Typhoon Simulation Using the 3-Dimensional Atmosphere-Ocean Regional Coupled Model, CReSS-NHOES

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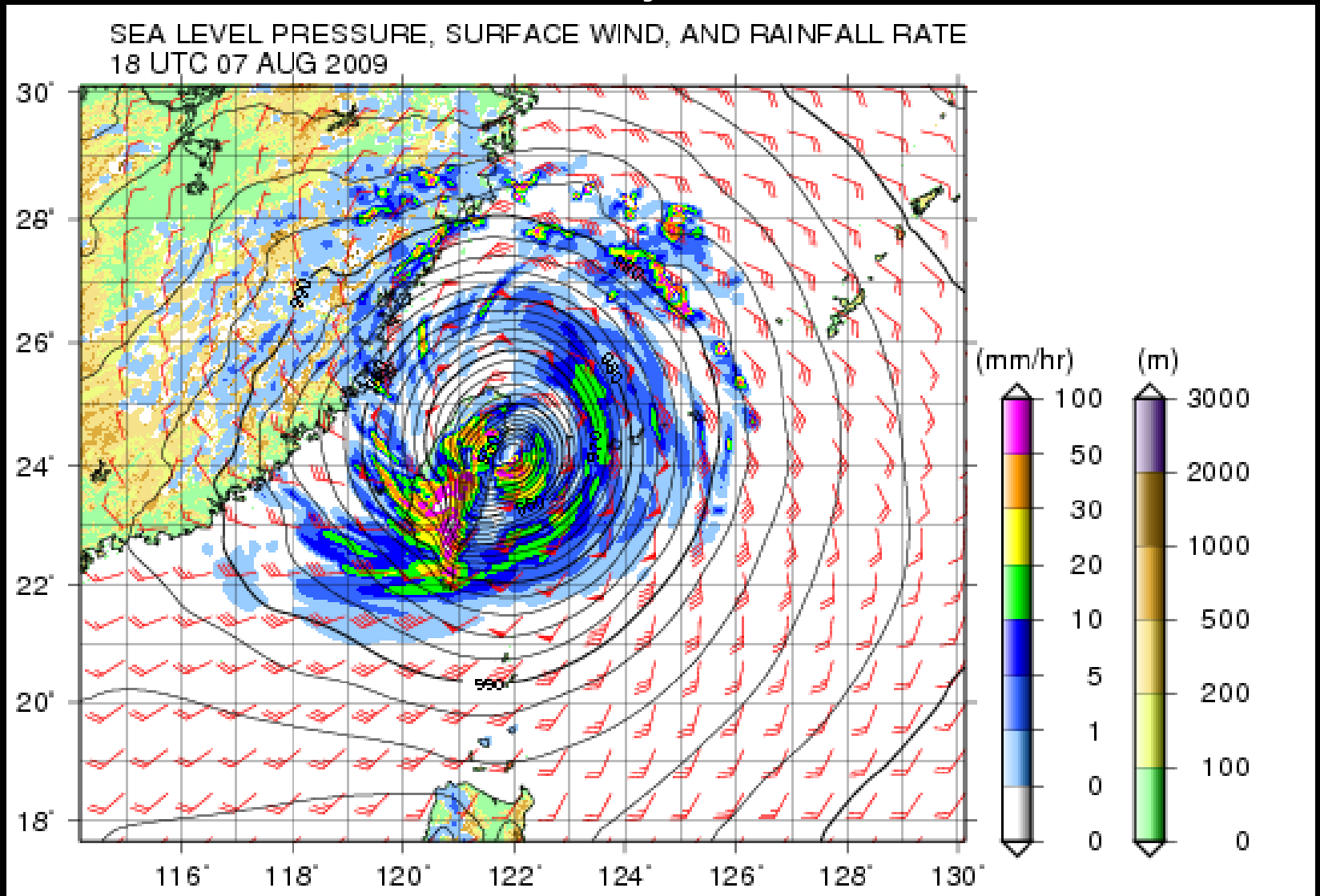
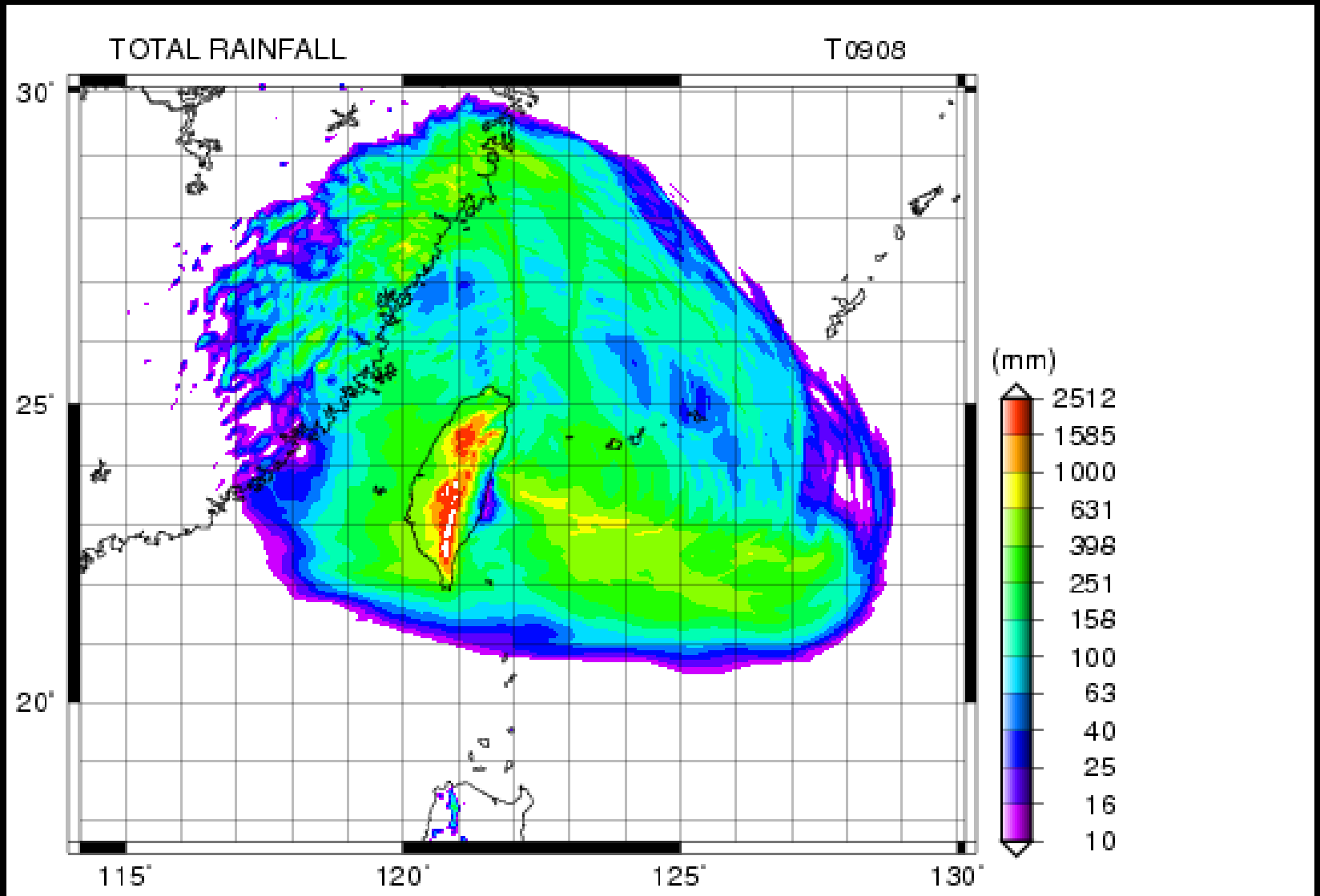
Motivation

- We have simulated **Typhoon Morakot (T0908) using the CReSS** to test the framework of the daily simulation for the SoWMEX2010.



Motivation

- **Maximum accumulated rainfall amount during this simulation reaches over 4300 mm around the CMR over Taiwan Island.**



Motivation

- **Maximum accumulated rainfall amount during this simulation reaches over 4300 mm around the CMR over Taiwan Island.**
- **This rainfall amount should overestimate the observed one (about 3000 mm).**

- **What are causes of the overestimation of accumulate rainfall amount?**
  - *** Cloud microphysics?（Suggestion from Dr. W.-K. Tao)**
  - *** Air-sea interaction?**

→ We focus on the air-sea interaction in this study.

- **The CReSS uses the slab-ocean scheme that solve the equation of heat conduction under the sea surface, but the initial vertical profile of temperature gives constant same as the prescribed SST.**
- **This scheme is not realistic that SST is not decreasing by the warm water upwelling.**

What's the CReSS-NHOES

- Dr. Aiki of JAMSTEC develop **a three dimensional regional atmosphere-ocean coupled model in non-hydrostatic system**, **CReSS-NHOES**.
- The model is developed to use investigations

  for **an effect of air-sea interaction**

  under the typhoon condition.
- **An intense typhoon should changed the SST distribution**, e.g., central pressure, wind speed, **rainfall amount**.
- **Upwelling** (coastal upwelling) after typhoon passage should be caused by the oceanic mixed-layer cooling, and changes the SST distribution.

Models: CReSS and NHOES

- **The Cloud Resolving Storm Simulator (CReSS)**

  To simulate mesoscale atmospheric phenomena

  developed by Tsuboki and Sakakibara (2002)

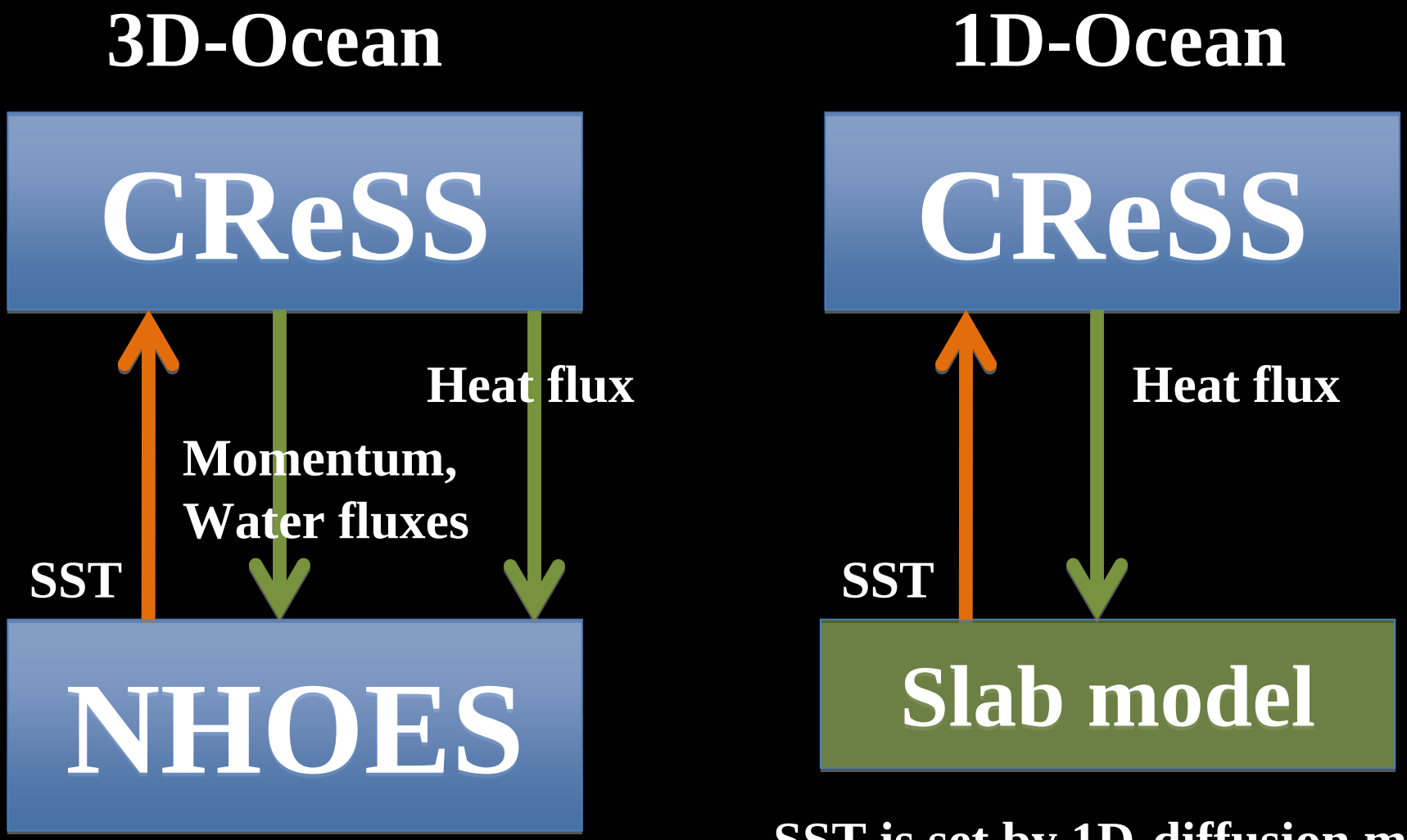
- **The NonHydrostatic Ocean model for ES (NHOES)**

  To simulate oceanic phenomena developed by

  Aiki and Yamagata (2004), Aiki et al. (2006),

  Menesguen et al. (2009)

  - **Three dimensional nonhydrostatic ocean model**
  - **Hybrid terrain-following and z-level system**
  - **Vertical mixed layer scheme near the surface is a simple diagnostic form based on *Ri*.**
  - **Wave model is not included in this framework.**


3D-Ocean
CReSS
Heat flux
Momentum,
Water fluxes
SST
NHOES
SST cooled by entrainment
and Ekman upwelling
1D-Ocean
CReSS
Heat flux
SST
Slab model
SST is set by 1D-diffusion model
No entrainment and
Ekman upwelling

Hypothesis applied 3-D ocean model

- **We hypothesized that accumulated rainfall amount reduce by using the CReSS-NHOES model compared with the 1-D ocean model.**

  (1) 3-D ocean model should activate upwelling and reduce SST.

  (2) Cooler SST should reduce LHF from the sea surface.

  (3) Reduced water vapor amount should reduce central minimum pressure and also reduce rainfall amount around typhoons.

Typhoon Experiments T0908 (Morakot)

T0908, Morakot experiments

● CReSS

- Resolution: **Hor. 4 km**, Ver. 200 m (surface) to 400 m (stretched)
- Domain: 512 x 256 x 64 grids, DT: = 4 sec.
- Initial and lateral boundary condition: JMA/RANAL dataset
- Simulation starts at 00 Z on **August 5**, 2009 and continues **120 hrs**.

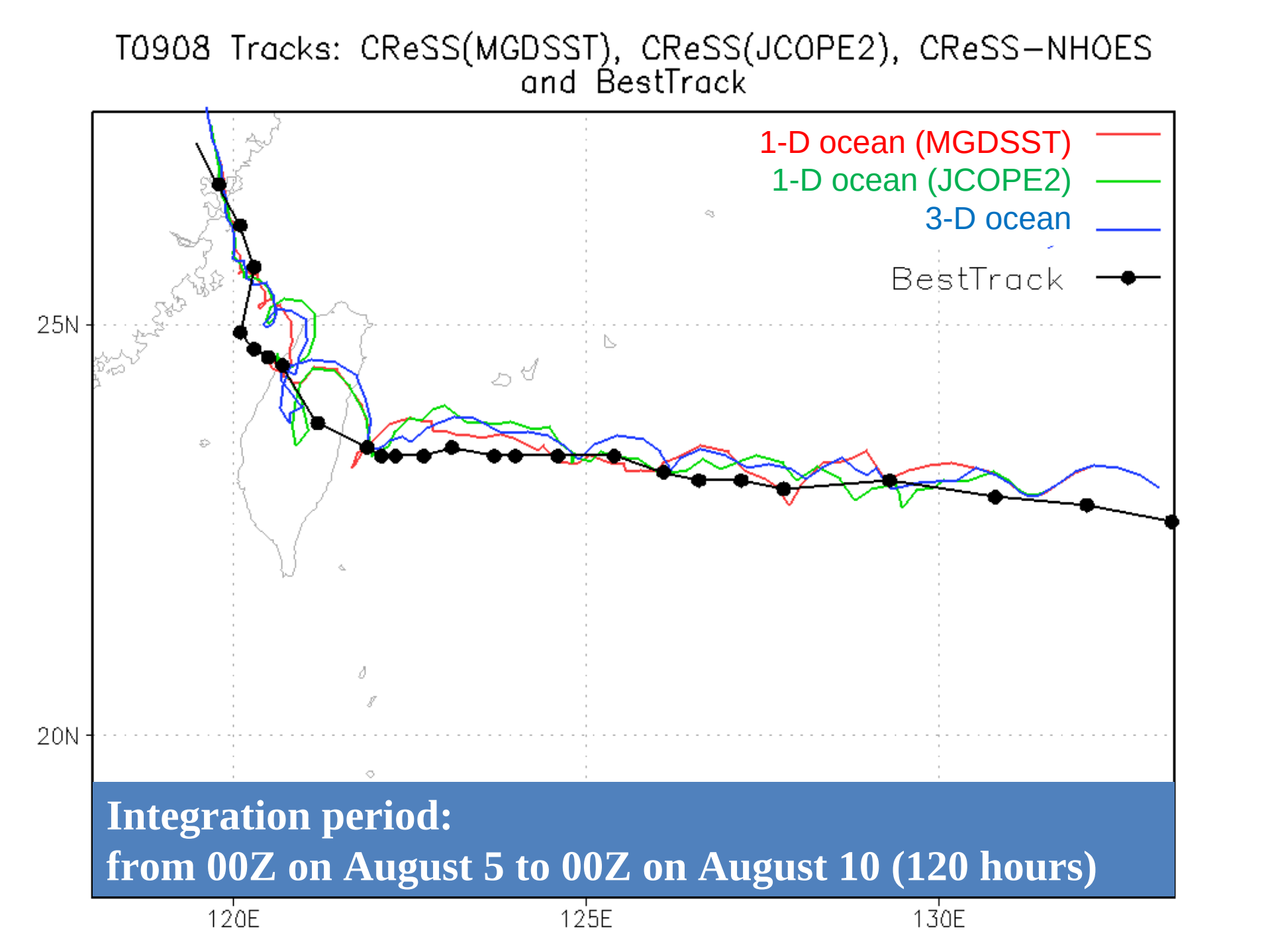
1. 3-D ocean: NHOES

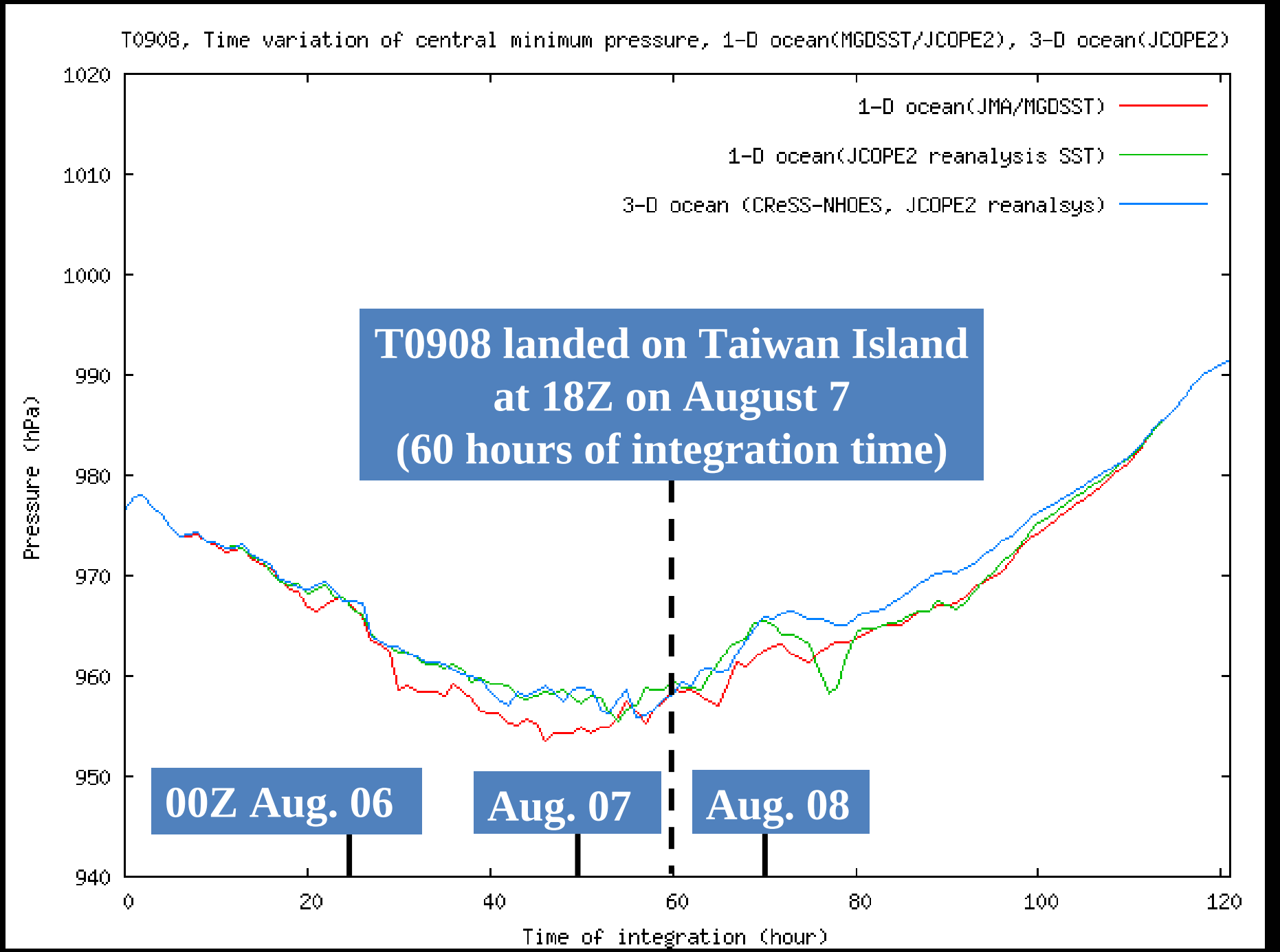
- Resolution: Hor. 4 km, Ver. 2 m for top 100 m (4000m depth)
- Domain: 512 x 256 x 100 grids
- Initial and lateral boundary condition: **JCOPE2 reanalysis**
  (3-D, lateral resolution of 1/12 degree)

2. 1-D ocean: JCOPE2 reanalysis SST

3. 1-D ocean: MGDSST

- Resolution: Hor. 0.25 deg., Ver. 0.5 m for top 30 m (60 layers)

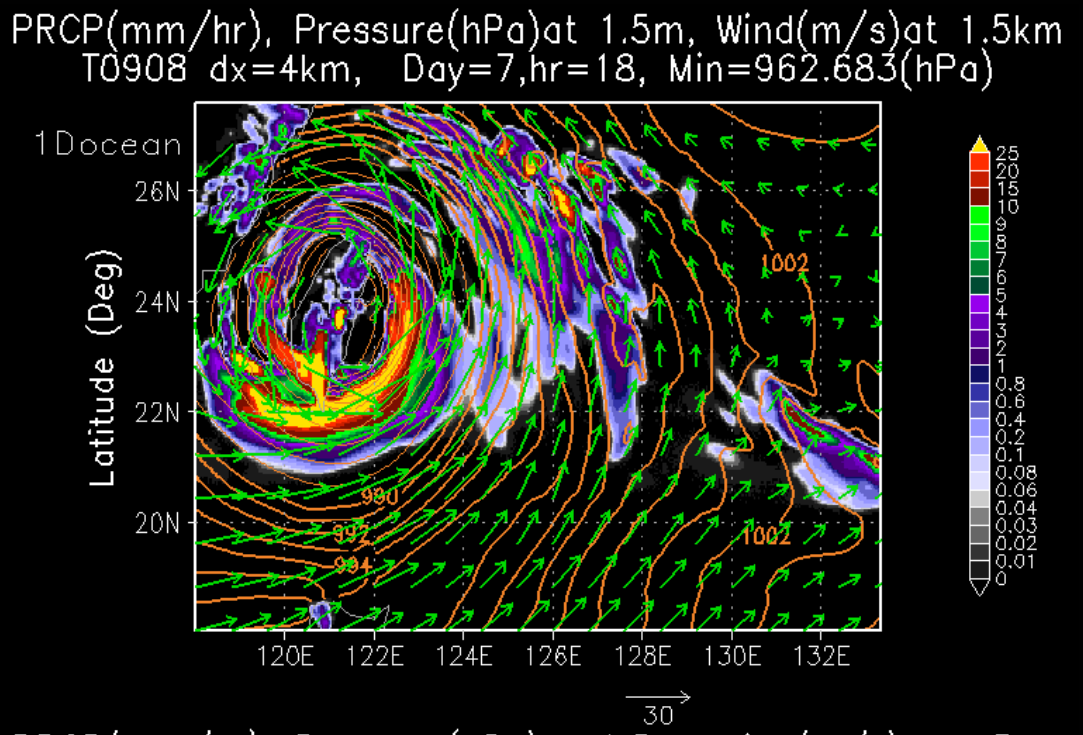

T0908 Tracks: CReSS(MGDSST), CReSS(JCOPE2), CReSS-NHOES and BestTrack
1-D ocean (MGDSST)
1-D ocean (JCOPE2)
3-D ocean
BestTrack
25N
20N
120E
125E
130E
Integration period:
from 00Z on August 5 to 00Z on August 10 (120 hours)

