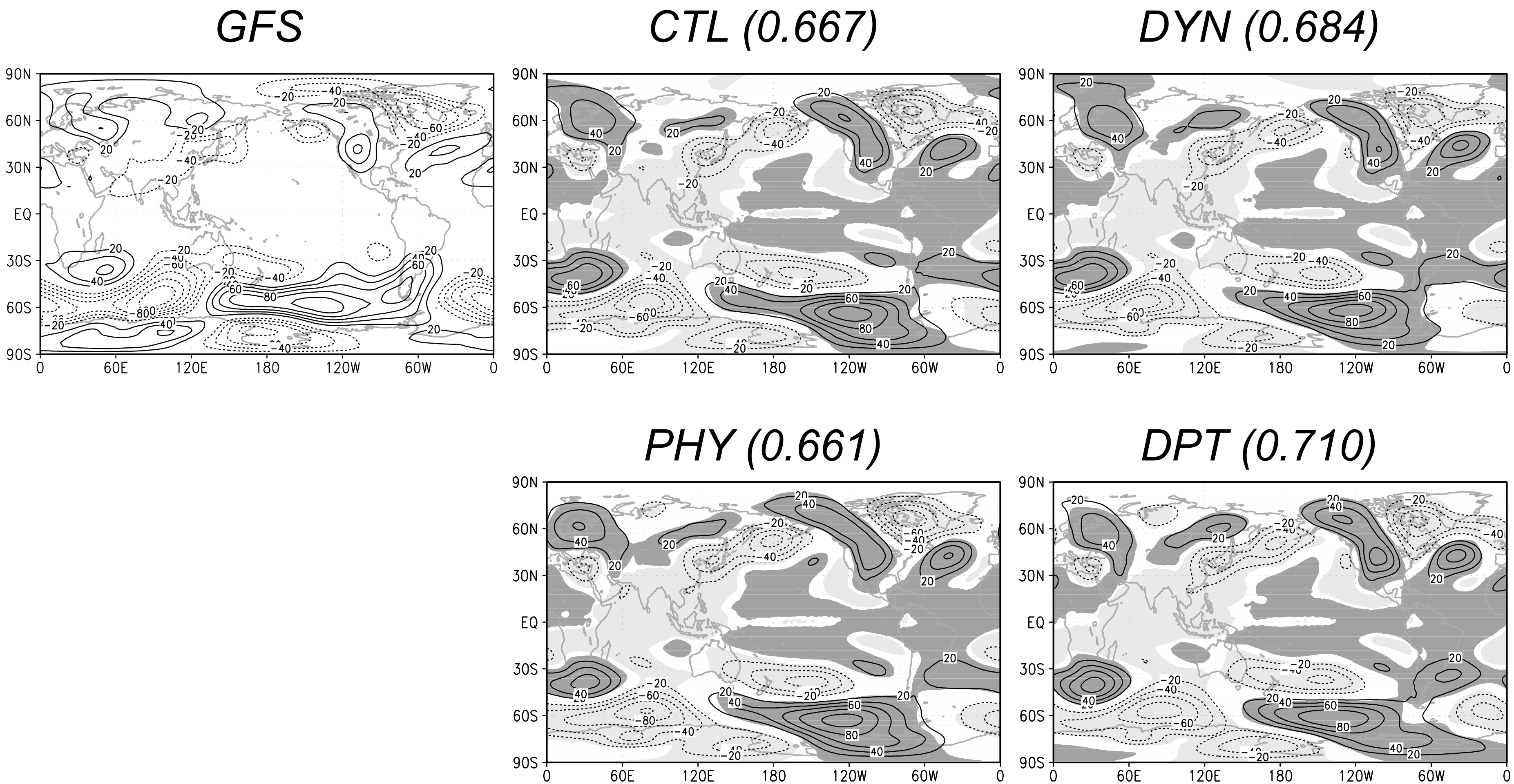
$$ex)\;\; I = 1.0:\;\; r_j \in [0.50, 1.50]$$

$$I(\eta, t) = \begin{cases} I_{\max} e^{\eta - 1} e^{\frac{t - t_r}{3}}, & if\ t \le t_r \\ I_{\max} e^{\eta - 1}, & if\ otherwise \end{cases}$$

Forecast skill in 500 hPa geopotential height (August 2010)



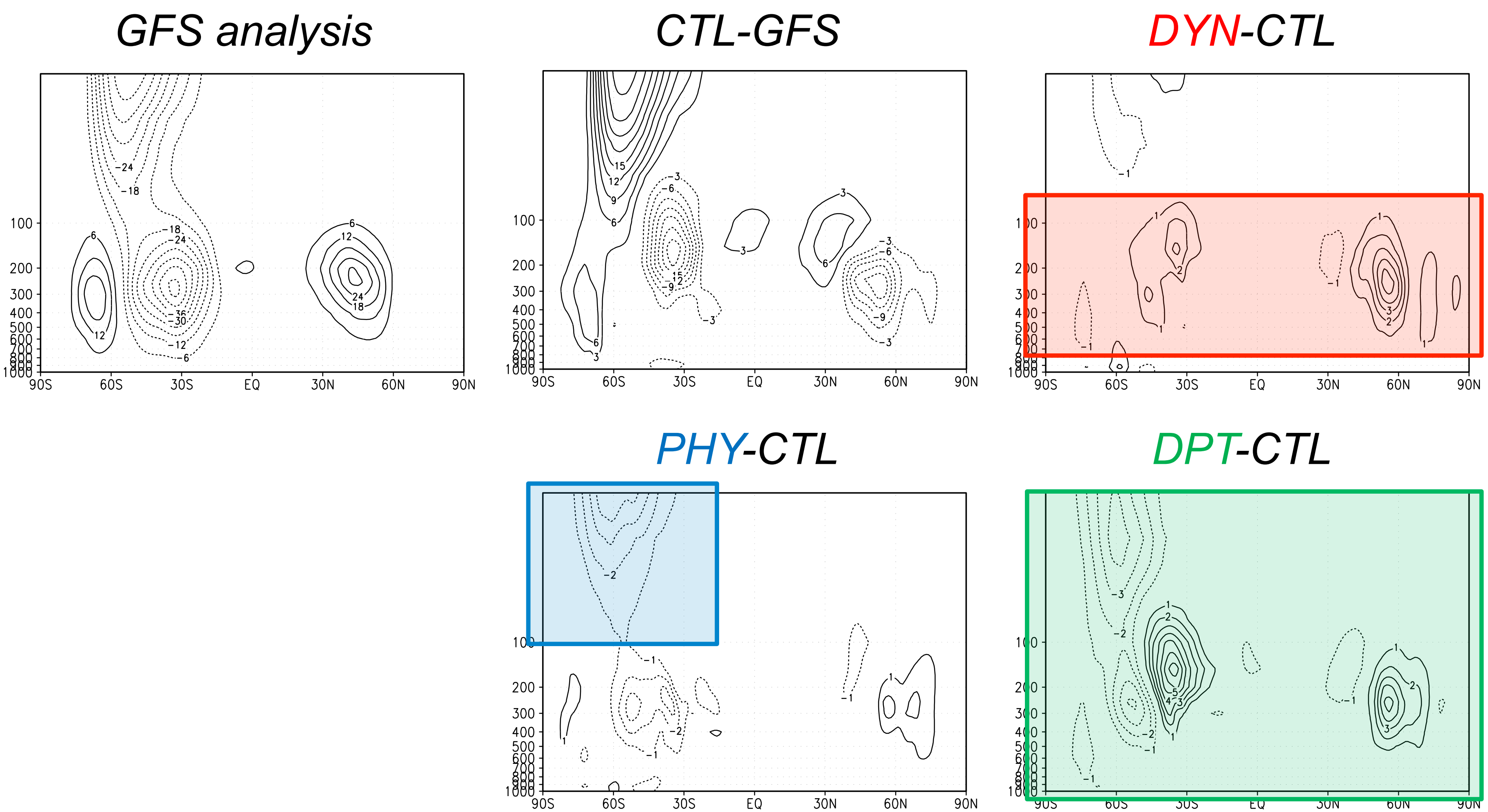
Standing eddy of 500 hPa geopotential height
: JJA 1996