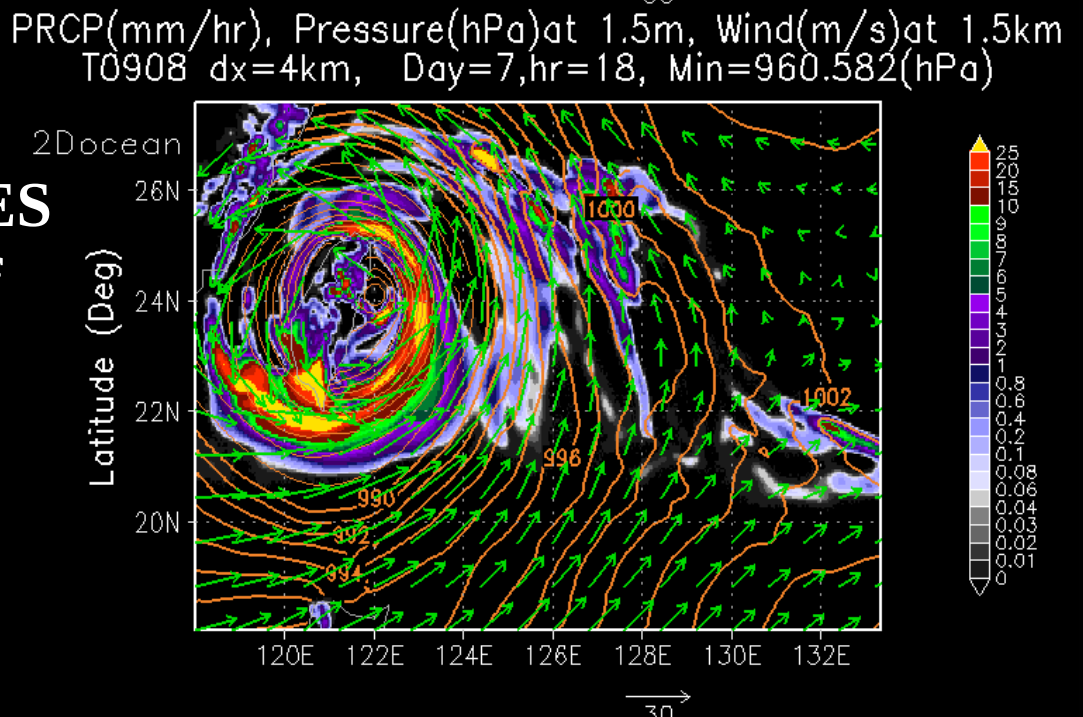

T0908, Time variation of central minimum pressure, 1-D ocean(MGDSST/JCOPE2), 3-D ocean(JCOPE2)
1-D ocean(JMA/MGDSST)
1-D ocean(JCOPE2 reanalysis SST)
3-D ocean (CReSS-NHOES, JCOPE2 reanalsys)
T0908 landed on Taiwan Island
at 18Z on August 7
(60 hours of integration time)
00Z Aug. 06
Aug. 07
Aug. 08
Pressure (hPa)
Time of integration (hour)
1020
1010
1000
990
980
970
960
950
940
0
20
40
60
80
100
120

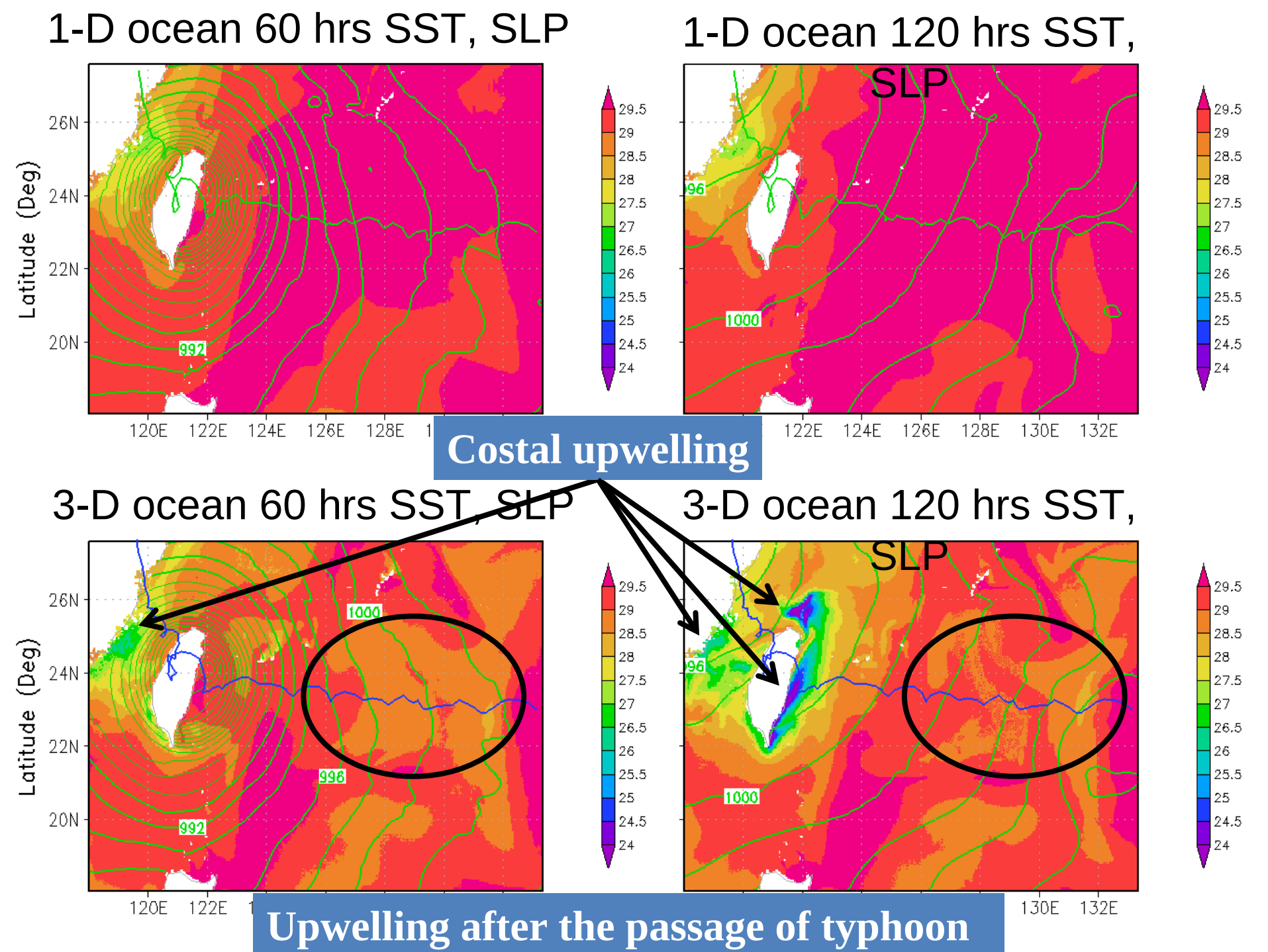
Surface precipitation (color)
Surface winds (arrows)
Sea-level pressure (contour)

60 hours starting from the simulation (at 18Z on August 7)

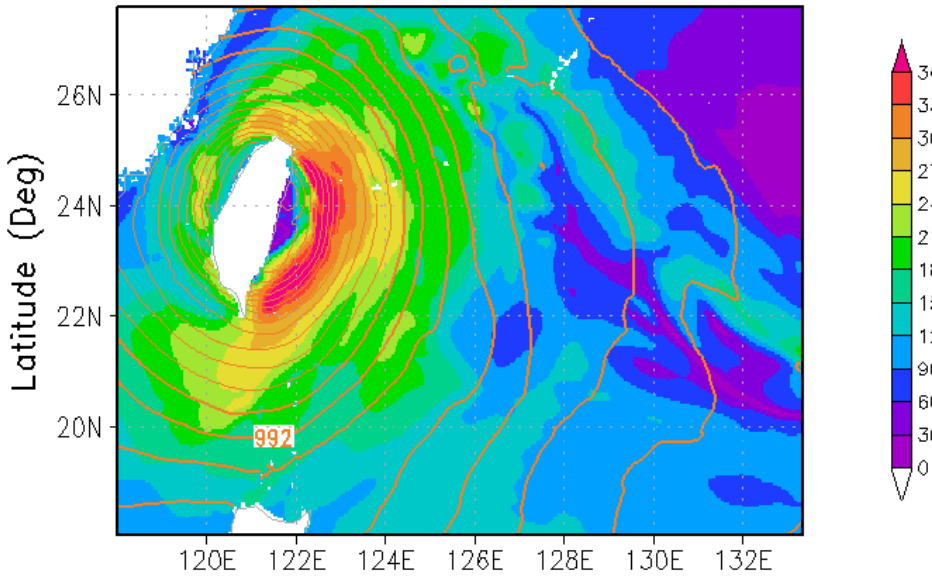
The pattern of rainfall distribution of the 3-D NHOES model is quite same to that of the 1-D slab ocean model.



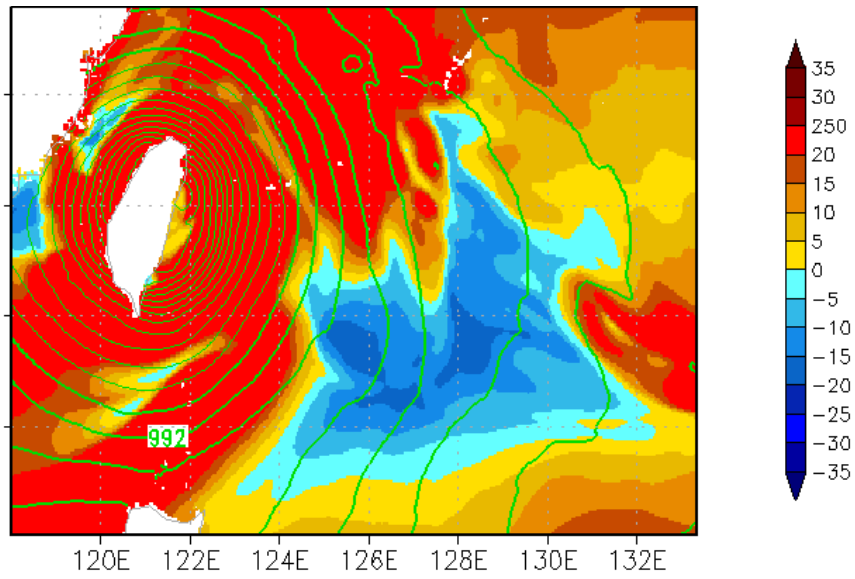



1-D ocean 60 hrs SST, SLP
1-D ocean 120 hrs SST, SLP
Costal upwelling
3-D ocean 60 hrs SST, SLP
3-D ocean 120 hrs SST, SLP
Upwelling after the passage of typhoon
Latitude (Deg)
26N
24N
22N
20N
120E
122E
124E
126E
128E
130E
132E
992
996
1000
29.5
29
28.5
28
27.5
27
26.5
26
25.5
25
24.5
24

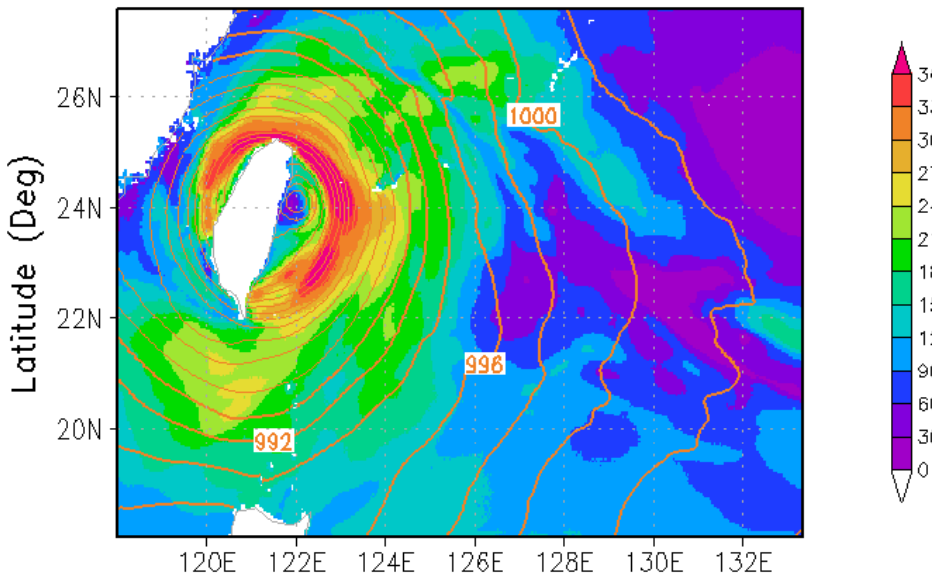
1-D ocean 60 hrs Latent Heat



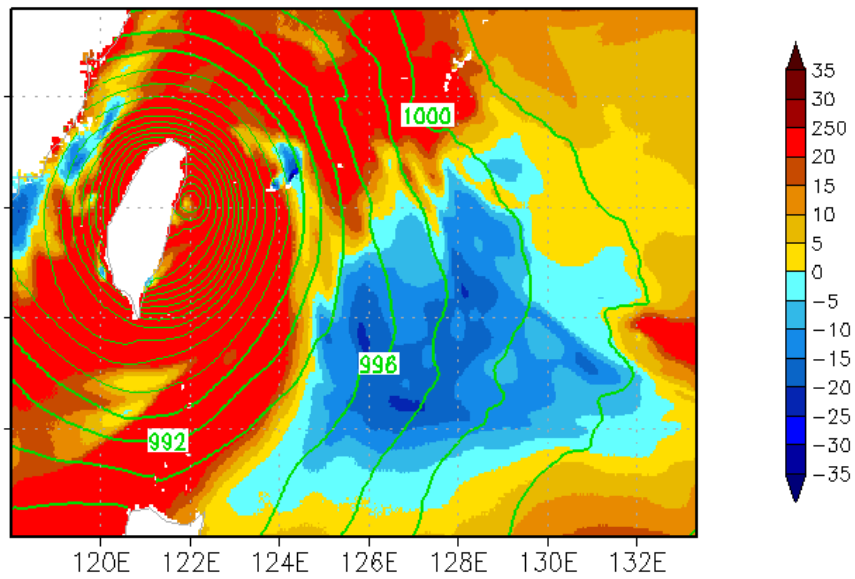
1-D ocean 60 hrs Sens. Heat



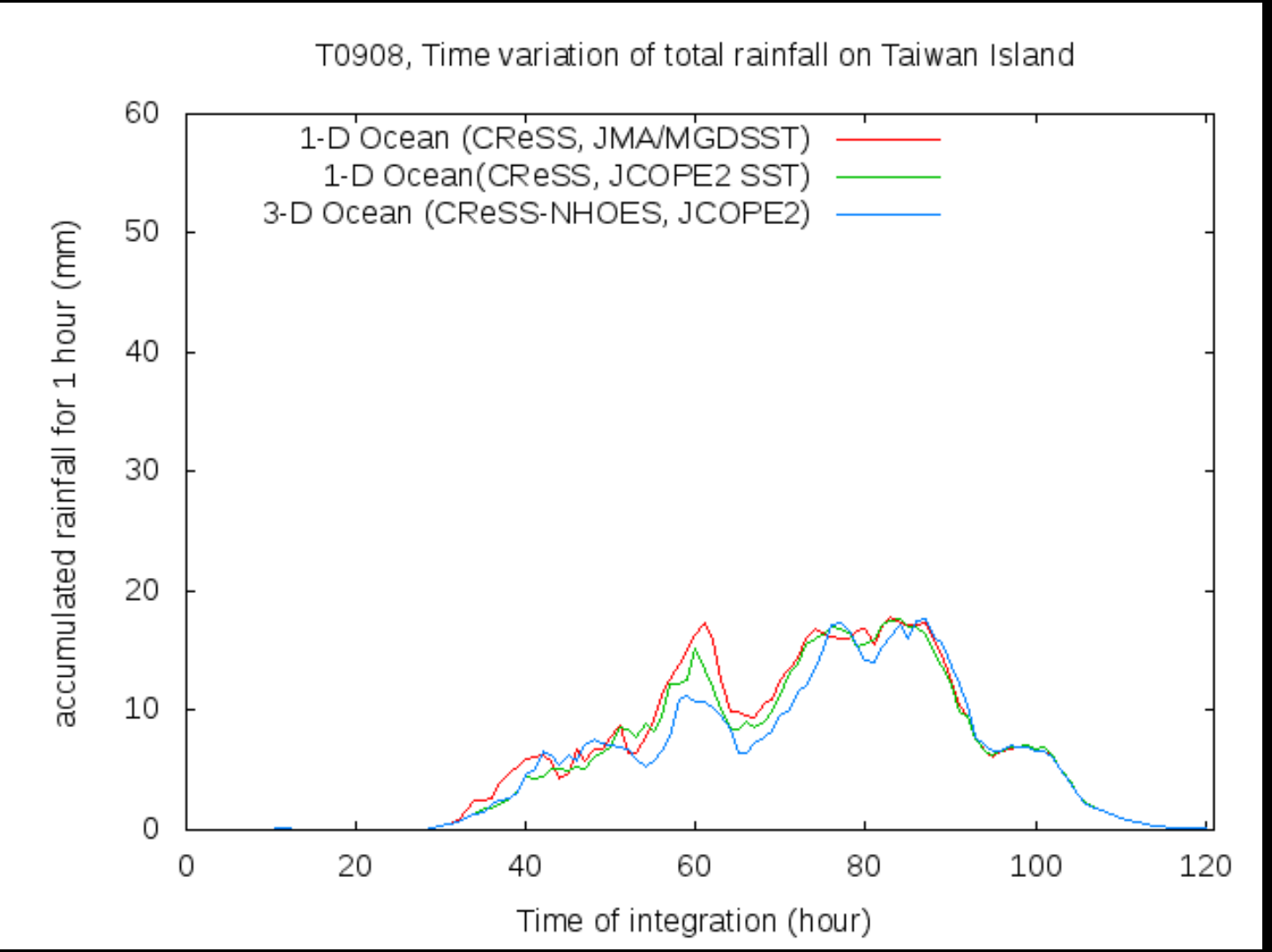
3-D ocean 60 hrs Latent Heat



3-D ocean 60 hrs Sens. Heat

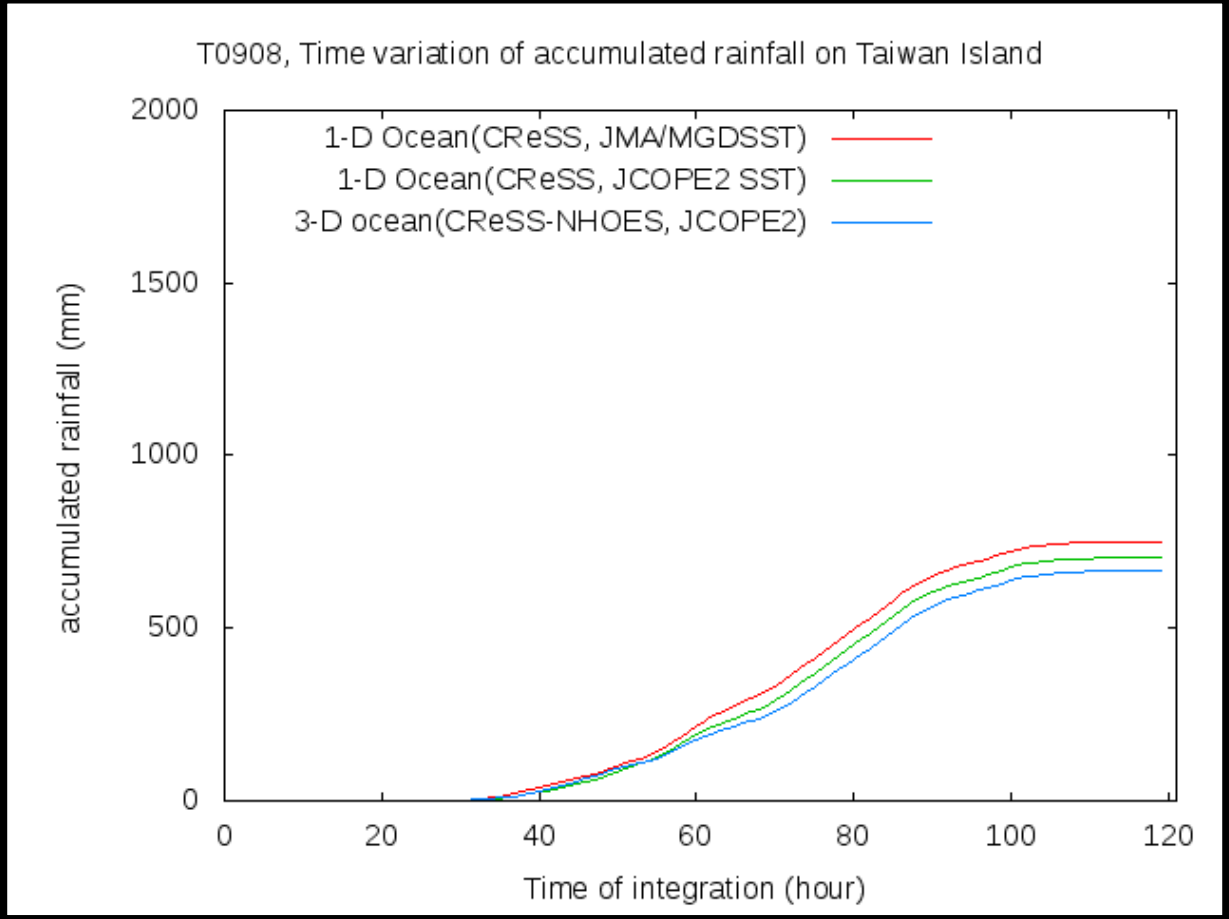


Time variation of hourly rainfall amount averaged all over Taiwan Island



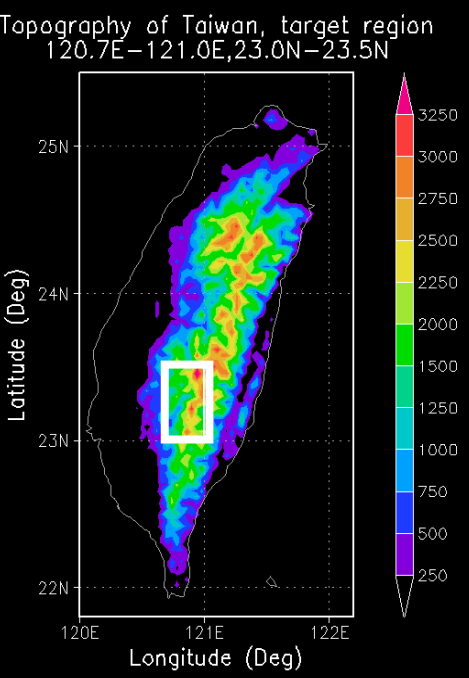
- **Hourly rainfall amount using the 3-D ocean model is decreasing a little compared with that 1-D ocean model from 50 to 80 hours.**

Time variation of accumulated rainfall amount averaged all over Taiwan Island

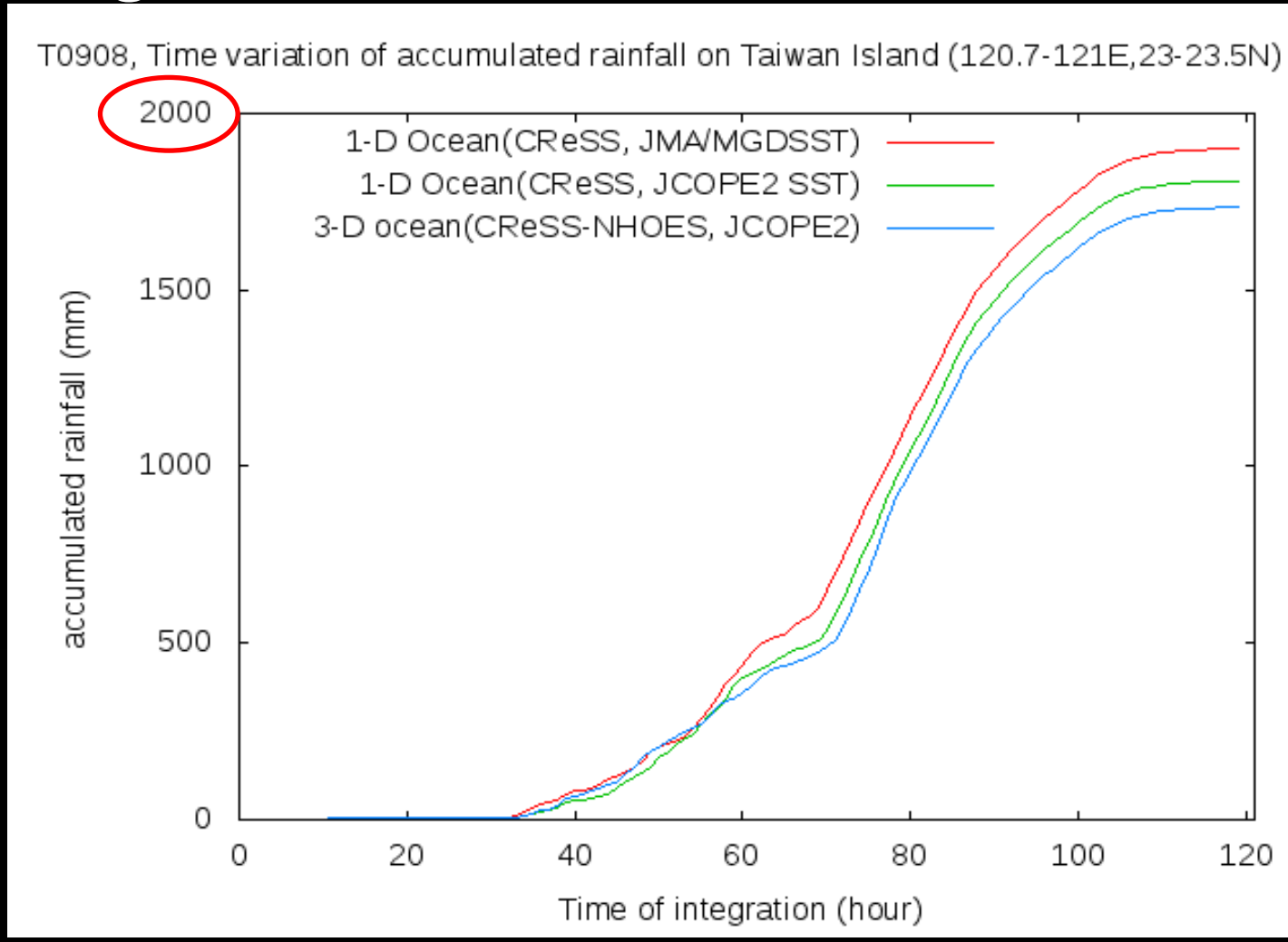


- Difference among these 3 experiments is significant in accumulated rainfall.
- Accumulated rainfall amount using the 3-D ocean model is decreasing compared with that 1-D ocean model.

Time variation of accumulated rainfall amount averaged over the western CMR

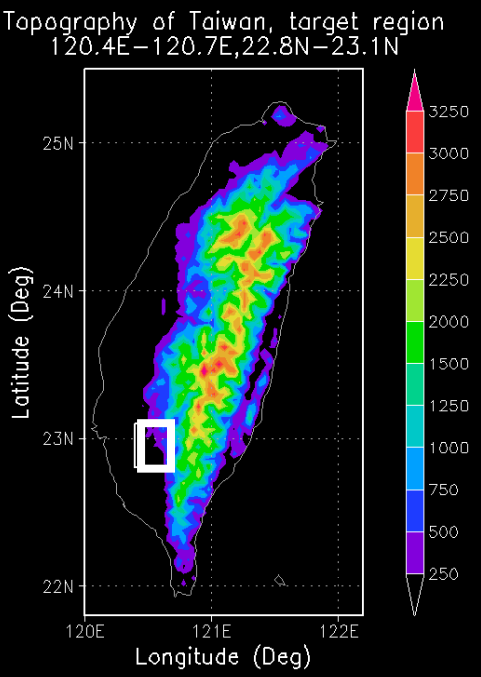


Color: topography

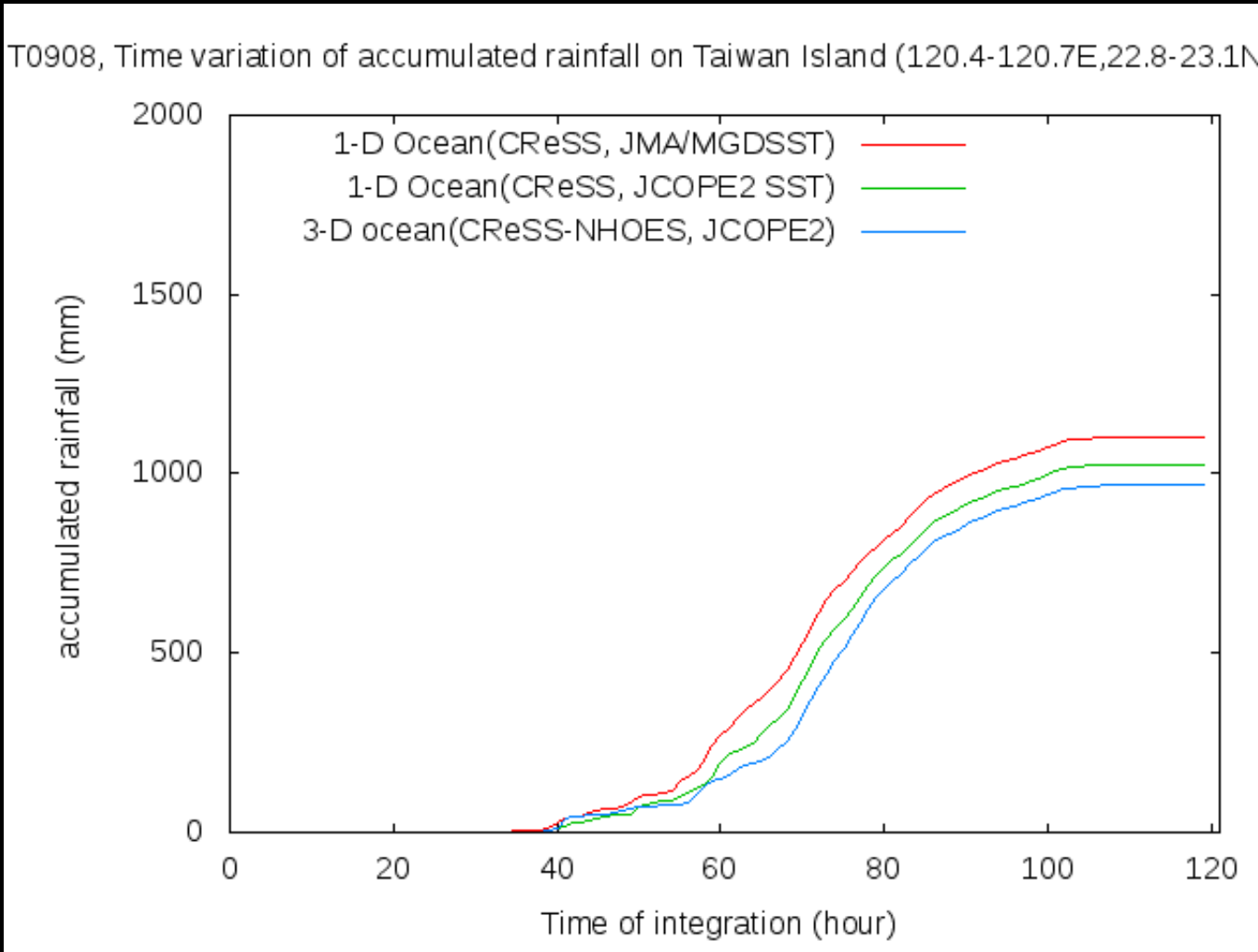


- **Accumulated rainfall amount averaged in this area using the 3-D ocean model is decreasing about 100 mm compared with that 1-D ocean model.**

Time variation of accumulated rainfall amount averaged over the foothill of western CMR

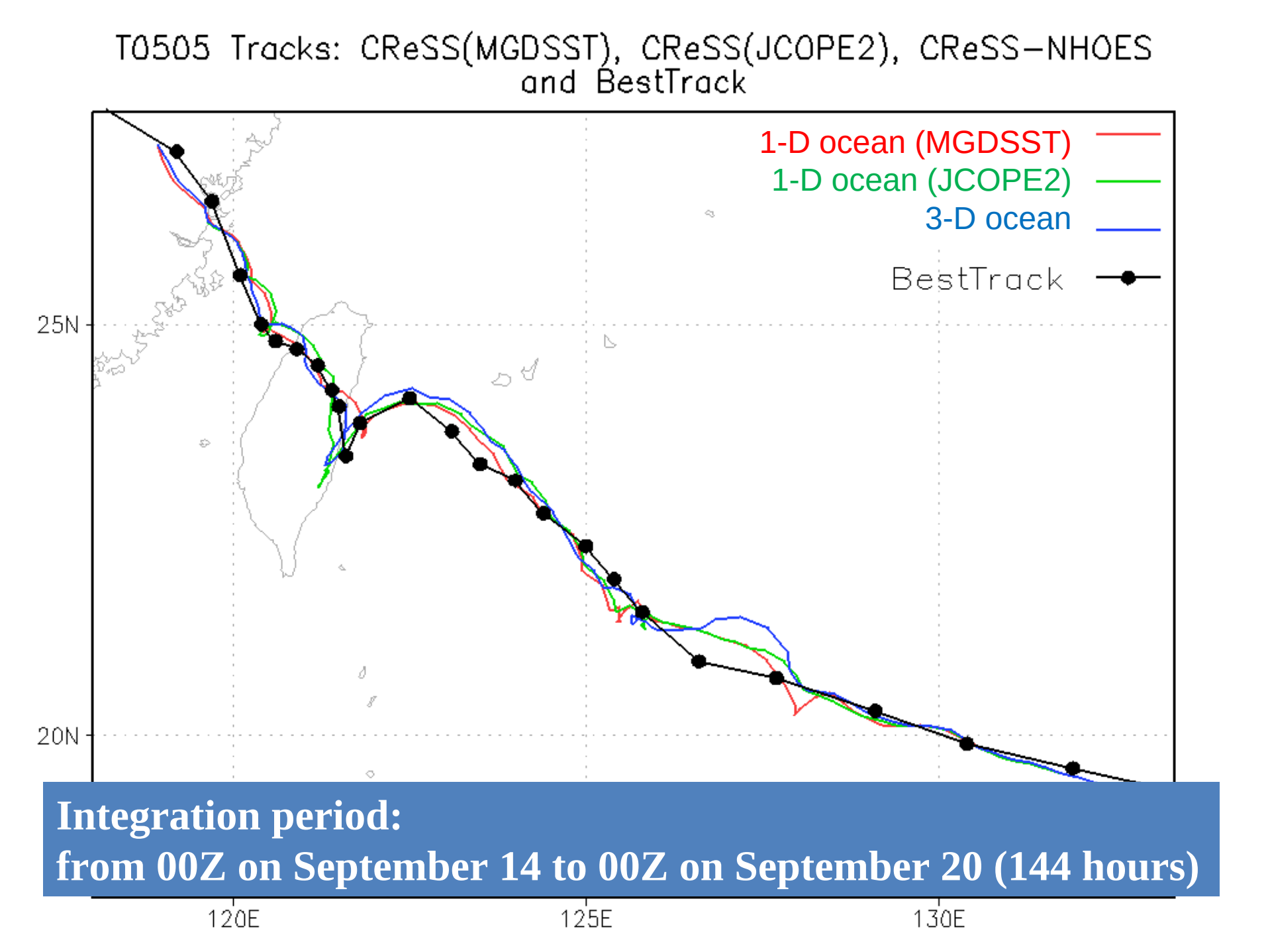


Color: topography



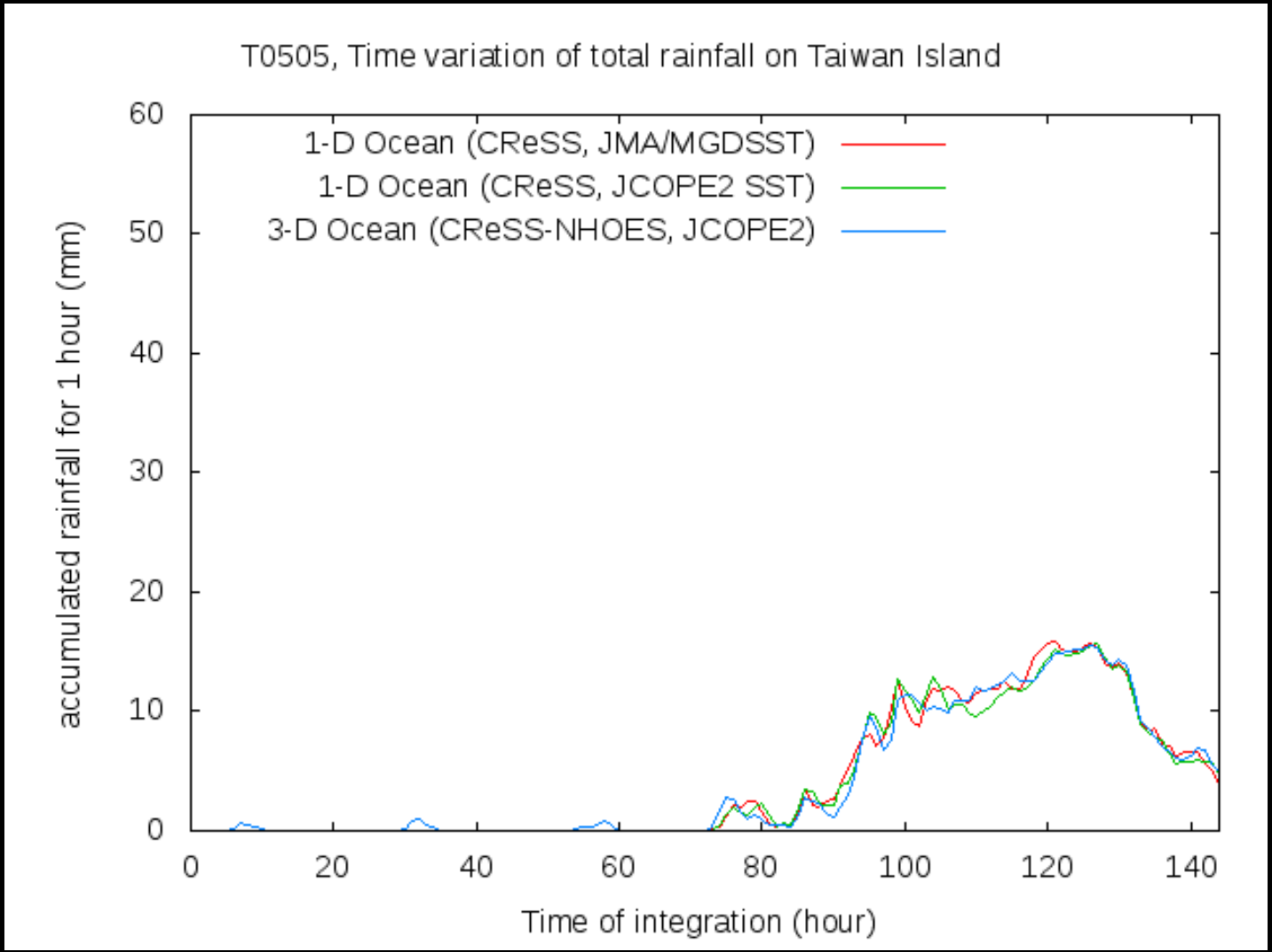
- **Also, accumulated rainfall amount averaged in this area using the 3-D ocean model is decreasing about 50 mm compared with that 1-D ocean model.**

Typhoon Experiments T0505 (Haitang)



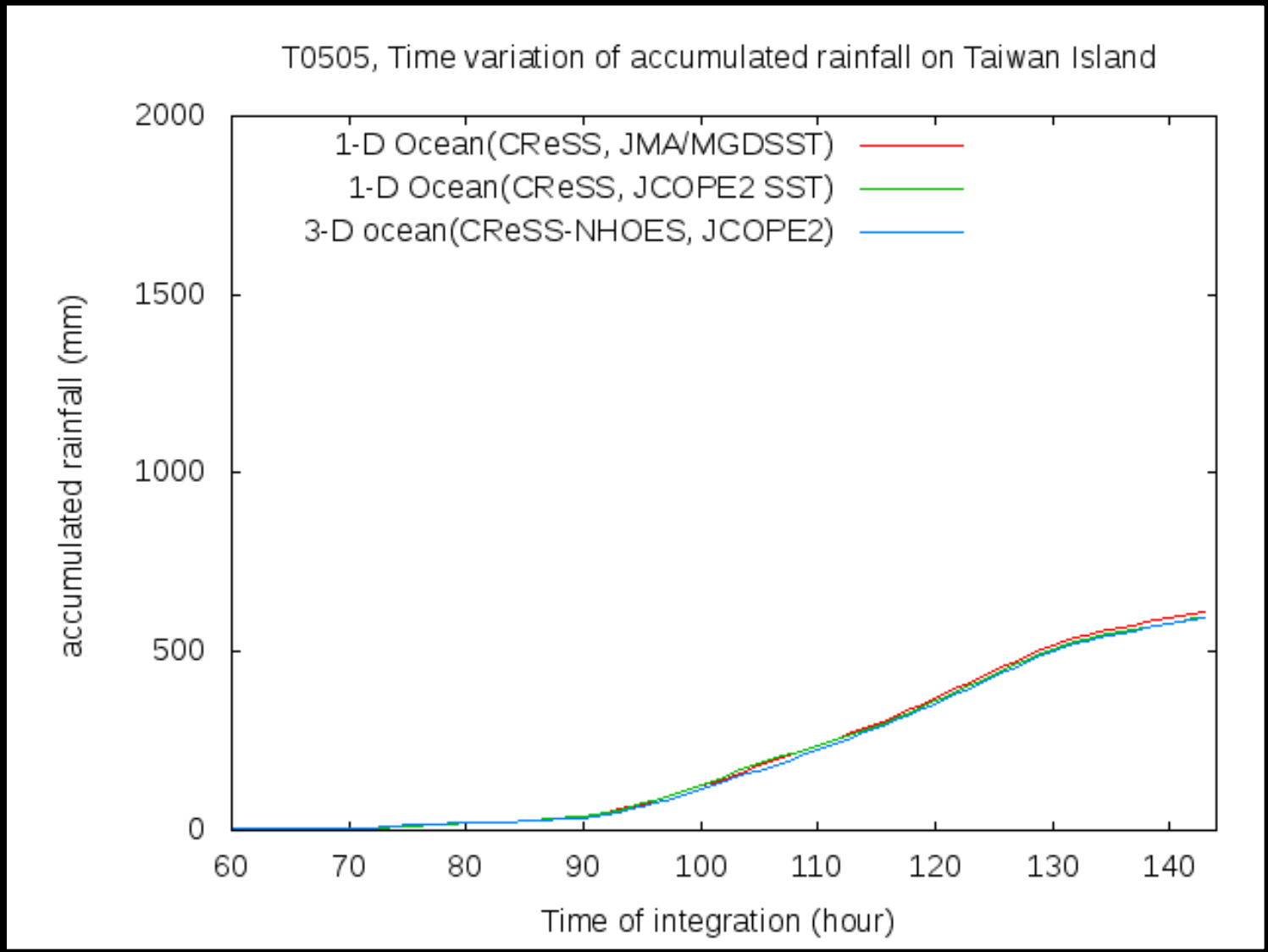
Integration period:
from 00Z on September 14 to 00Z on September 20 (144 hours)

Time variation of hourly rainfall amount averaged all over Taiwan Island



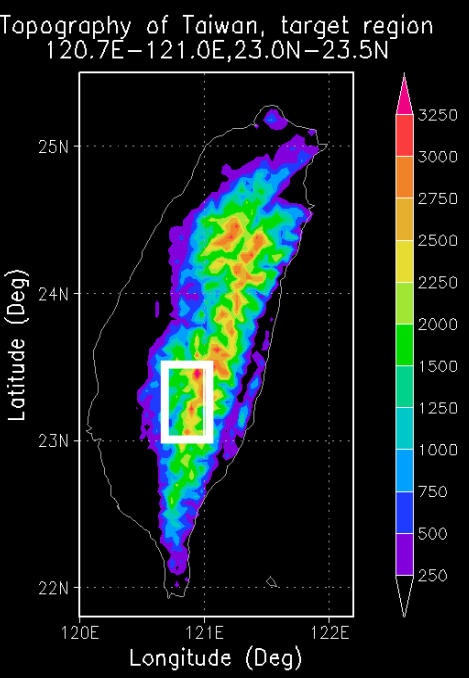
- **Hourly rainfall amount using the 3-D ocean model is quite same compared with that 1-D ocean model.**

Time variation of accumulated rainfall amount averaged all over Taiwan Island

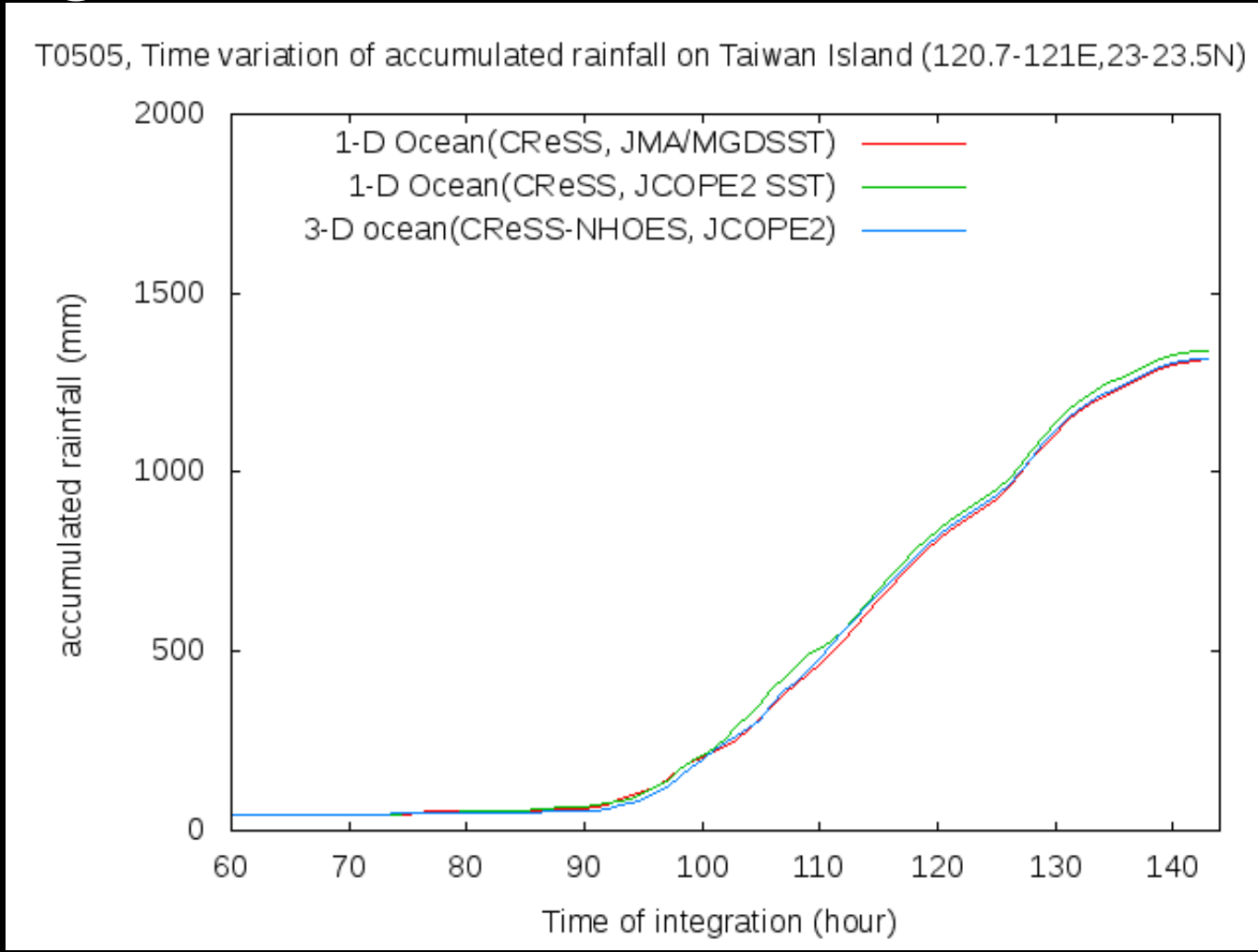


- **Difference among these 3 experiments is quite small.**

Time variation of accumulated rainfall amount averaged over the western CMR



Color: topography



- **Accumulated rainfall amount averaged in this area using the 3-D ocean model is quite same compared with that 1-D ocean model.**

Summary

- **The developed 3-D non-hydrostatic regional atmosphere-ocean coupled model, CReSS-NHOES, successfully simulates typhoons, T0505 and T0908.**
  - *** Tracks were close to the JMA best-tracks.**
- **Accumulated rainfall was reduced about 5%**

  using the 3-D ocean experiments in T0908 case.
  - *** That was quite same in T0505 case.**
  - *** We have to explore the reason not to reduce rainfall amount in T0505 case. Shall we mistake our hypothesis?**
  - *** We have to compare with the observation data (surface raingauge).**

Future Plans of the CReSS-NHOES

- **Comparison/Check the case on PALAU 2010**
  *** We have carried out daily simulation using the non-coupled CReSS.**
- **Application for CINDY/DYNAMO 2011 over the Indian Ocean for daily simulation (forecasting).**
- **Application for snow clouds over/in the Sea of Japan using high resolution of 1-km or higher.**
- **Application for the variation over/in the Yellow Sea after extra-tropical cyclones' passing.**

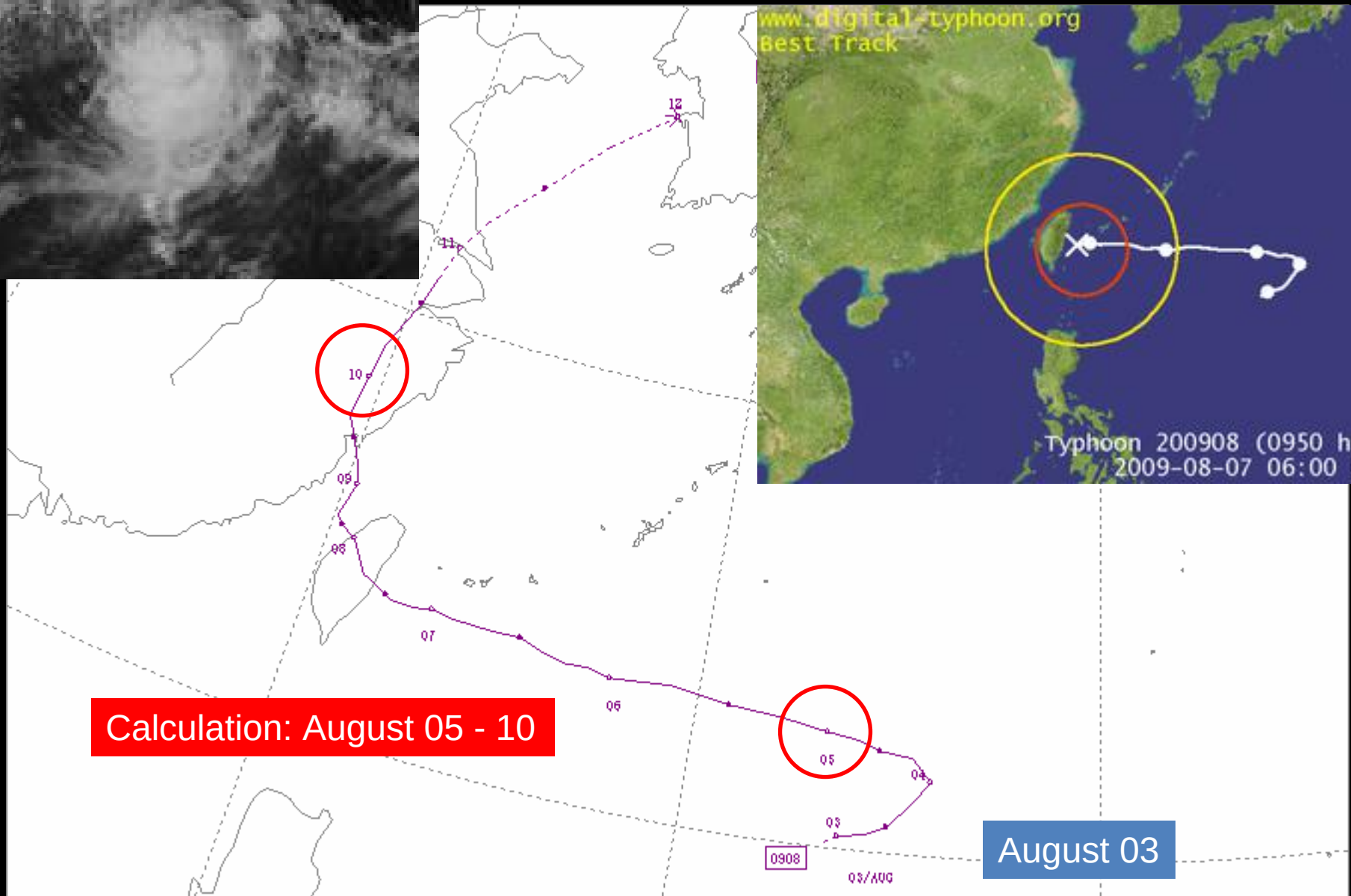
Thank you for you kind attention!!