contour: standing eddy
shading: 95% confidence level

DPT > DYN > CTL > PHY

Transient eddy momentum flux (u'v') for JJA 1996



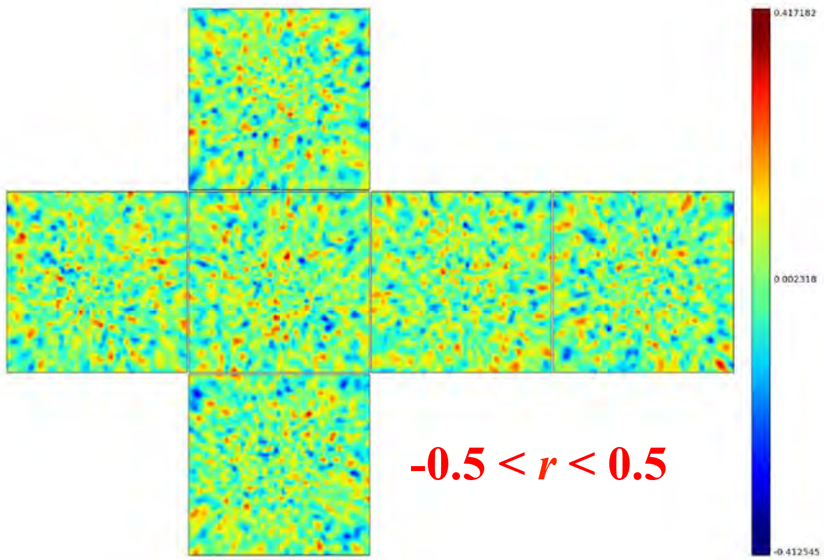
Seasonal Simulation (2017 JJA)

* To see stochastic effect in ocean-atmos coupling

- 01 May 2017 : MJJA (4-mon integration)
  * JJA for analysis
- 5 ensemble members

EXP	Description
CNTL	KIM3.2 (about 100 km resolution)
STOC	CNTL + Stochastically parameter perturbing (ch, cm only over ocean)

Random forcing to surface exchange coefficient



$$u^{*} = \sqrt{C_m(1+r)}\left|\vec{U}\right|$$

$$SH = \rho C_p C_h (1+r)\Delta\theta\left|\vec{U}\right|$$

$$LH = \rho C_h (1+r)\Delta q\left|\vec{U}\right|$$

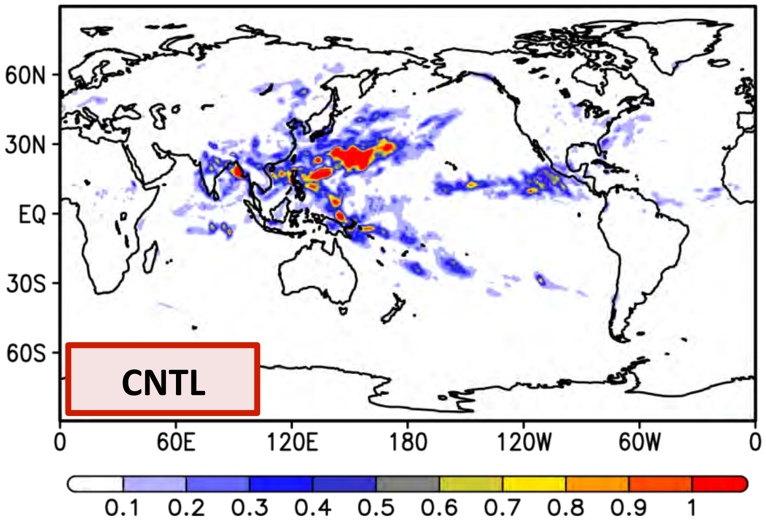
- **Stochastic perturbation to ocean surface**

  1) perturbed parameter : C_m, C_h over oceans
  2) Length scale : 100 km
  3) time decorrelation : 6 hour
  4) standard deviation : 0.5