Backup slides

CReSS-NHOES

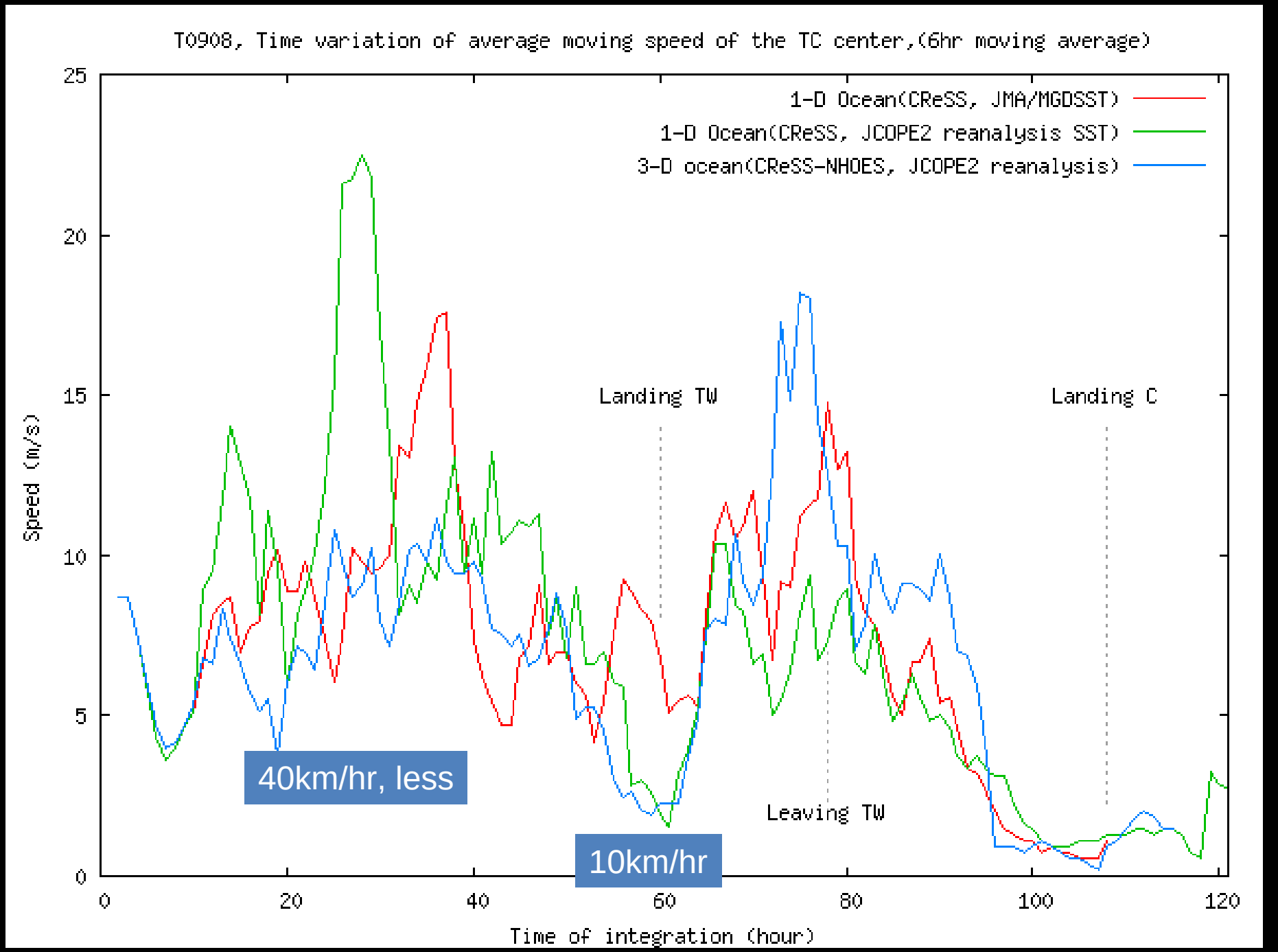
- Both single models are well developed models:
  - Non-hydrostatic system
  - Three dimensional model
  - Apply regional domain in latitude-longitude coordinate
  - Utilize MPI communication method in parallelization
  - Available hybrid parallel decomposition methods
    - MPI for inter-nodes and OpenMP/microtask for intra-nodes
  - Conduct calculations mainly on the Earth Simulator (ES) and show good performance
  - Achieve mesoslcale simulations at high resolution

T0908, Morakot

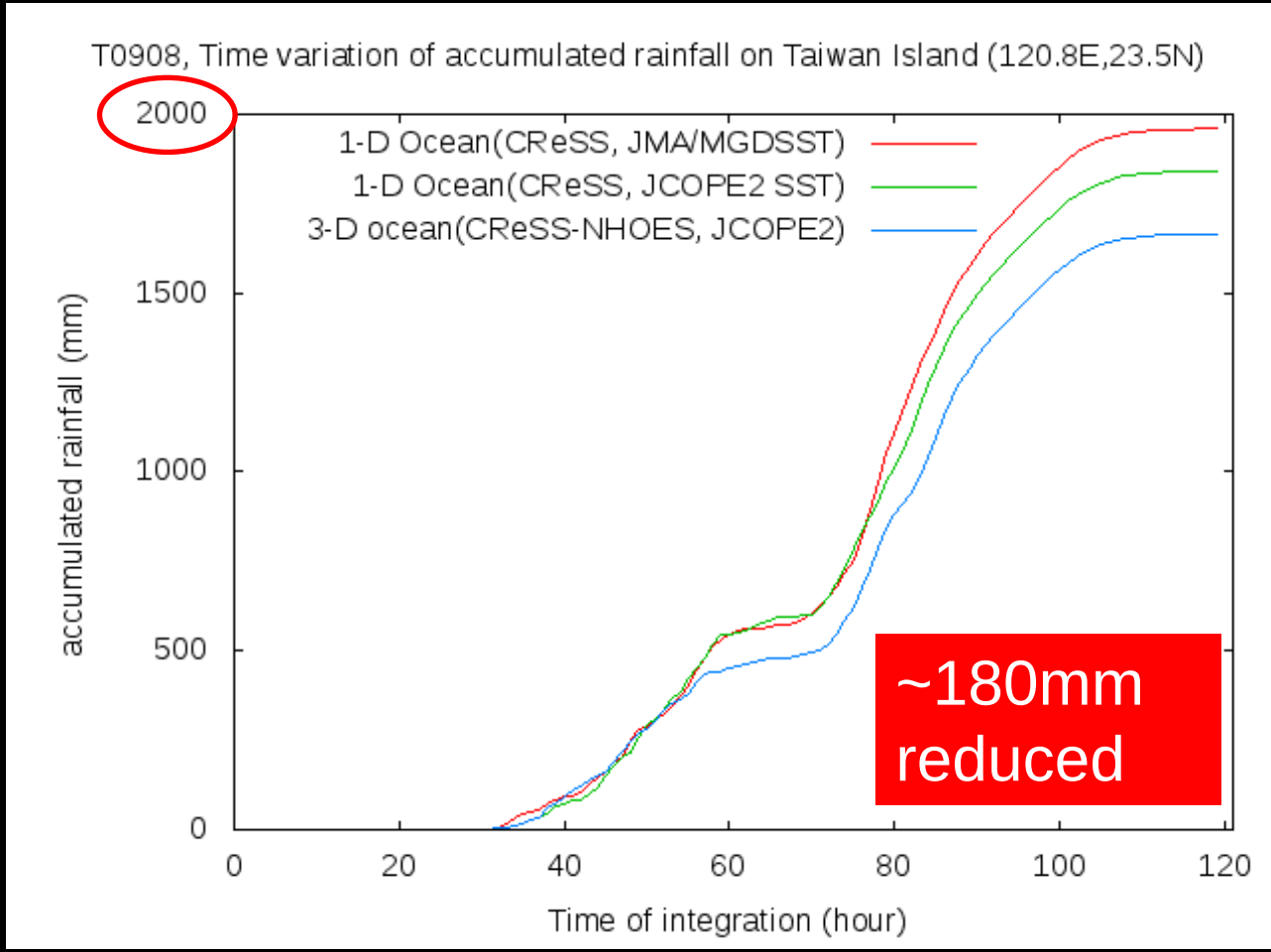


Calculation: August 05 - 10

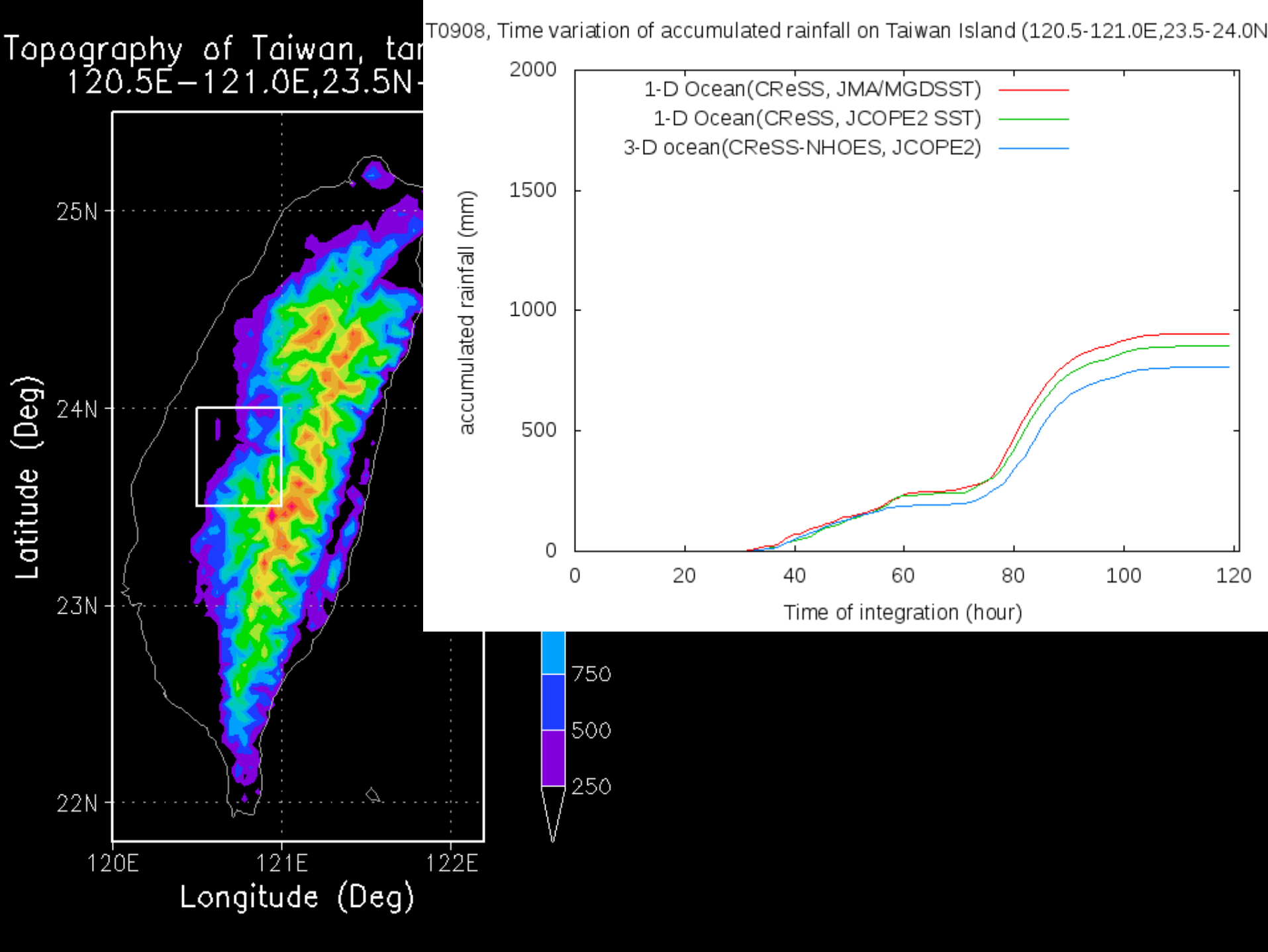
August 03

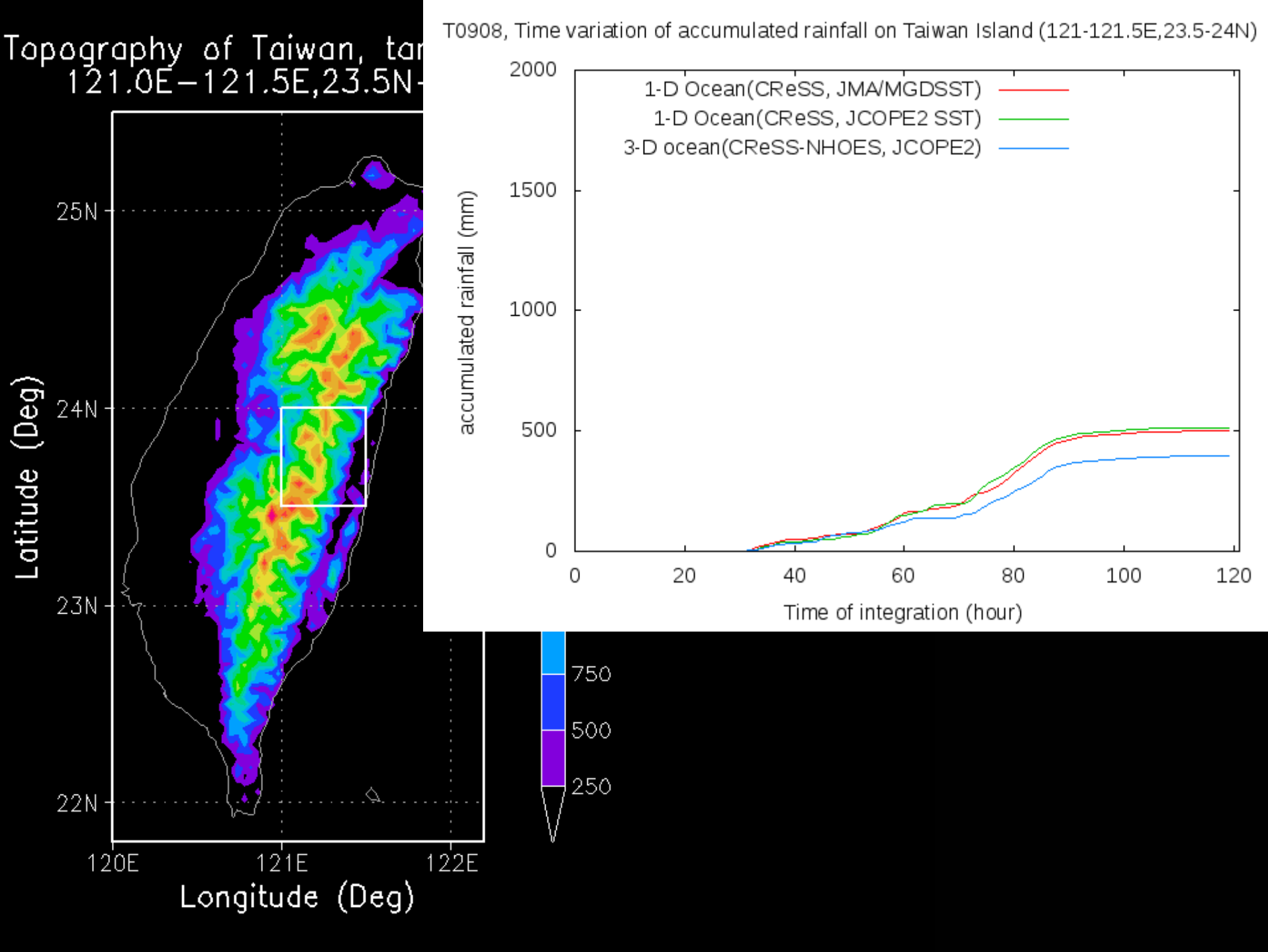

T0908, Time variation of average moving speed of the TC center,(6hr moving average)
1-D Ocean(CReSS, JMA/MGDSST)
1-D Ocean(CReSS, JCOPE2 reanalysis SST)
3-D ocean(CReSS-NHOES, JCOPE2 reanalysis)
Landing TW
Landing C
Leaving TW
40km/hr, less
10km/hr
Speed (m/s)
Time of integration (hour)
0
5
10
15
20
25
0
20
40
60
80
100
120

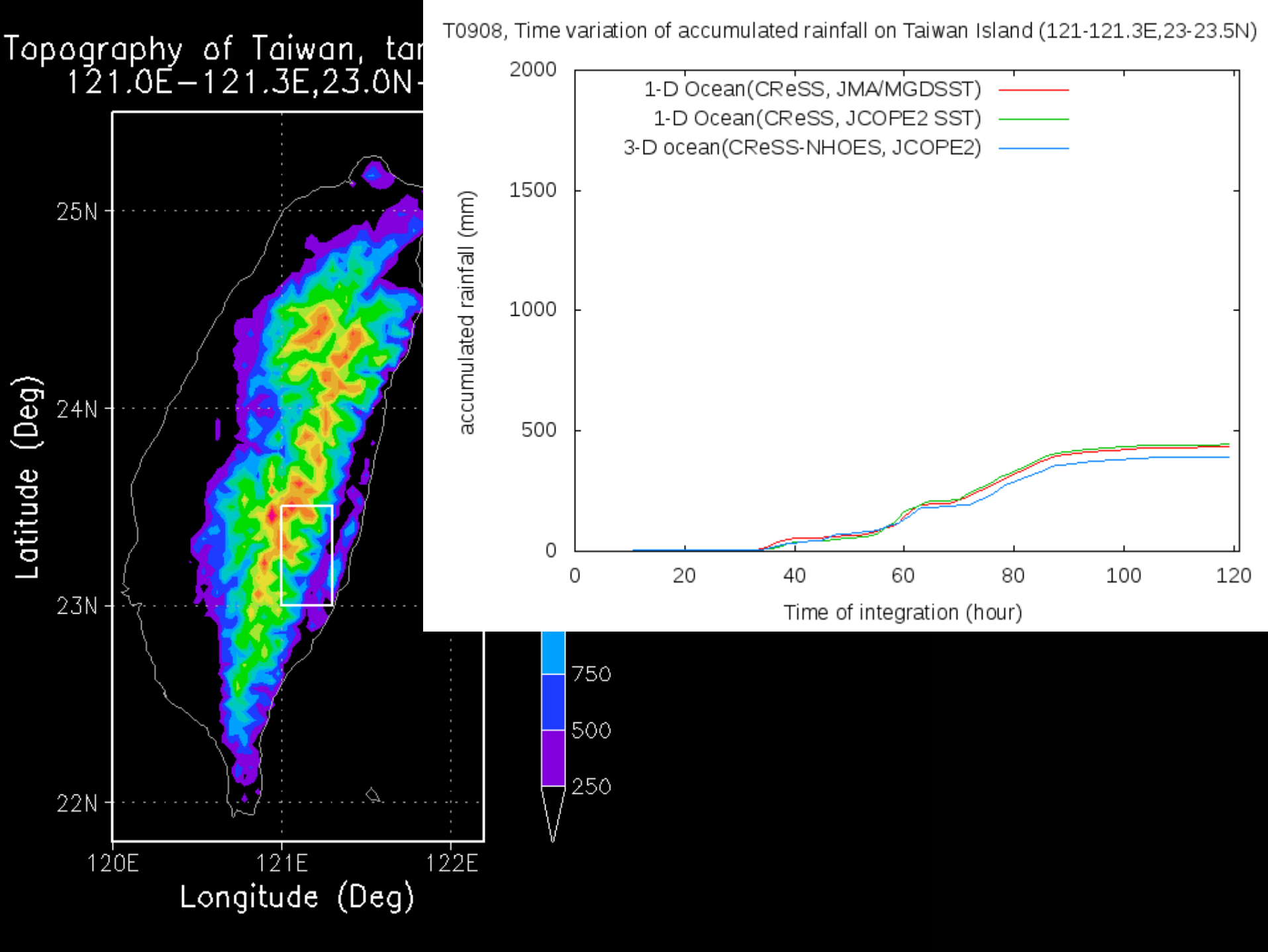
Time variation of accumulated rainfall amount at Alishan (阿里山) point

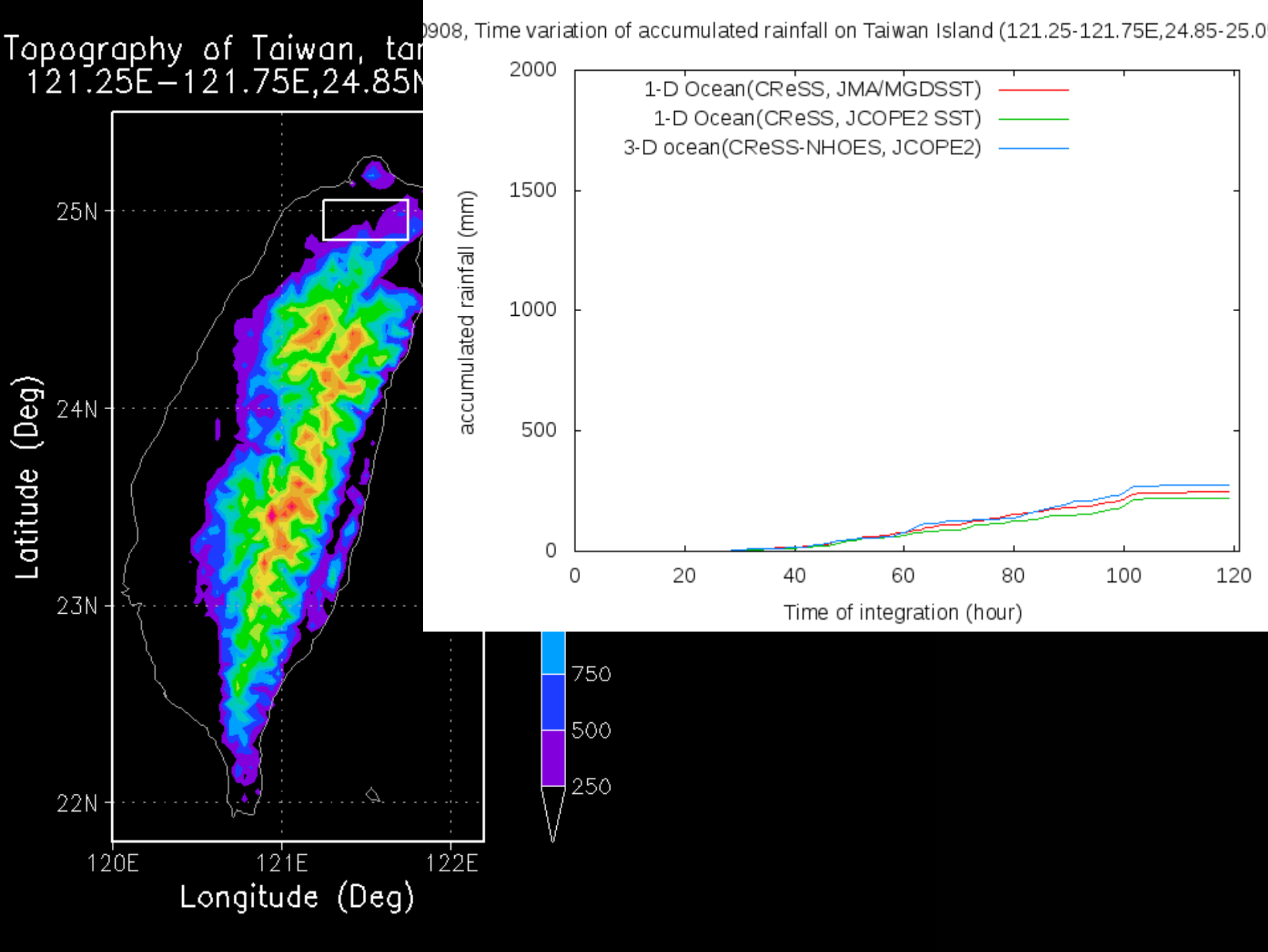


- Accumulated rainfall amount at Alishan point (120.8E, 23.5N) was 2935 mm from August 6 to 10 (from Japanese newspaper).
- That in this area using the 3-D ocean model is decreasing about 180 mm compared with that 1-D ocean model.

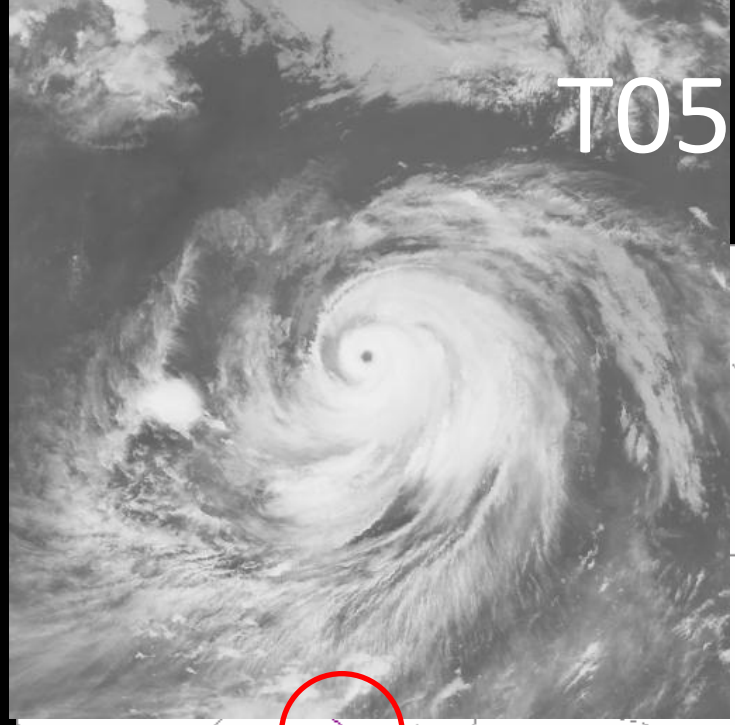

Topography of Taiwan, tar
120.5E−121.0E,23.5N-
25N
24N
23N
22N
Latitude (Deg)
120E
121E
122E
Longitude (Deg)
750
500
250
T0908, Time variation of accumulated rainfall on Taiwan Island (120.5-121.0E,23.5-24.0N
1-D Ocean(CReSS, JMA/MGDSST)
1-D Ocean(CReSS, JCOPE2 SST)
3-D ocean(CReSS-NHOES, JCOPE2)
accumulated rainfall (mm)
2000
1500
1000
500
0
0
20
40
60
80
100
120
Time of integration (hour)

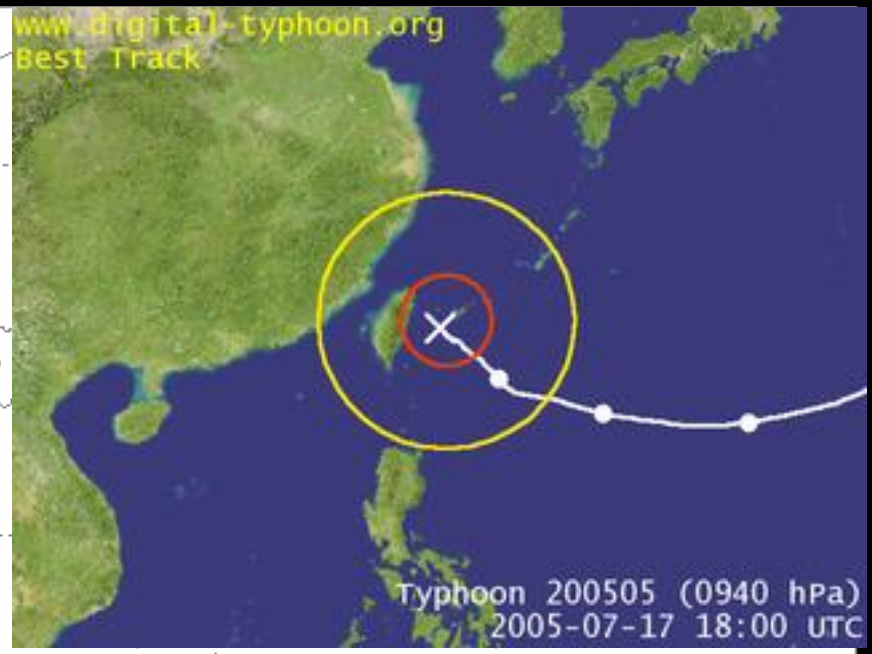

Topography of Taiwan, tar
121.0E−121.5E,23.5N-
25N
24N
23N
22N
Latitude (Deg)
120E
121E
122E
Longitude (Deg)
750
500
250
T0908, Time variation of accumulated rainfall on Taiwan Island (121-121.5E,23.5-24N)
1-D Ocean(CReSS, JMA/MGDSST)
1-D Ocean(CReSS, JCOPE2 SST)
3-D ocean(CReSS-NHOES, JCOPE2)
accumulated rainfall (mm)
2000
1500
1000
500
0
0
20
40
60
80
100
120
Time of integration (hour)

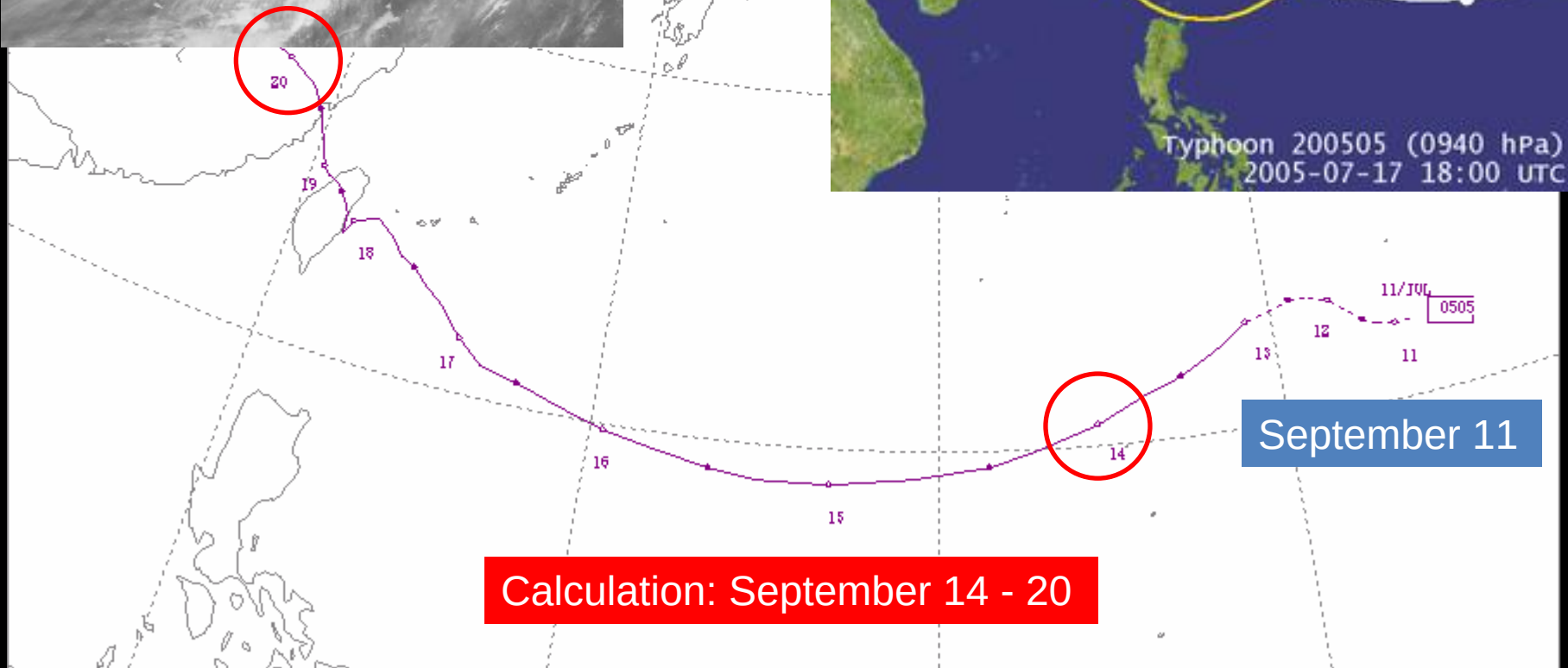

Topography of Taiwan, tar
121.0E−121.3E,23.0N-
25N
24N
23N
22N
Latitude (Deg)
120E
121E
122E
Longitude (Deg)
750
500
250
T0908, Time variation of accumulated rainfall on Taiwan Island (121-121.3E,23-23.5N)
1-D Ocean(CReSS, JMA/MGDSST)
1-D Ocean(CReSS, JCOPE2 SST)
3-D ocean(CReSS-NHOES, JCOPE2)
accumulated rainfall (mm)
2000
1500
1000
500
0
0
20
40
60
80
100
120
Time of integration (hour)


Topography of Taiwan, tar
121.25E−121.75E,24.85N
0908, Time variation of accumulated rainfall on Taiwan Island (121.25-121.75E,24.85-25.0
1-D Ocean(CReSS, JMA/MGDSST)
1-D Ocean(CReSS, JCOPE2 SST)
3-D ocean(CReSS-NHOES, JCOPE2)
accumulated rainfall (mm)
Time of integration (hour)
2000
1500
1000
500
0
0
20
40
60
80
100
120
25N
24N
23N
22N
Latitude (Deg)
120E
121E
122E
Longitude (Deg)
750
500
250

T0505, Haitang







September 11

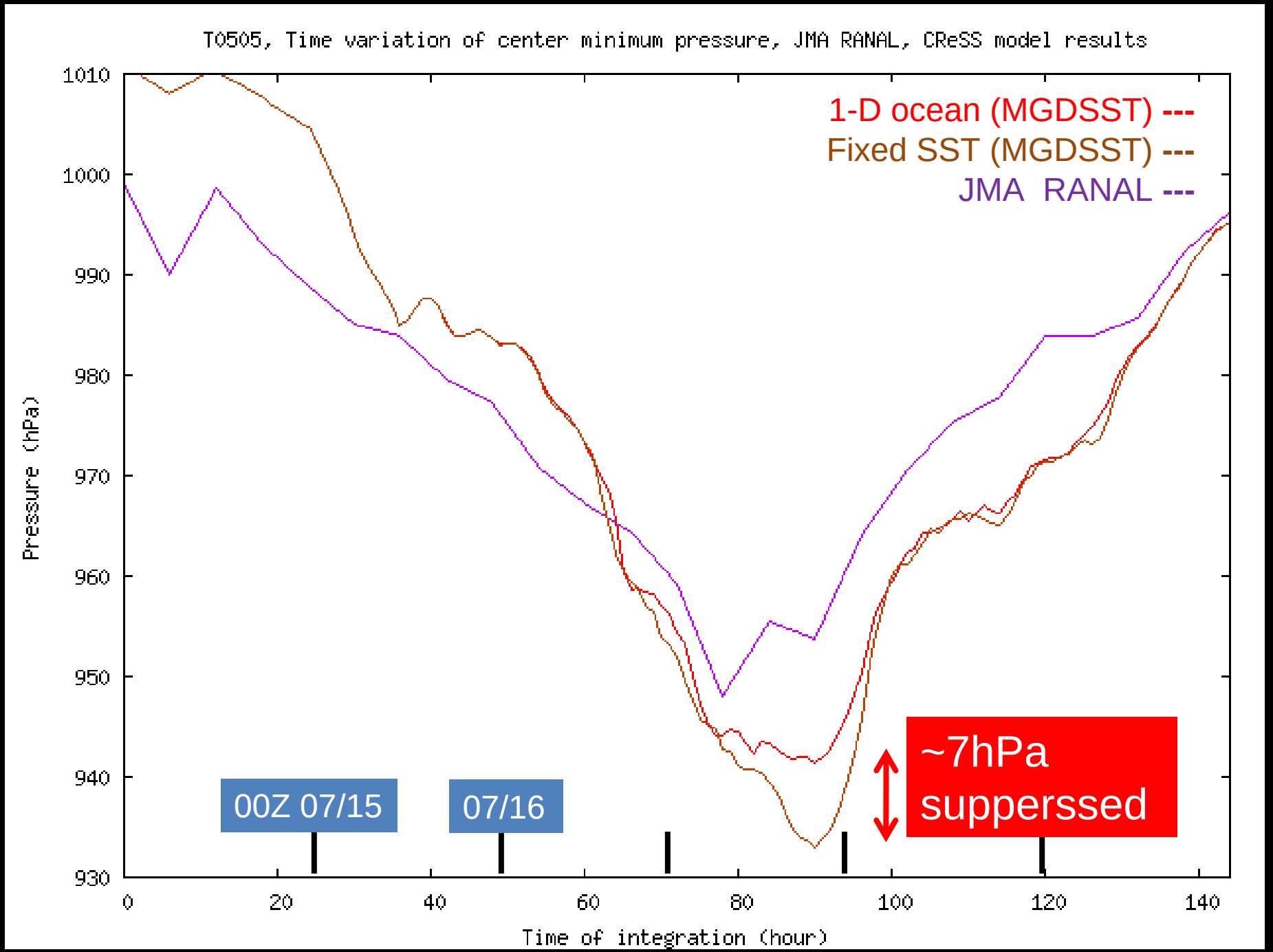
Calculation: September 14 - 20

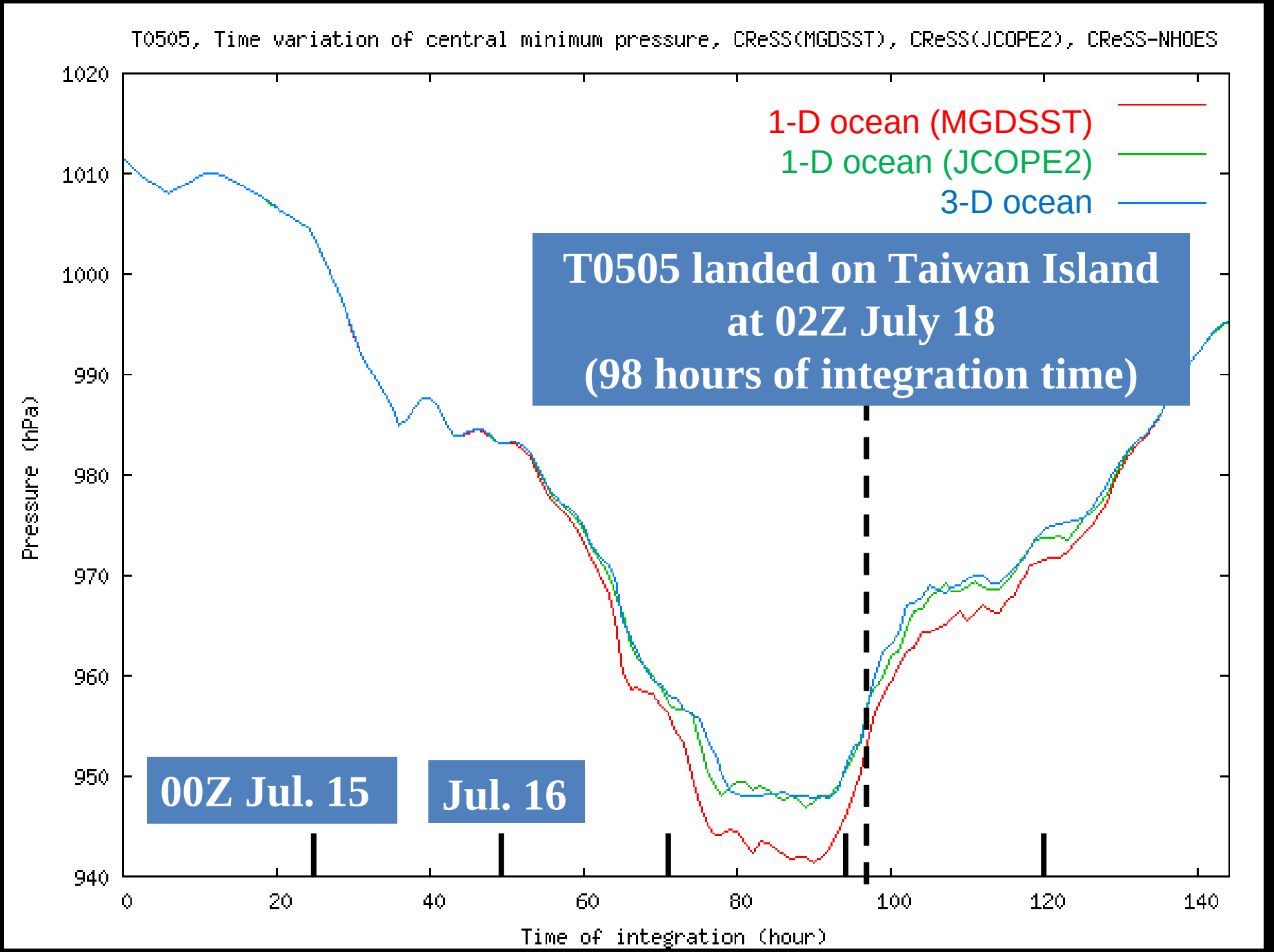
T0505, Haitang experiments

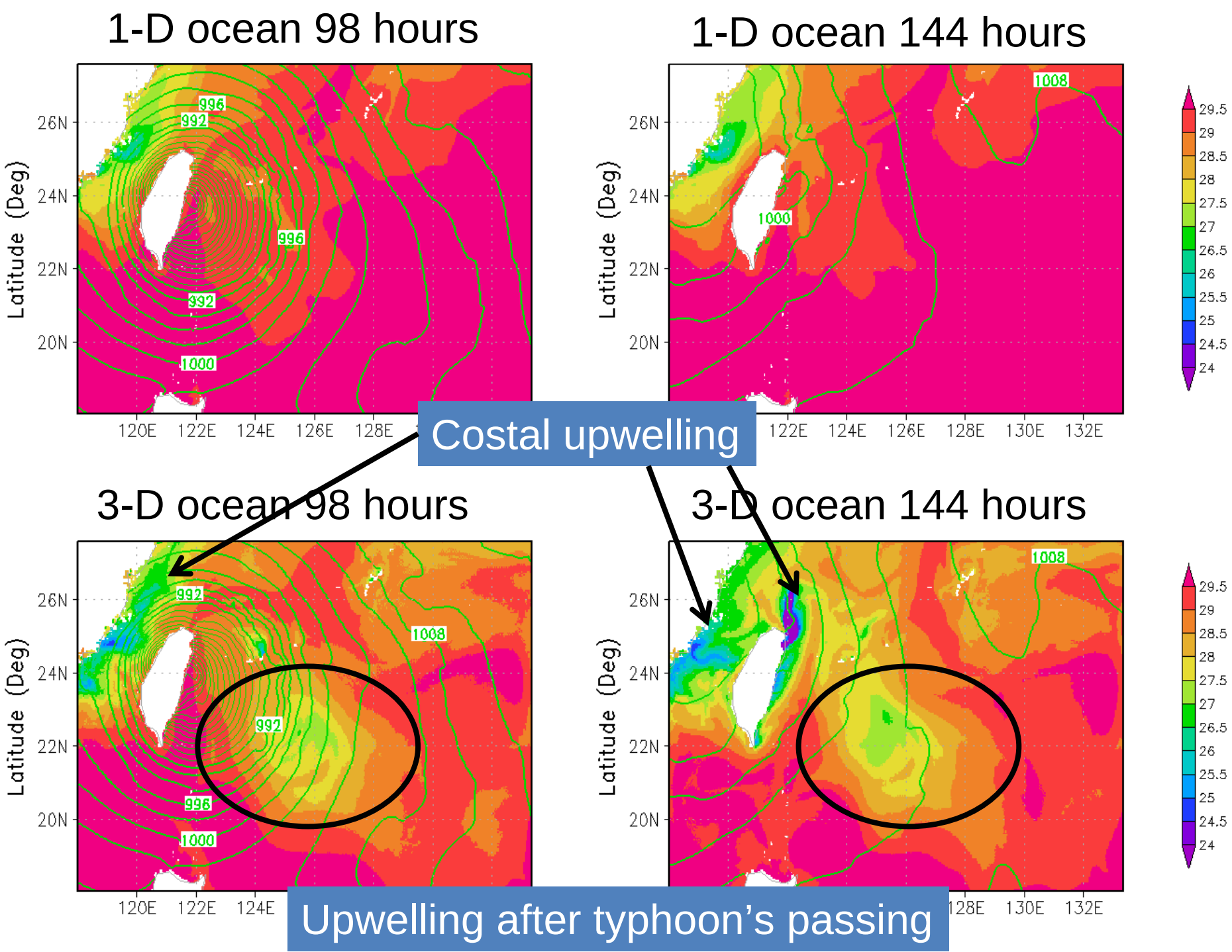
CReSS

- DX=DY=4km, DZ = 200m(surface) to 400m (stretched)
- 380 x 250 x 60 grid, DT=4sec
- Initial and lateral boundary condition: JMA/RANAL dataset

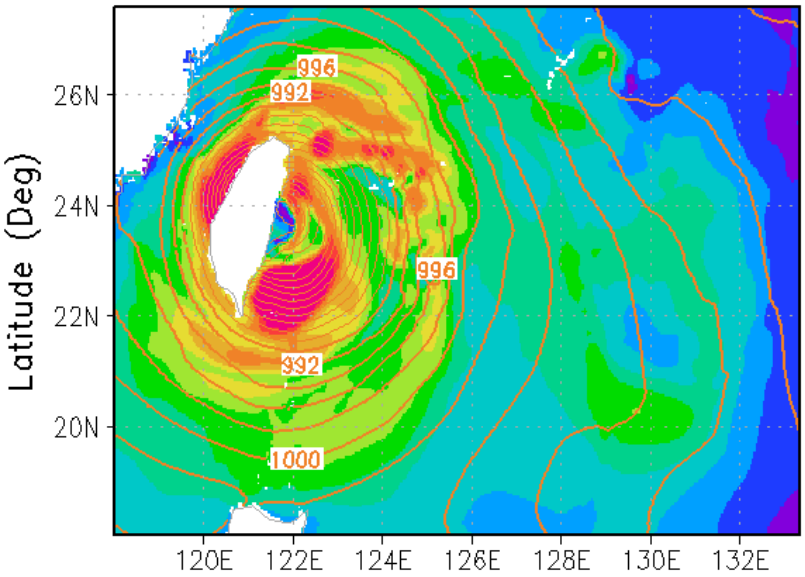
1. 3-D ocean: NHOES
   - DX=DY=4km, DZ = 2 m for top 100 m (4000m depth)
   - 380 x 250 x 100 grid
   - Initial and lateral boundary condition: JCOPE2 reanalysis(3-D)
2. 1-D ocean: 30m depth (60 layers)
   - Initial SST dataset is MGDSST (0.25degree)
   - Initial SST dataset is JCOPE2 reanalysis (1/12 degree ~ 10km)
3. Fixed-SST (NO time variation) with MGDSST


T0505, Time variation of center minimum pressure, JMA RANAL, CReSS model results
1-D ocean (MGDSST) ---
Fixed SST (MGDSST) ---
JMA RANAL ---
Pressure (hPa)
Time of integration (hour)
1010
1000
990
980
970
960
950
940
930
0
20
40
60
80
100
120
140
00Z 07/15
07/16
~7hPa
supperssed

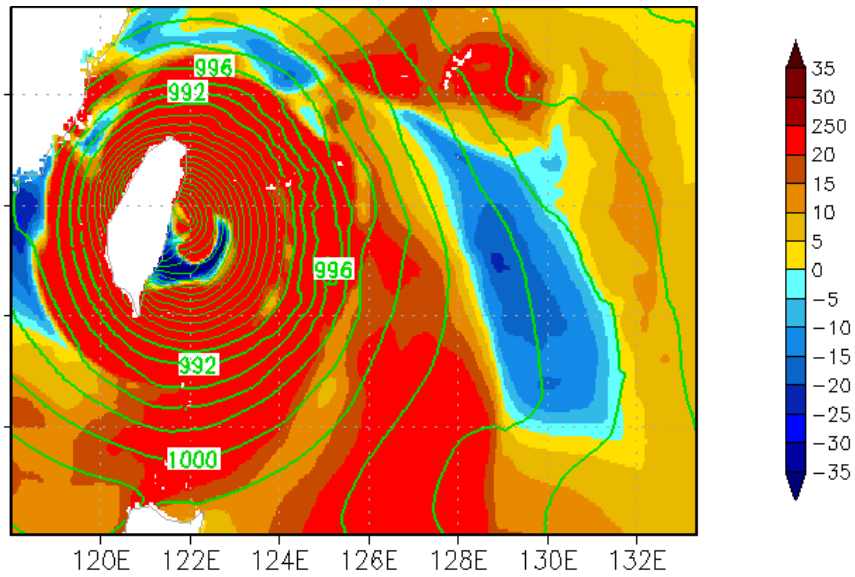

T0505, Time variation of central minimum pressure, CReSS(MGDSST), CReSS(JCOPE2), CReSS-NHOES
1-D ocean (MGDSST)
1-D ocean (JCOPE2)
3-D ocean
T0505 landed on Taiwan Island
at 02Z July 18
(98 hours of integration time)
00Z Jul. 15
Jul. 16
Pressure (hPa)
Time of integration (hour)
1020
1010
1000
990
980
970
960
950
940
0
20
40
60
80
100
120
140


1-D ocean 98 hours
1-D ocean 144 hours
Costal upwelling
3-D ocean 98 hours
3-D ocean 144 hours
Upwelling after typhoon's passing
Latitude (Deg)
26N
24N
22N
20N
120E
122E
124E
126E
128E
130E
132E
996
992
1000
1008
29.5
29
28.5
28
27.5
27
26.5
26
25.5
25
24.5
24