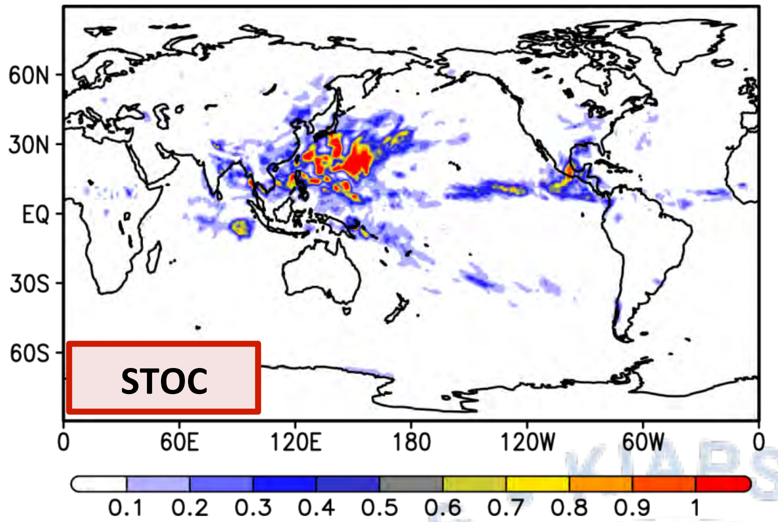
Stochastically perturbed forcing
Ollinaho et al. 2017

Precipitation Variance

[cntl] JJA Rain Variance

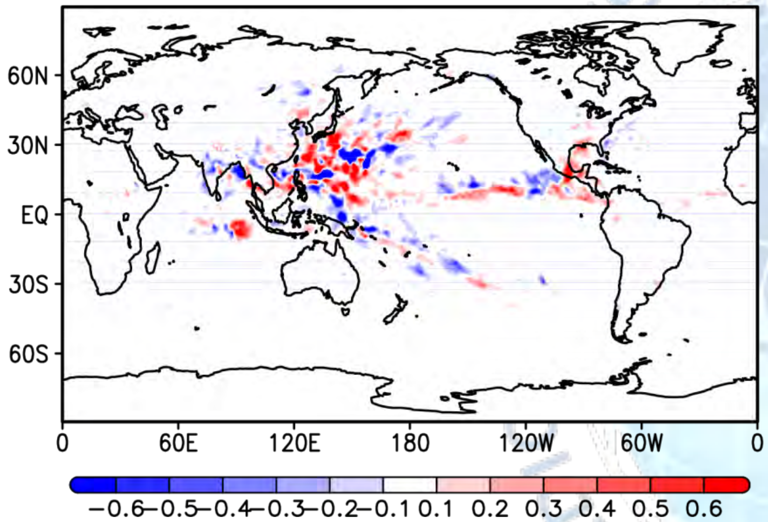


[stoc] JJA Rain Variance



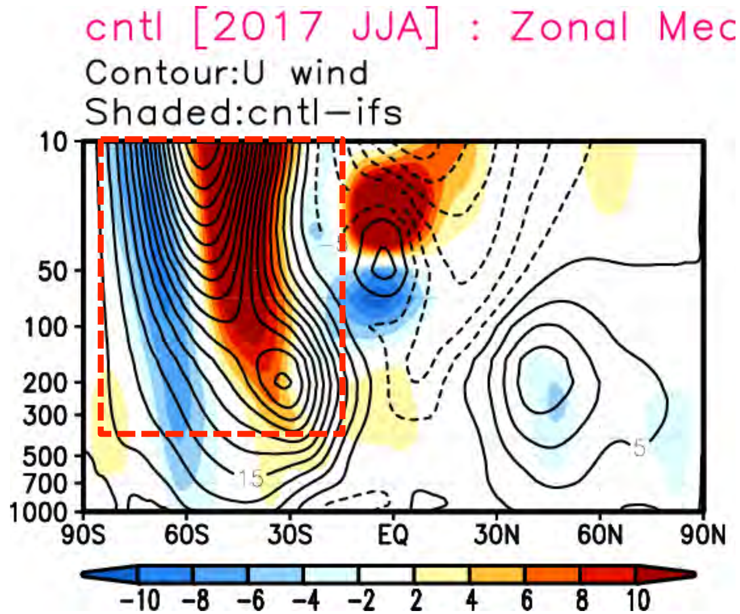
STOC - CNTL

[stoc−cntl] JJA Rain Variance Diff

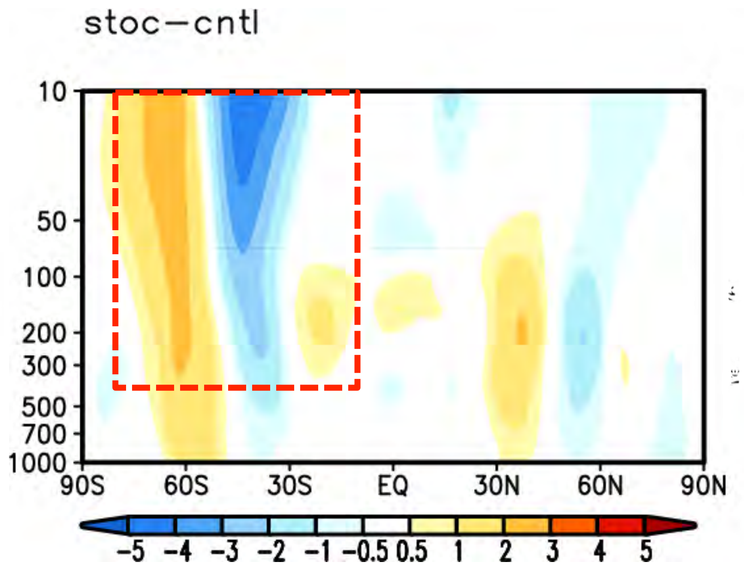


Zonal Mean Bias

CNTL-IFS

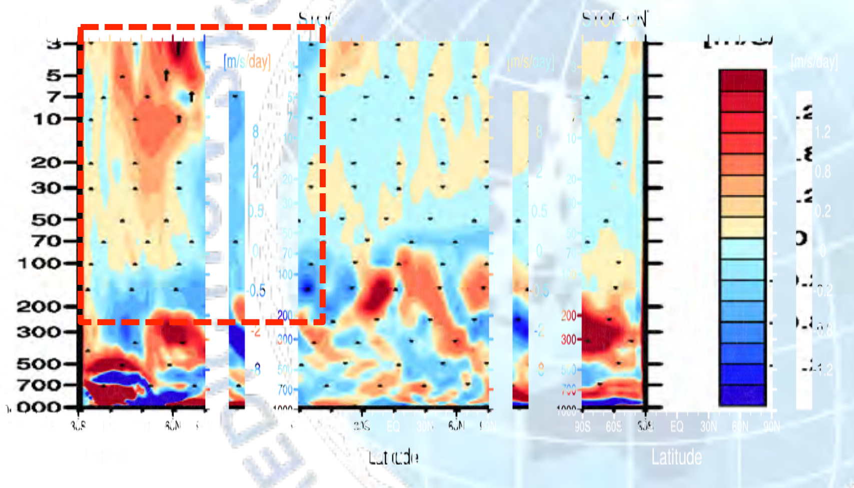


STOC-CNTL



Negative EP divergence in jet region
➔ weakening of westerly flow
➔ Polar shift of planetary waves :

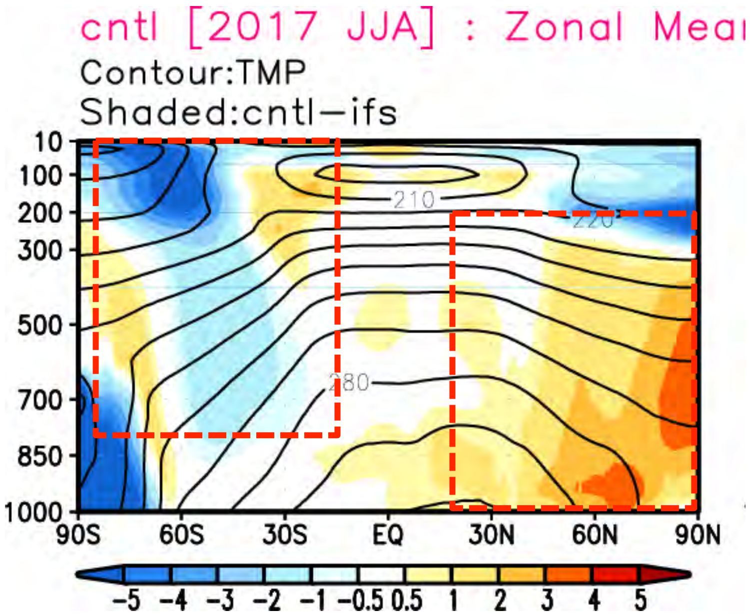
* vector : EP flux vector
* shading : EP divergence