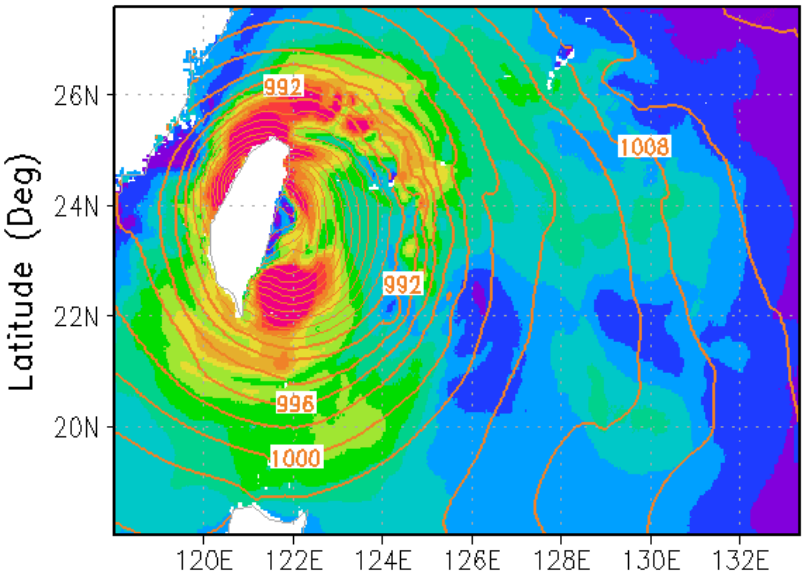
1-D ocean 98 hours



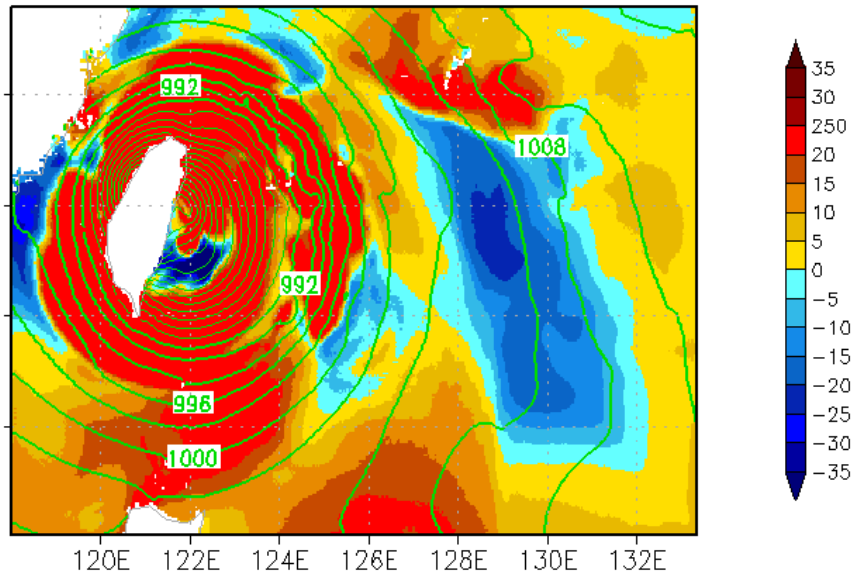
1-D ocean 144 hours

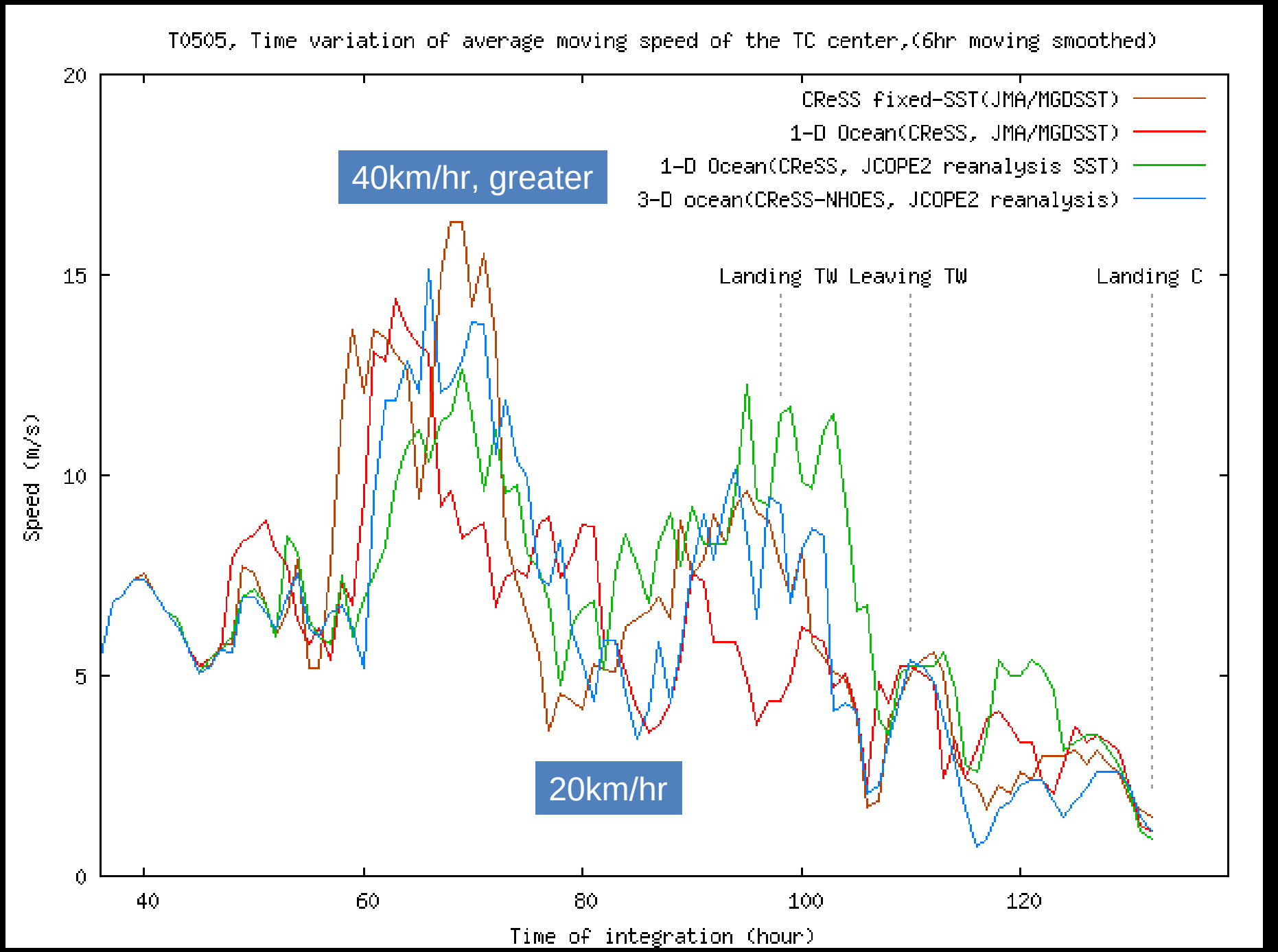


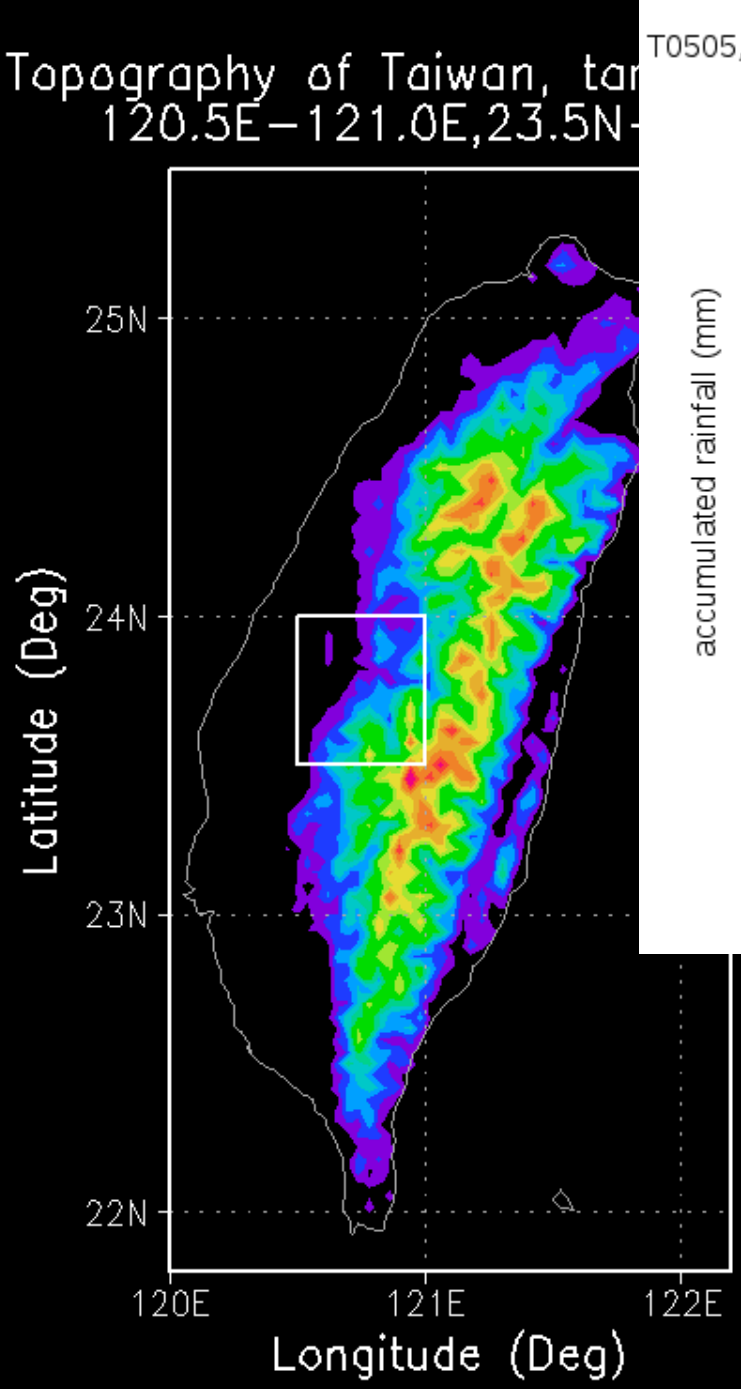
3-D ocean 98 hours

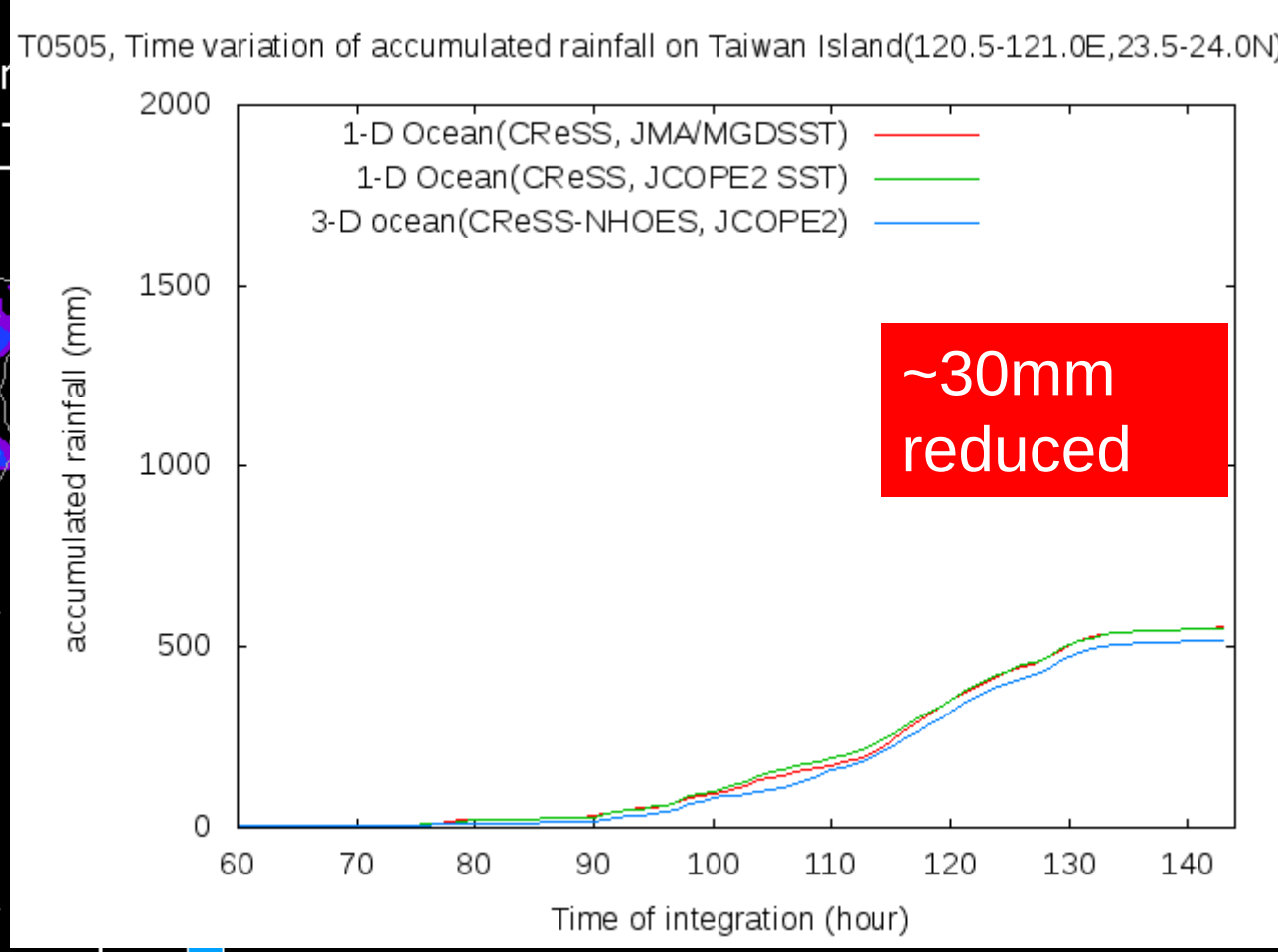


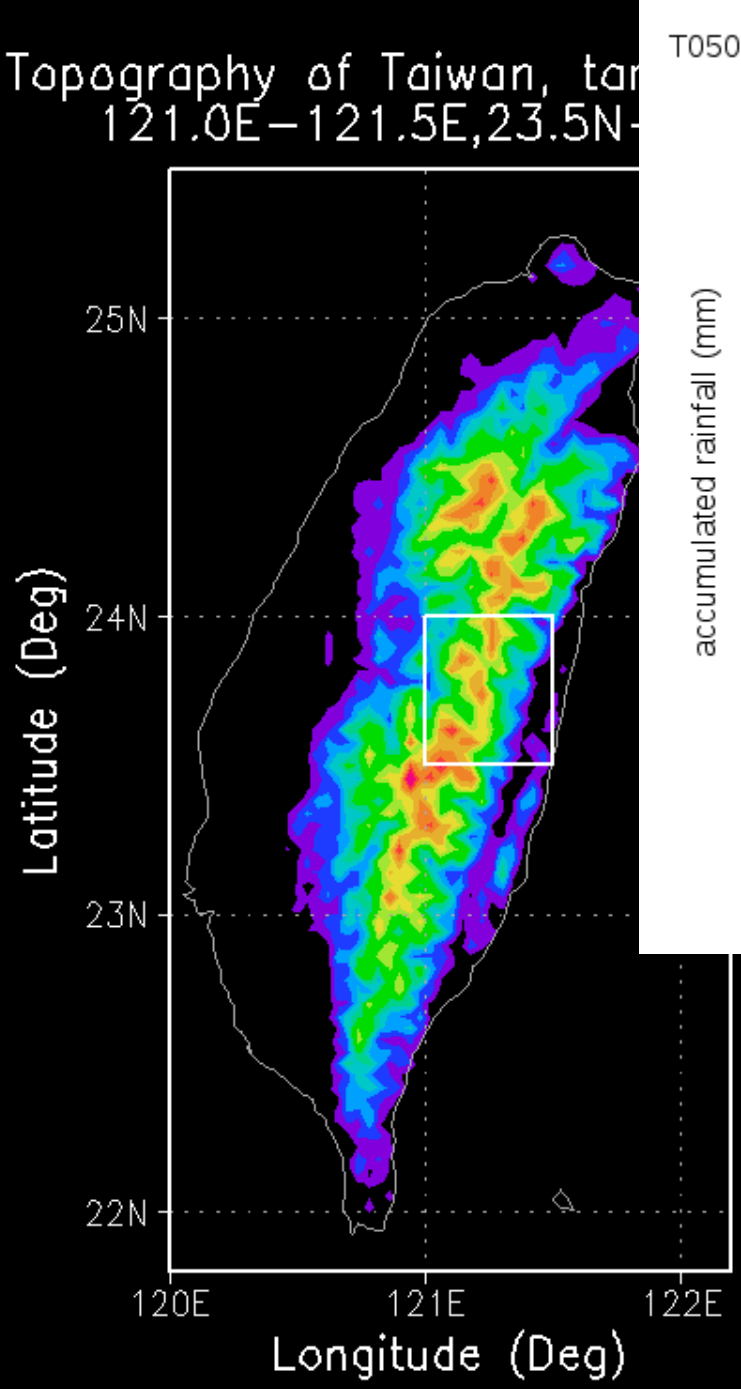
3-D ocean 144 hours

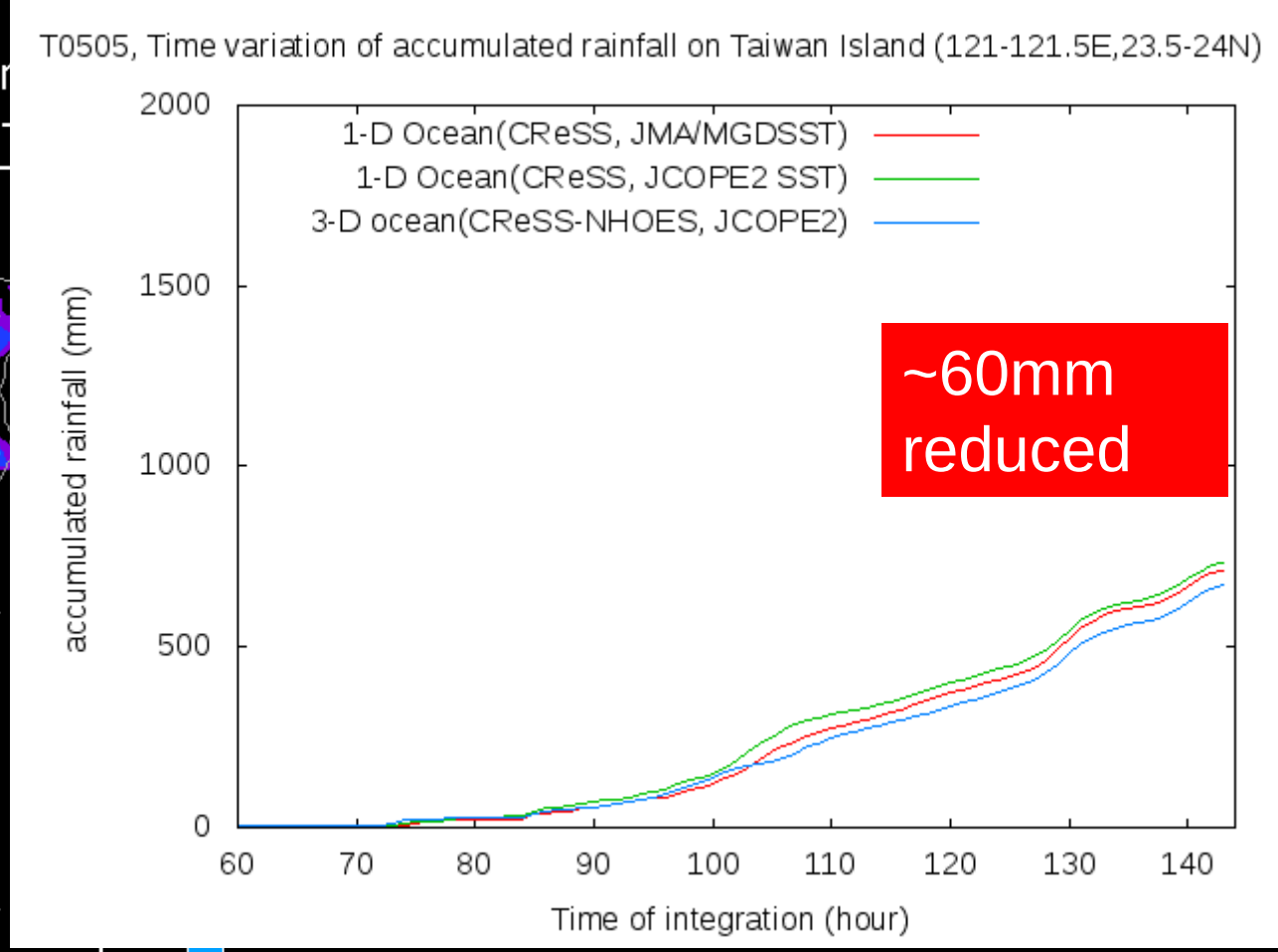


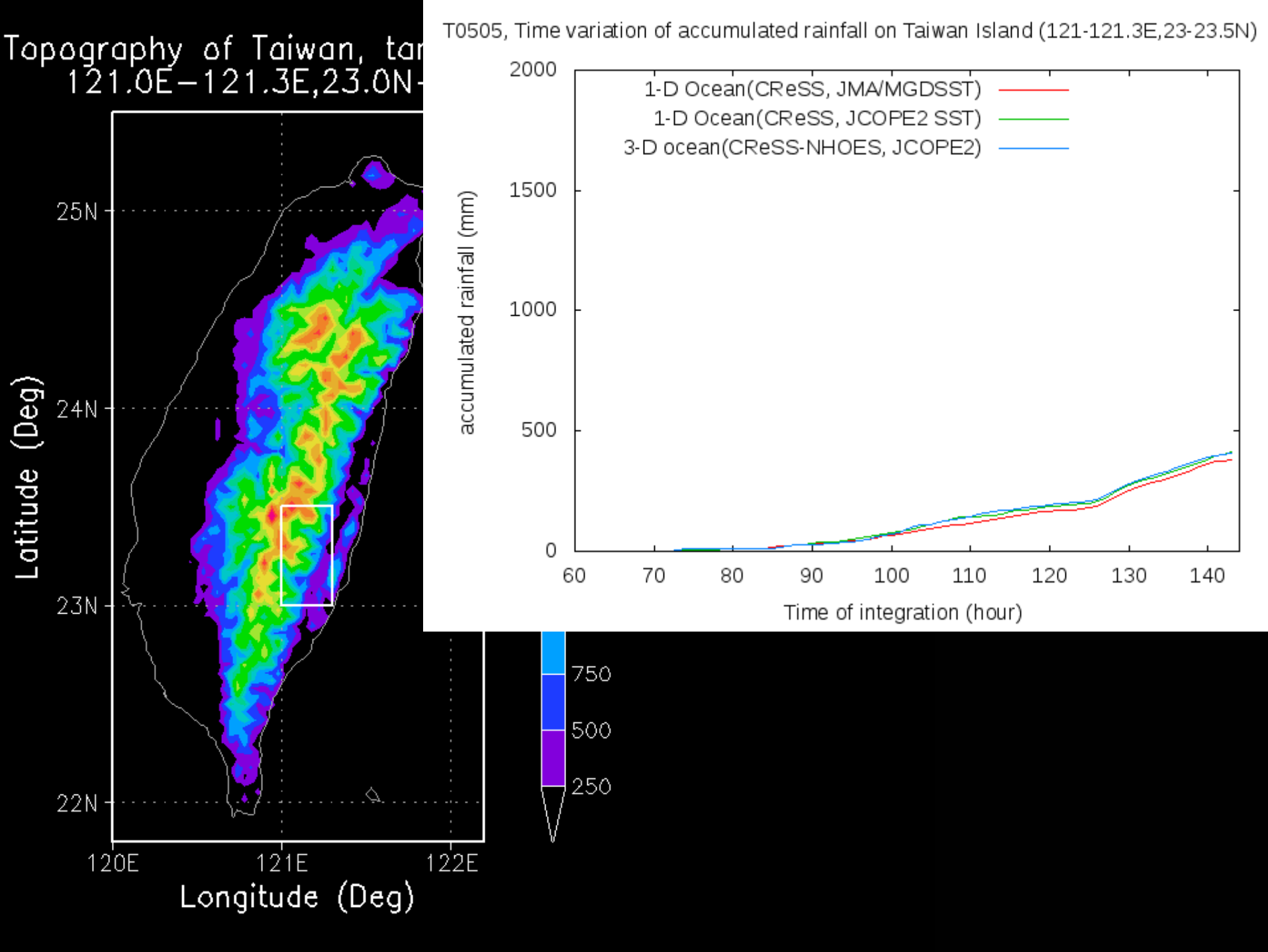

T0505, Time variation of average moving speed of the TC center,(6hr moving smoothed)
CReSS fixed-SST(JMA/MGDSST)
1-D Ocean(CReSS, JMA/MGDSST)
1-D Ocean(CReSS, JCOPE2 reanalysis SST)
3-D ocean(CReSS-NHOES, JCOPE2 reanalysis)
40km/hr, greater
20km/hr
Landing TW
Leaving TW
Landing C
Speed (m/s)
Time of integration (hour)
0
5
10
15
20
40
60
80
100
120

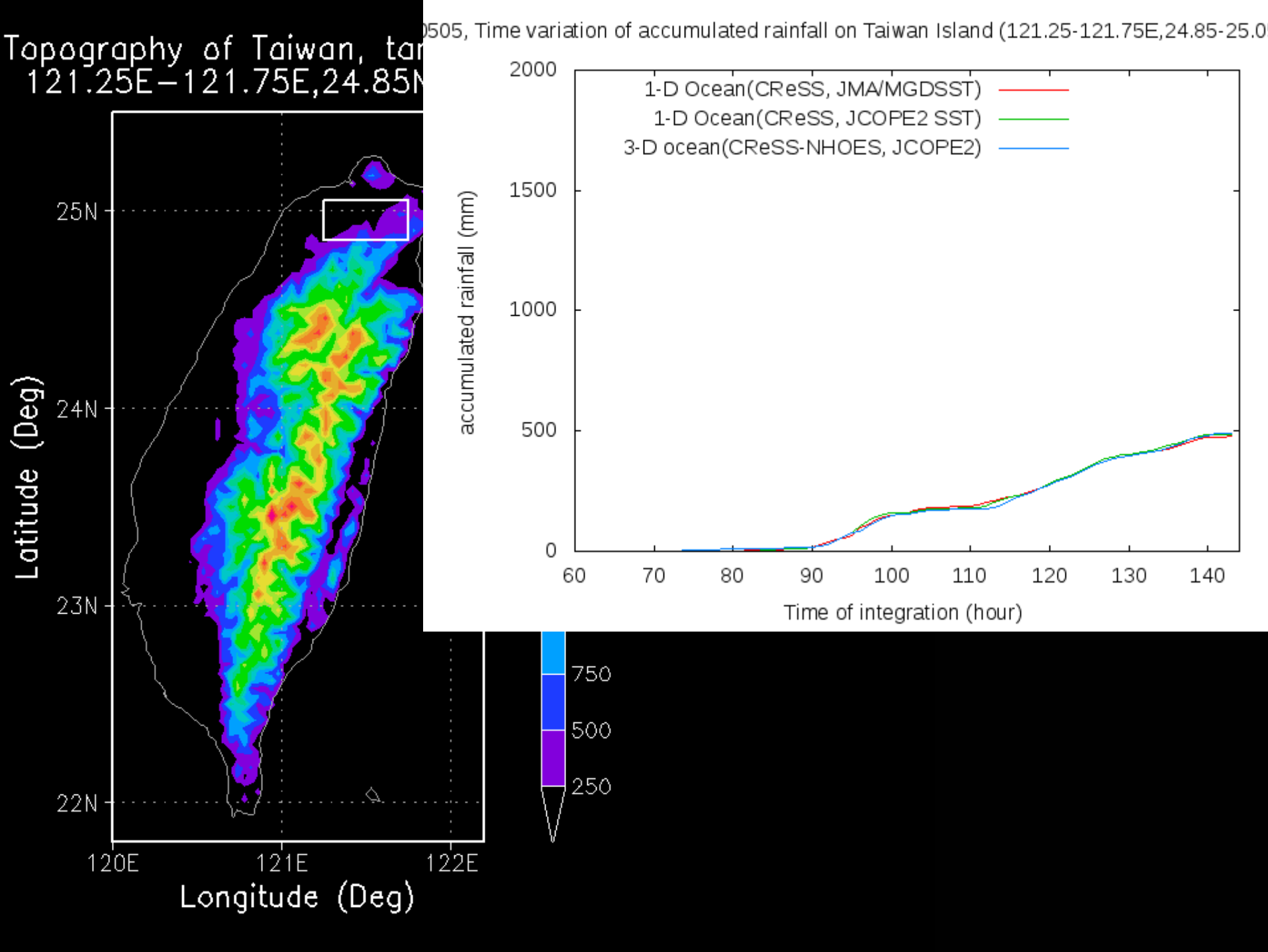

Topography of Taiwan, tar
120.5E−121.0E,23.5N-
25N
24N
23N
22N
Latitude (Deg)
120E
121E
122E
Longitude (Deg)
750
500
250