KIAPS

Temperature

CNTL-IFS



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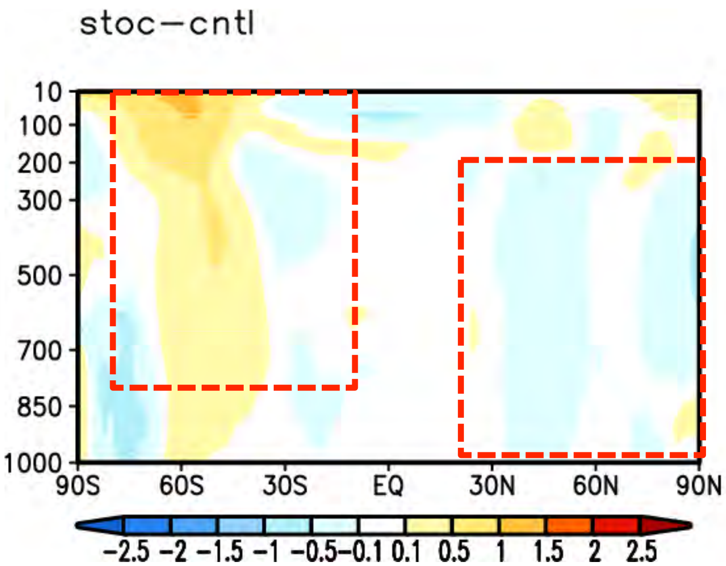
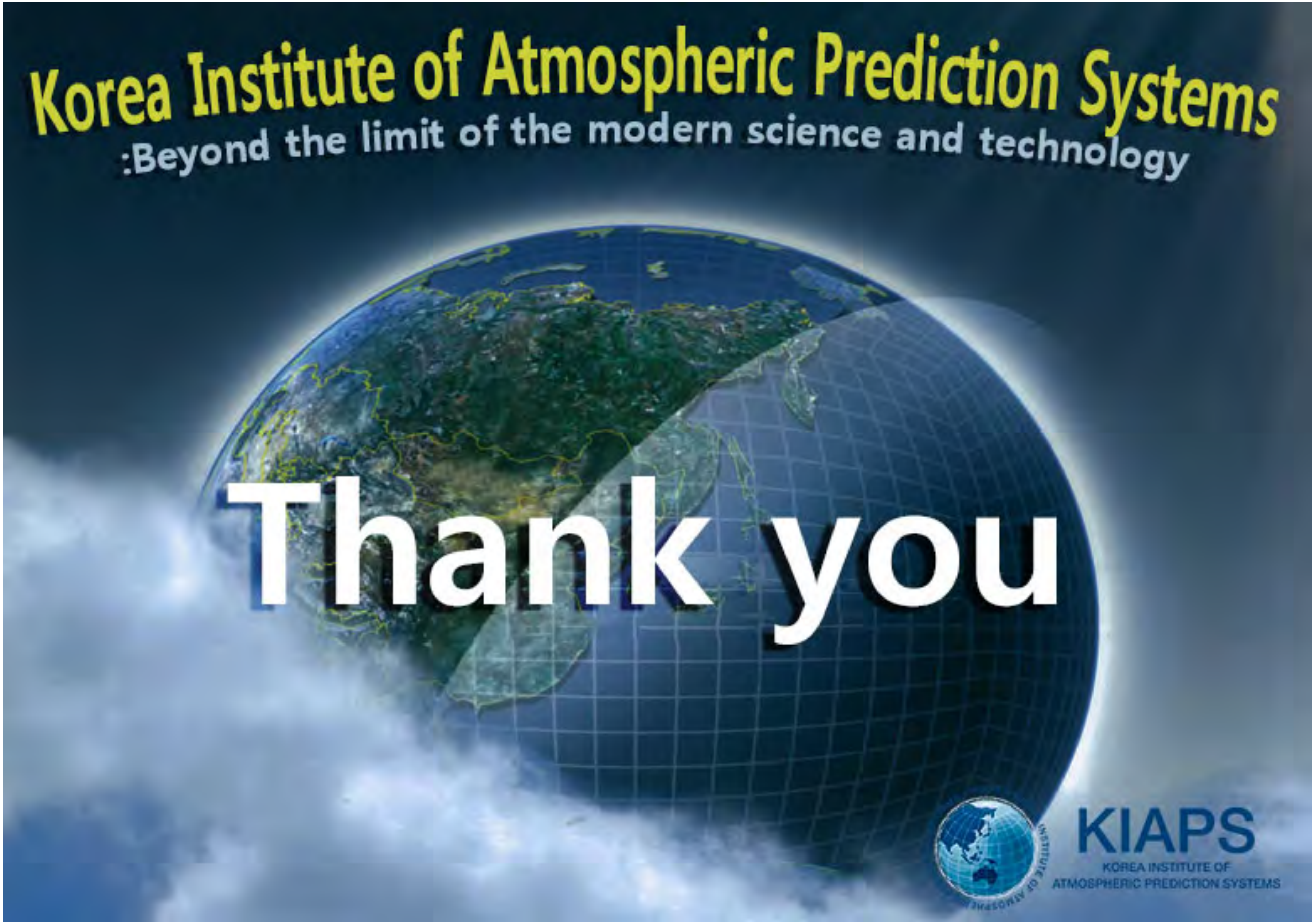


Temperature bias was a lso improved …. by the improvement of wind fie lds...

Stochastic perturbation is needed….

The issue is how to app ly …


Korea Institute of Atmospheric Prediction Systems
:Beyond the limit of the modern science and technology
Thank you
KIAPS
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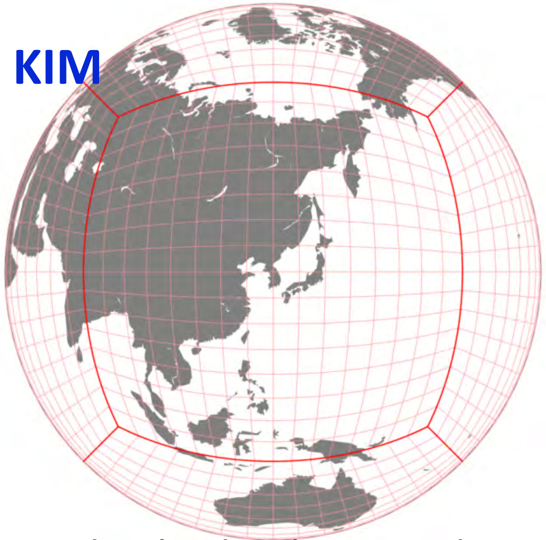
ATMOSPHERIC PREDICTION SYSTEMS