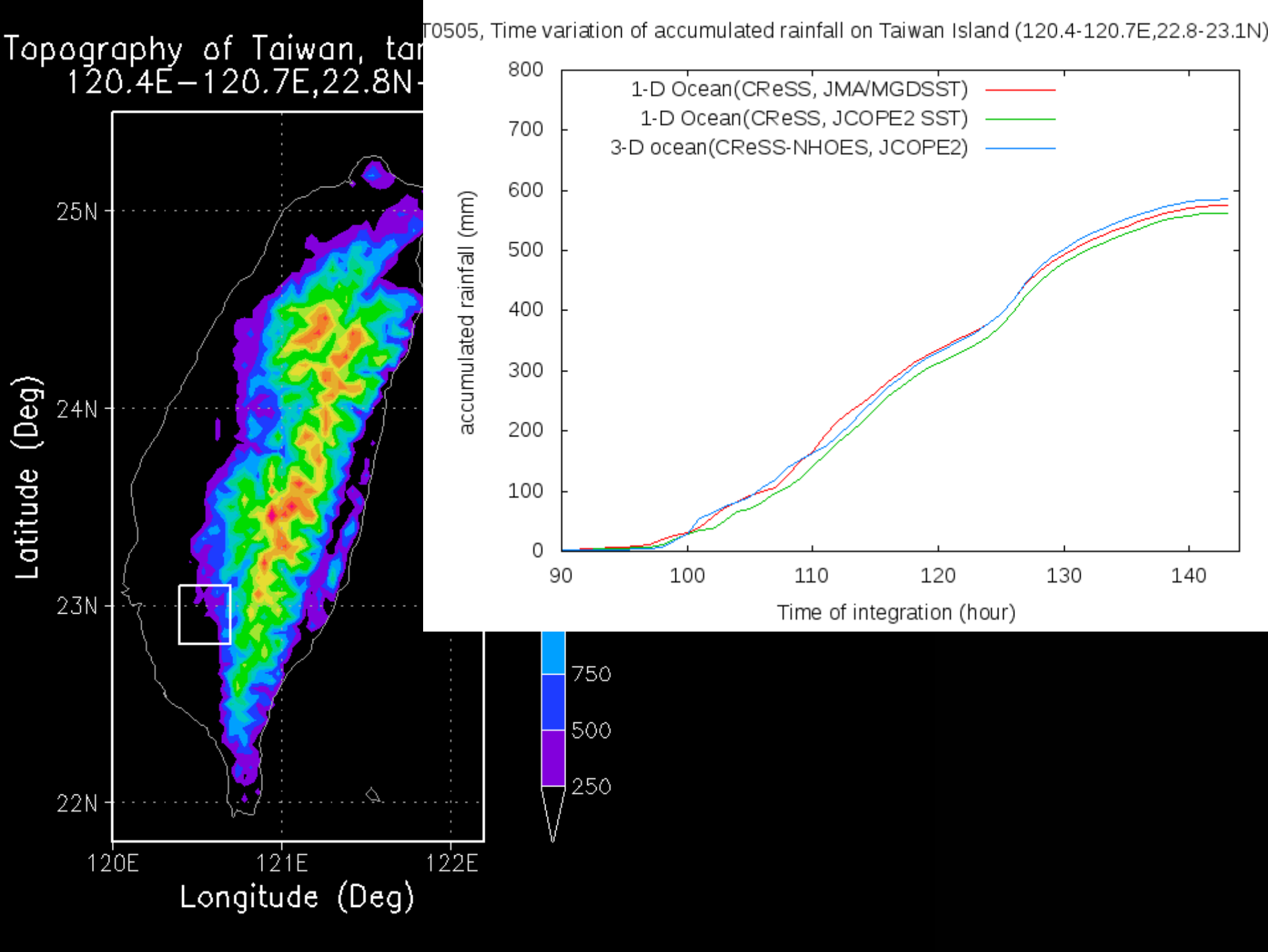

T0505, Time variation of accumulated rainfall on Taiwan Island(120.5-121.0E,23.5-24.0N)
1-D Ocean(CReSS, JMA/MGDSST)
1-D Ocean(CReSS, JCOPE2 SST)
3-D ocean(CReSS-NHOES, JCOPE2)
accumulated rainfall (mm)
2000
1500
1000
500
0
60
70
80
90
100
110
120
130
140
Time of integration (hour)
~30mm reduced


Topography of Taiwan, tar
121.0E−121.5E,23.5N-
25N
24N
23N
22N
Latitude (Deg)
120E
121E
122E
Longitude (Deg)
750
500
250


T0505, Time variation of accumulated rainfall on Taiwan Island (121-121.5E,23.5-24N)
1-D Ocean(CReSS, JMA/MGDSST)
1-D Ocean(CReSS, JCOPE2 SST)
3-D ocean(CReSS-NHOES, JCOPE2)
~60mm reduced
accumulated rainfall (mm)
2000
1500
1000
500
0
60
70
80
90
100
110
120
130
140
Time of integration (hour)

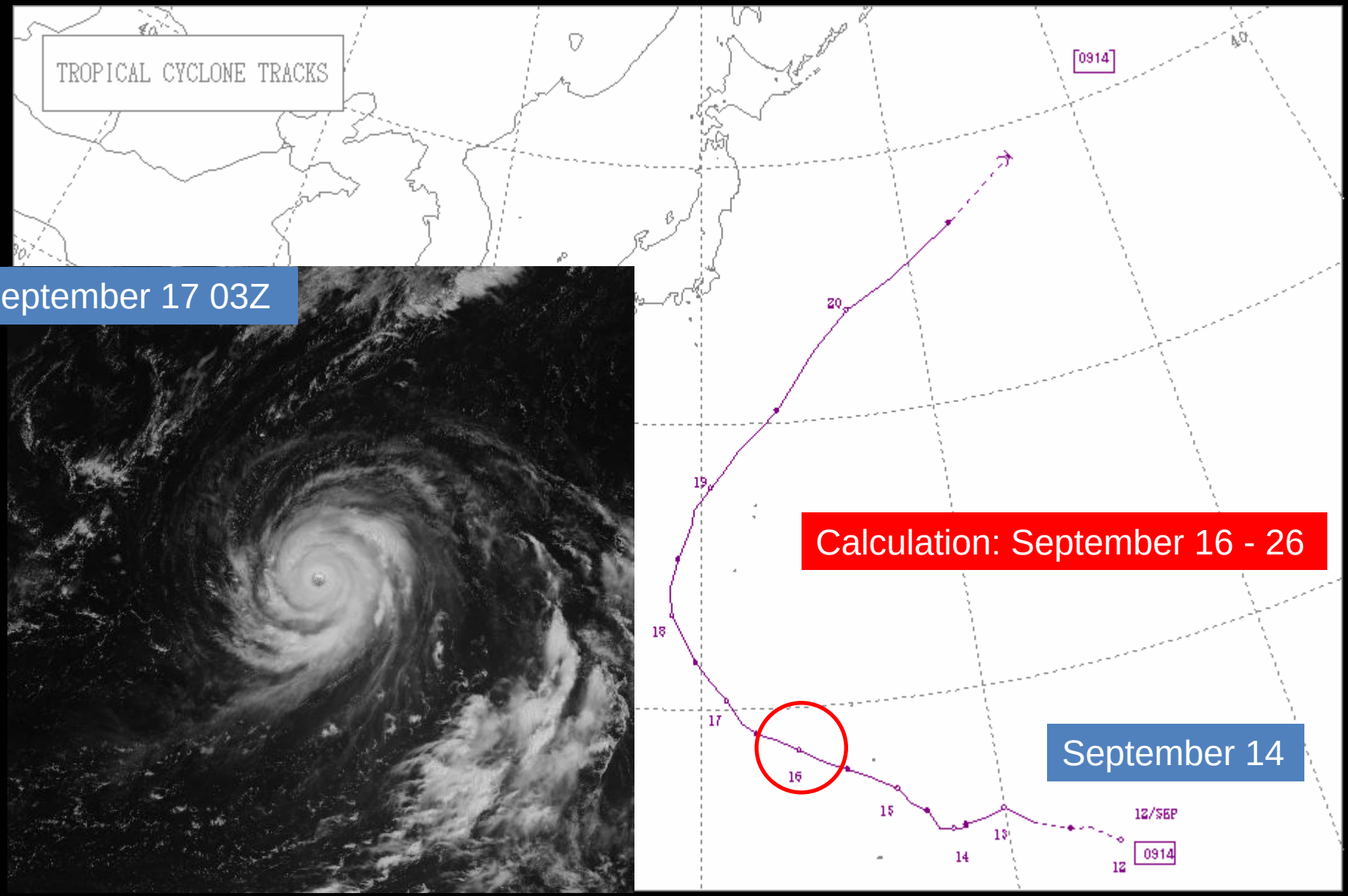

Topography of Taiwan, tar
121.0E−121.3E,23.0N-
25N
24N
23N
22N
Latitude (Deg)
120E
121E
122E
Longitude (Deg)
750
500
250
T0505, Time variation of accumulated rainfall on Taiwan Island (121-121.3E,23-23.5N)
1-D Ocean(CReSS, JMA/MGDSST)
1-D Ocean(CReSS, JCOPE2 SST)
3-D ocean(CReSS-NHOES, JCOPE2)
accumulated rainfall (mm)
2000
1500
1000
500
0
60
70
80
90
100
110
120
130
140
Time of integration (hour)


Topography of Taiwan, tar
121.25E−121.75E,24.85N
0505, Time variation of accumulated rainfall on Taiwan Island (121.25-121.75E,24.85-25.0
1-D Ocean(CReSS, JMA/MGDSST)
1-D Ocean(CReSS, JCOPE2 SST)
3-D ocean(CReSS-NHOES, JCOPE2)
accumulated rainfall (mm)
Time of integration (hour)
2000
1500
1000
500
0
60
70
80
90
100
110
120
130
140
25N
24N
23N
22N
Latitude (Deg)
120E
121E
122E
Longitude (Deg)
750
500
250


Topography of Taiwan, tar
120.4E−120.7E,22.8N-
25N
24N
23N
22N
Latitude (Deg)
120E
121E
122E
Longitude (Deg)
750
500
250
T0505, Time variation of accumulated rainfall on Taiwan Island (120.4-120.7E,22.8-23.1N)
1-D Ocean(CReSS, JMA/MGDSST)
1-D Ocean(CReSS, JCOPE2 SST)
3-D ocean(CReSS-NHOES, JCOPE2)
accumulated rainfall (mm)
0
100
200
300
400
500
600
700
800
90
100
110
120
130
140
Time of integration (hour)

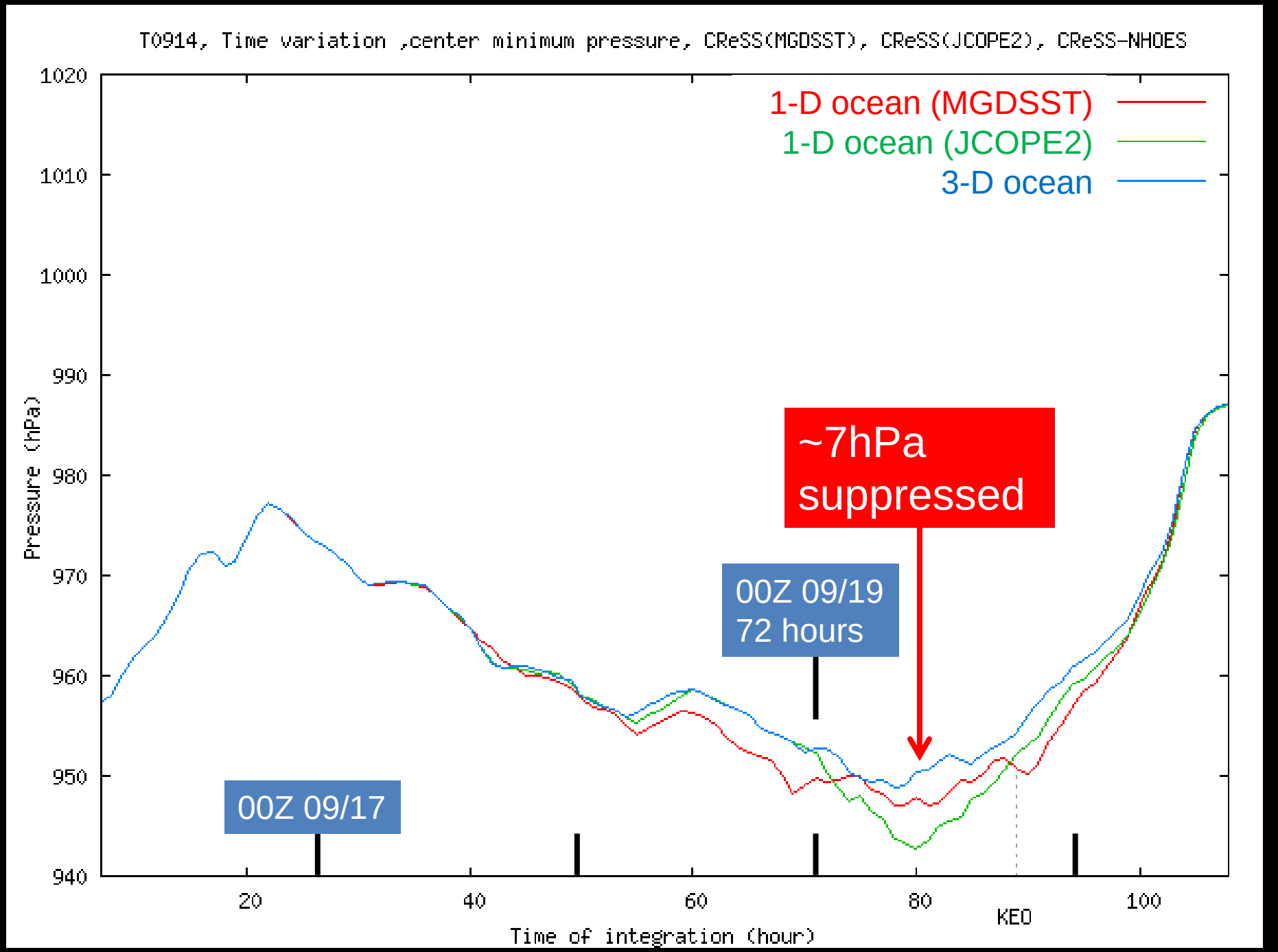
Backup slides-2

T0914, Choi-Wan



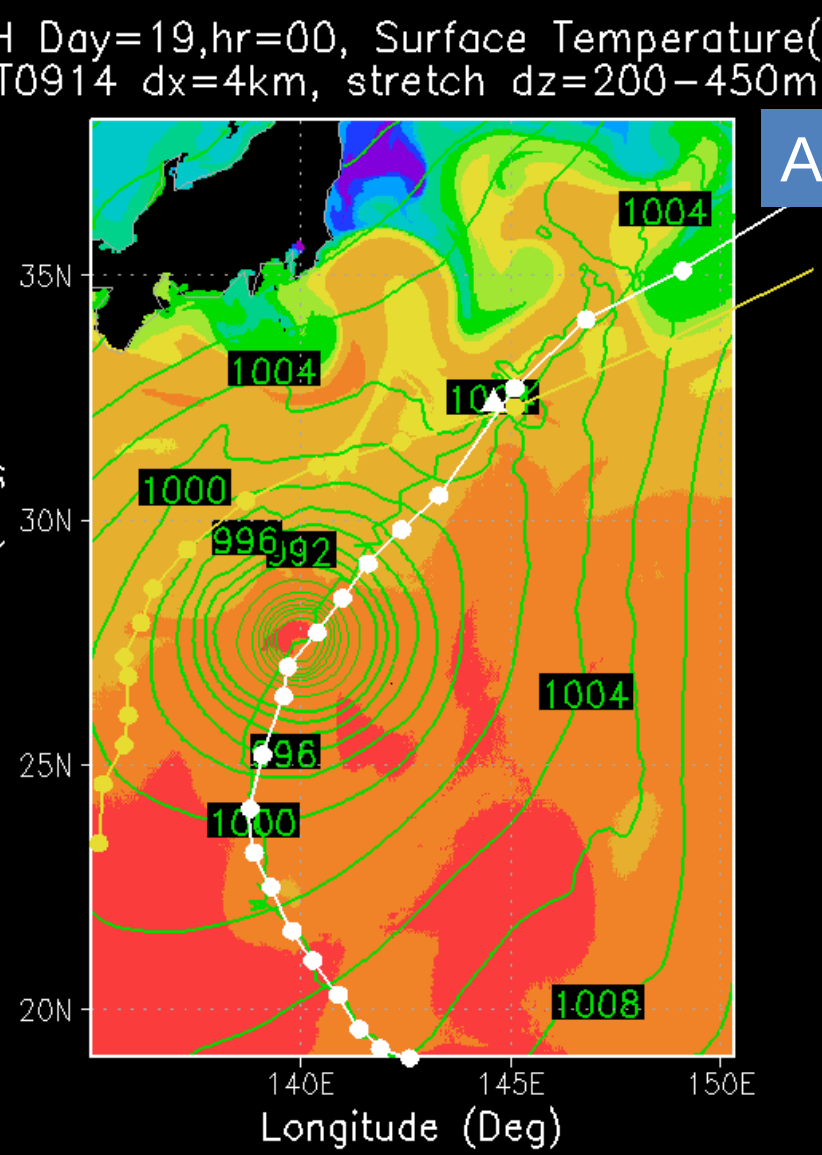
T0914, Choi-Wan experiments

- CReSS
  - DX=DY=4km, DZ = 200m(surface) to 400m (stretched)
  - 380 x 480 x 60 grid
  - Initial and lateral boundary condition: JMA/RANAL dataset
- 3-D ocean: NHOES
  - DX=DY=4km, DZ = 2 m for top 100 m
  - 380 x 480 x 100 grid
  - Initial and lateral boundary condition: JCOPE2 reanalysis
- 1-D ocean:
  - 30m depth (60 layers of dz=0.5m) with JCOPE2 SST
- Integration period: 00Z 9/16 -- 00Z 9/26 (10days)

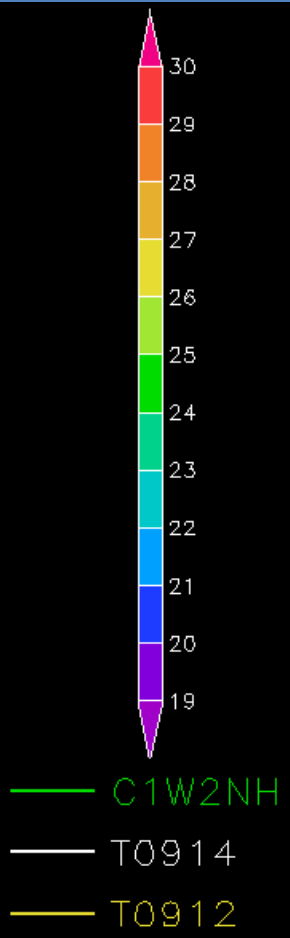

T0914, Time variation ,center minimum pressure, CReSS(MGDSST), CReSS(JCOPE2), CReSS-NHOES
1-D ocean (MGDSST)
1-D ocean (JCOPE2)
3-D ocean
~7hPa
suppressed
00Z 09/19
72 hours
00Z 09/17
Pressure (hPa)
Time of integration (hour)
KEO
1020
1010
1000
990
980
970
960
950
940
20
40
60
80
100