KIM-HYCOM Coupling

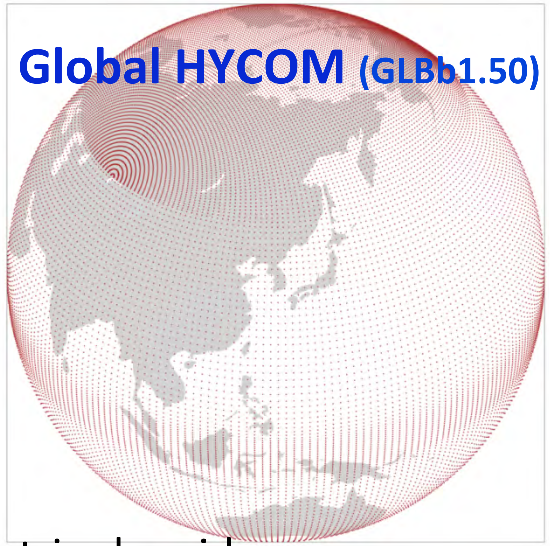
KIM



MCT-based Coupler

* Remap
* Variable exchanges

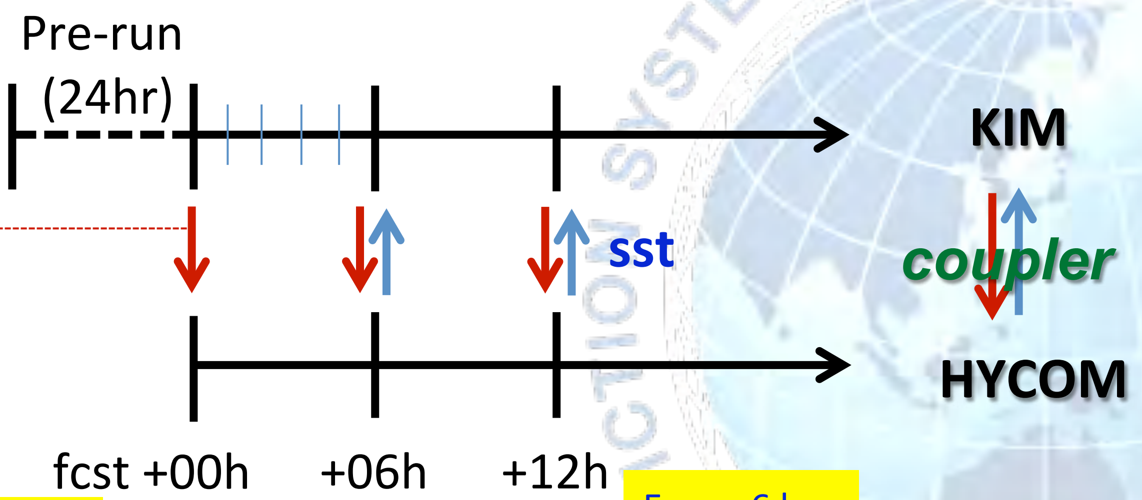
Global HYCOM (GLBb1.50)



- rotated cubed-sphere grid centered Korean Peninsula in the cube panel

- tripole grid
- Insert bi-polar patch in north pole

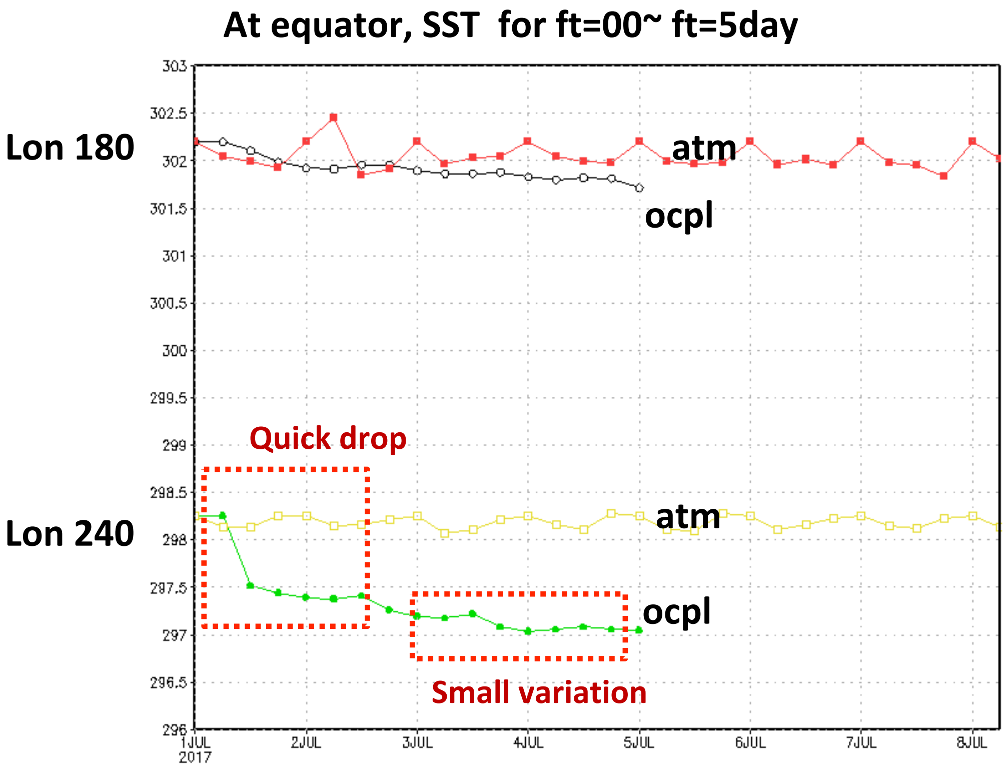
net sw flux, net rad flux, wind stress (avg), precipitation,
water vapor mixing ratio, wind speed



Skip receiving sst at intial

Every 6 hr

Coupling Issues



(1) Need to use ocean reanalysis as an temperature initial con. (currently climatology used), but hard to inter polate (hycom uses hybrid coordin ate)

(2) Need to check another bug for dec reasing SST and small diurnal cycle.

(3) HYCOM GLBb version does not exp ect serious results. (just for test) Considering to replace with NEMO.