T0914: SLP and SST distribution

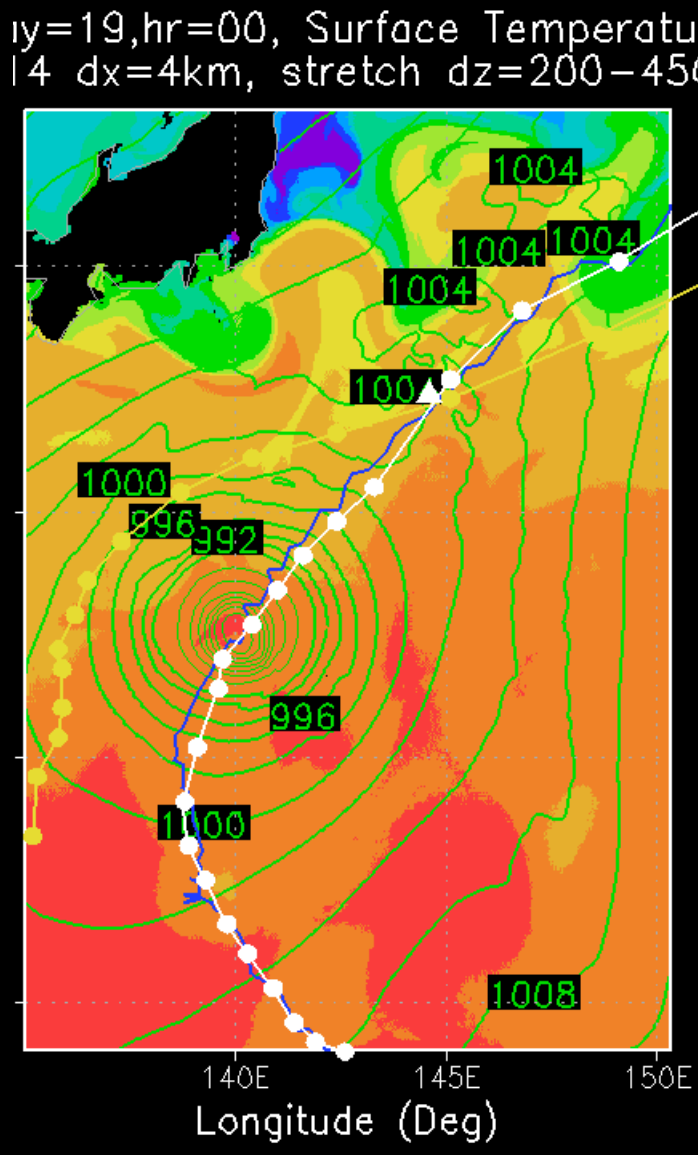
1-D ocean



After 72 hours

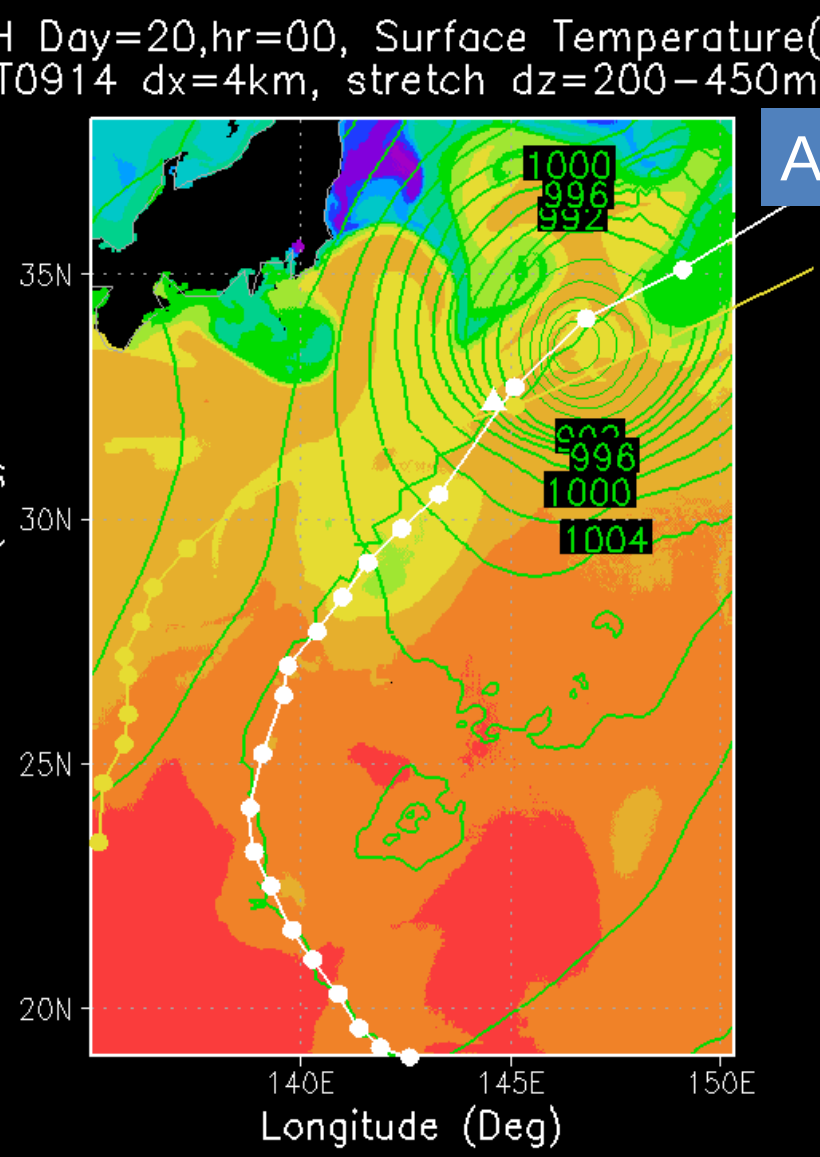


3-D ocean

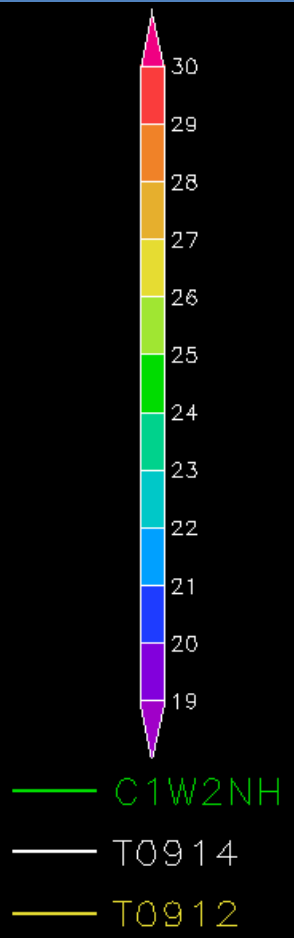


T0914: SLP and SST distribution

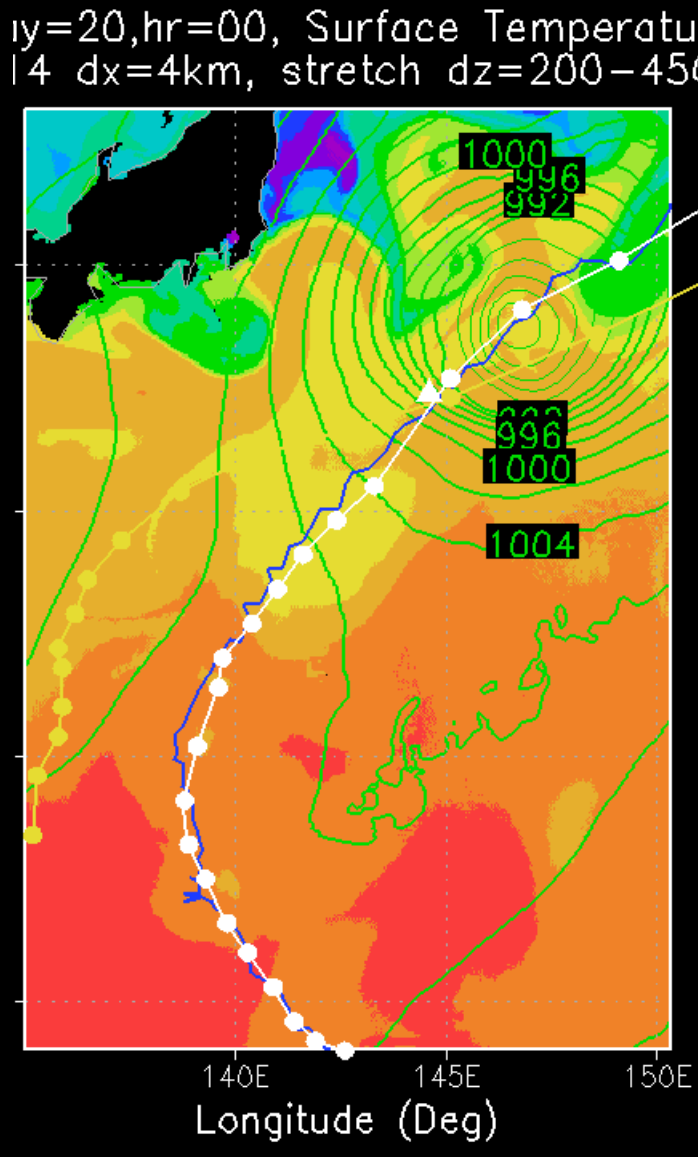
1-D ocean

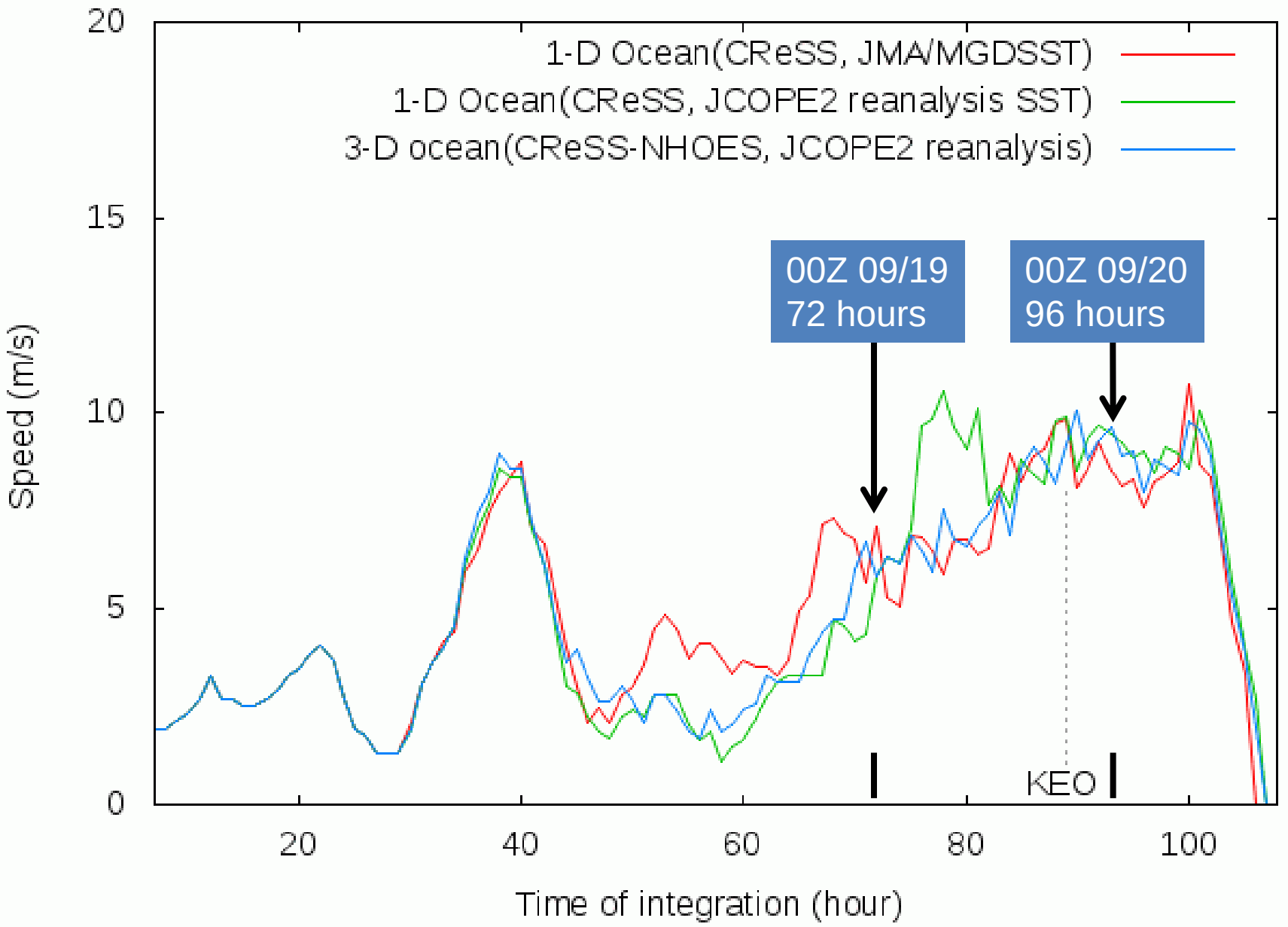


After 96 hours

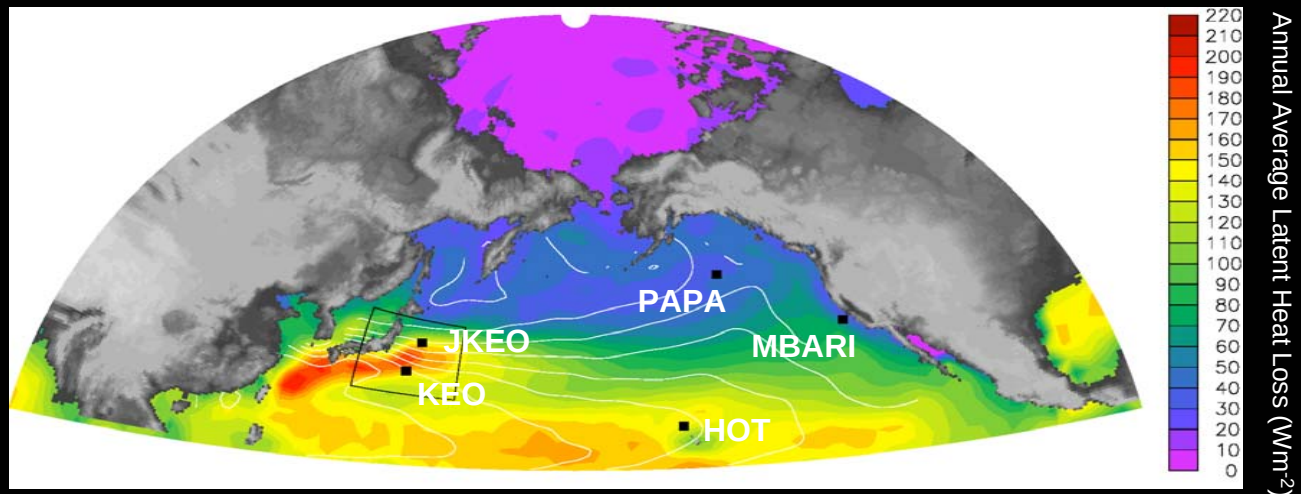


3-D ocean




T0914, Time variation of average moving speed of TC, (6hr moving average)
1-D Ocean(CReSS, JMA/MGDSST)
1-D Ocean(CReSS, JCOPE2 reanalysis SST)
3-D ocean(CReSS-NHOES, JCOPE2 reanalysis)
00Z 09/19
72 hours
00Z 09/20
96 hours
KEO
Speed (m/s)
Time of integration (hour)
0
5
10
15
20
20
40
60
80
100

KEO and JKEO are part of the global network of OceanSITES time series reference sites: http://www.oceansites.org



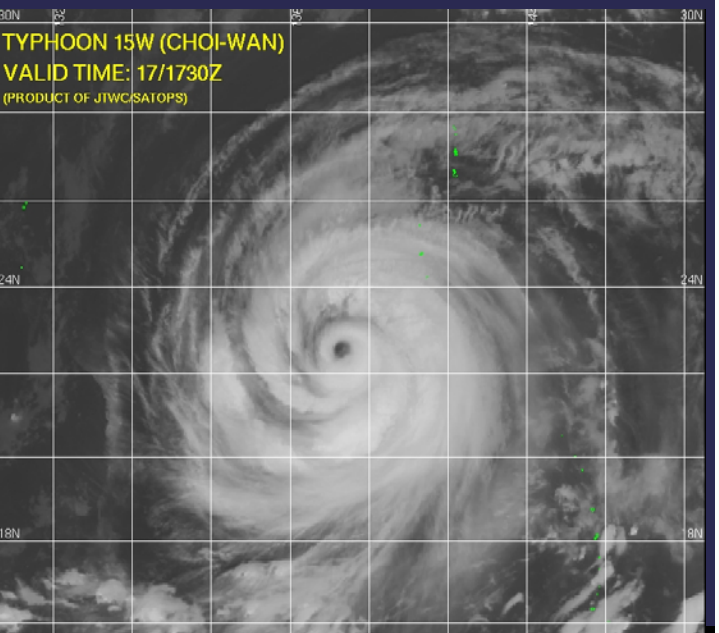
Purpose of OceanSITES reference stations

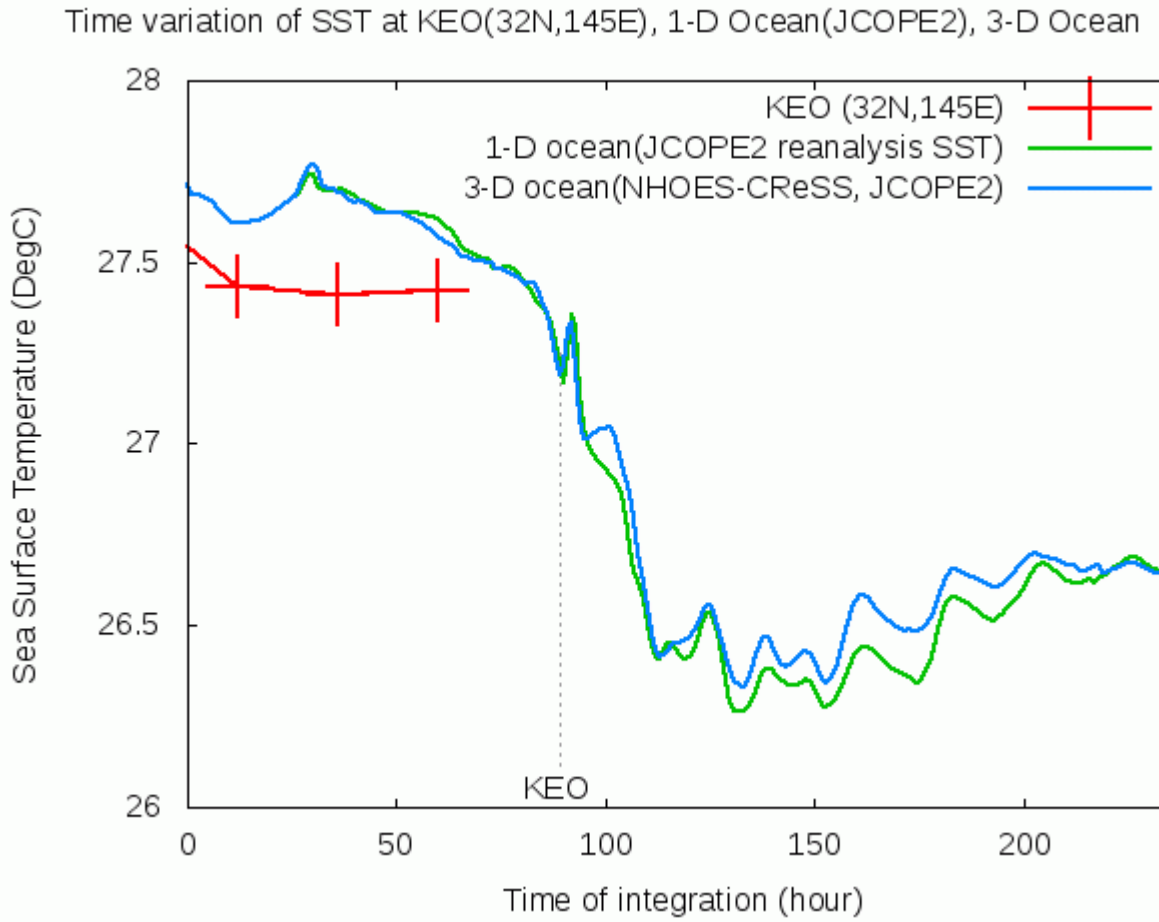
- To provide data for assessing model, data, and satellite products
- To detect rapid changes and episodic events, as well as long-term changes in the climate system
- To provide a test-bed for studying processes within the climate system

OceanSITES data are…

- Long, ongoing time series, following best practices and quality control
- Common netcdf format that includes all necessary meta data
- Freely available through OceanSITES DACS and GDACS

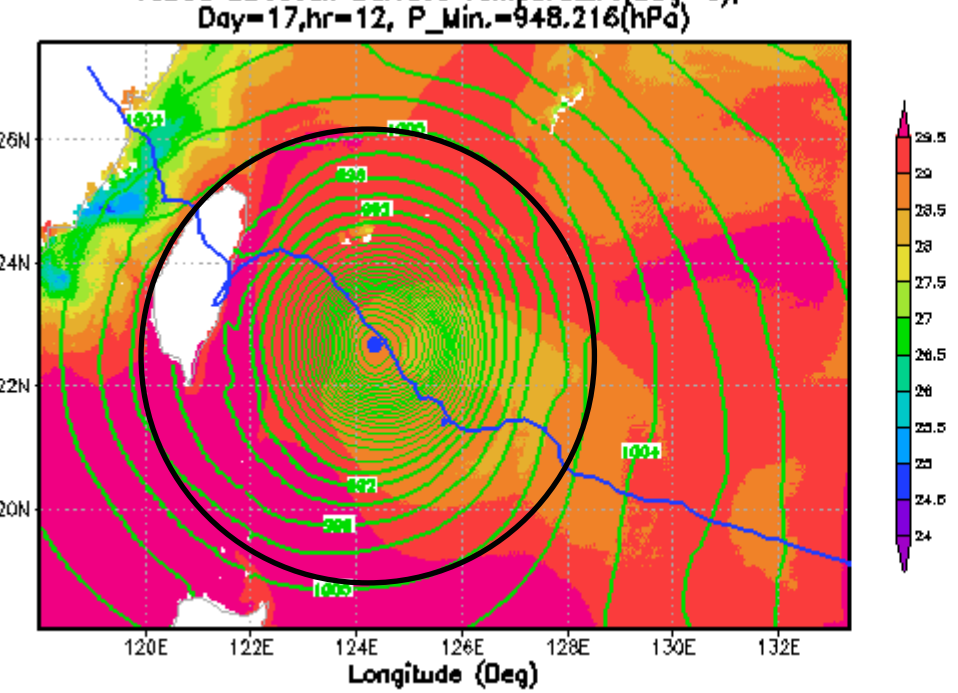

K
Passed KEO - 19 Sept 17Z

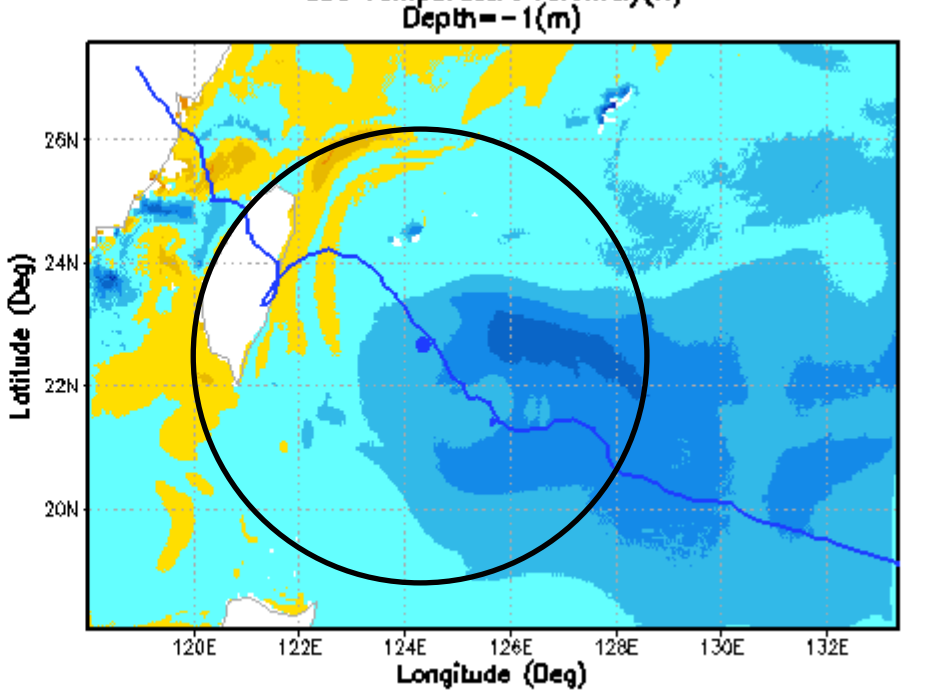

TYPHOON 15W (CHOI-WAN)
VALID TIME: 17/1730Z
(PRODUCT OF JTWC/SATOPS)

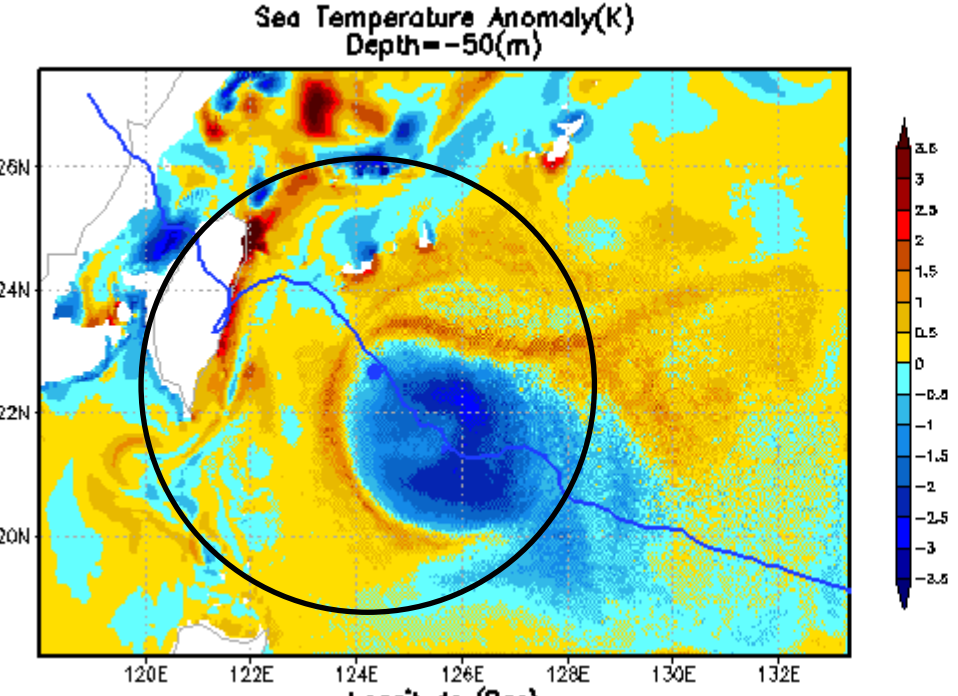

Time variation of SST at KEO(32N,145E), 1-D Ocean(JCOPE2), 3-D Ocean
KEO (32N,145E)
1-D ocean(JCOPE2 reanalysis SST)
3-D ocean(NHOES-CReSS, JCOPE2)
Sea Surface Temperature (DegC)
28
27.5
27
26.5
26
KEO
0
50
100
150
200
Time of integration (hour)

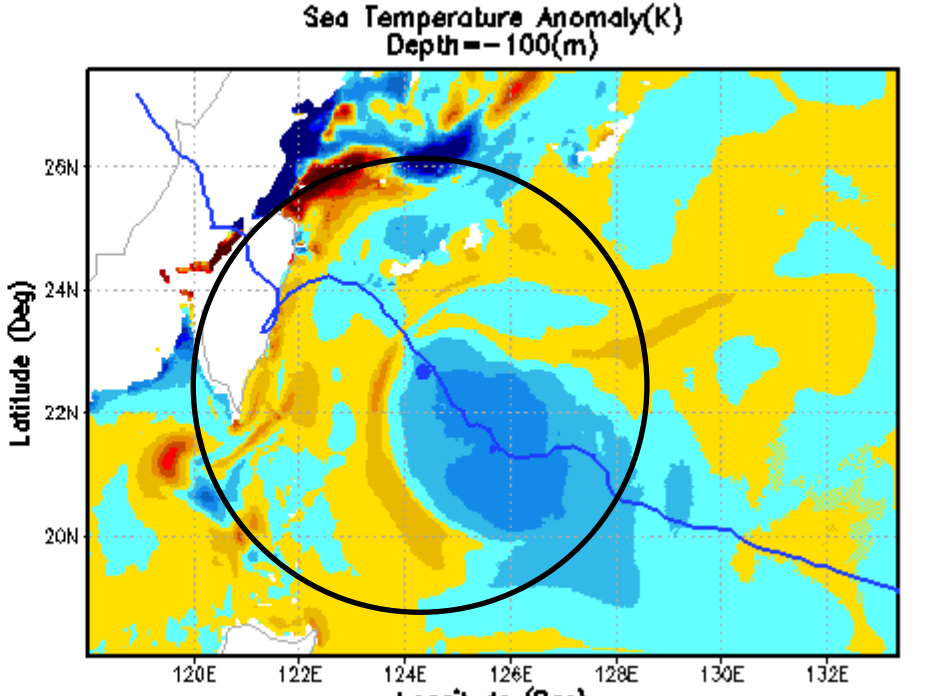
More Investigation for Choi-wan…

- We are planning to use KEO data to check difference between observation and simulation…
  - BUT, KEO dataset is NOT available in the target period, NOT completed after passing T0914… because of T0914 itself (caused some trouble on the KEO buoy)
  - People of KEO group in NOAA/PMEL are working on quality check now.
  - We are waiting for uploading data…


Day=17,hr=12, P_Min.=948.216(hPa)
26N
24N
22N
20N
120E
122E
124E
126E
128E
130E
132E
Longitude (Deg)
1004
29.5
29
28.5
28
27.5
27
26.5
26
25.5
25
24.5
24


Depth=-1(m)
26N
24N
22N
20N
Latitude (Deg)
120E
122E
124E
126E
128E
130E
132E
Longitude (Deg)

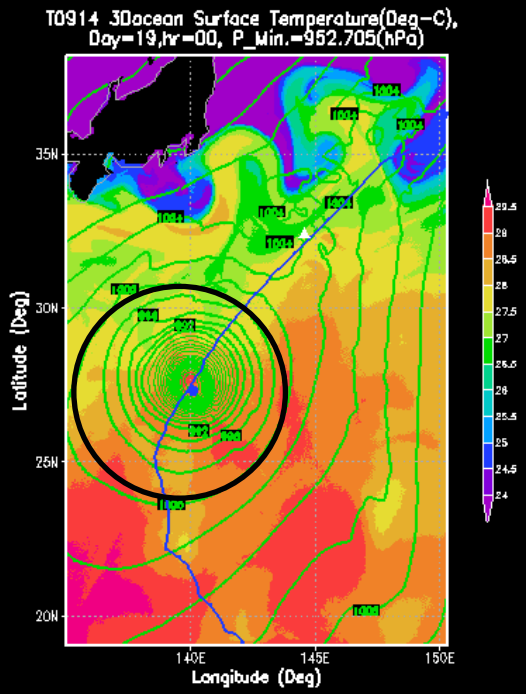

Sea Temperature Anomaly(K)
Depth=-50(m)
26N
24N
22N
20N
120E
122E
124E
126E
128E
130E
132E
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5

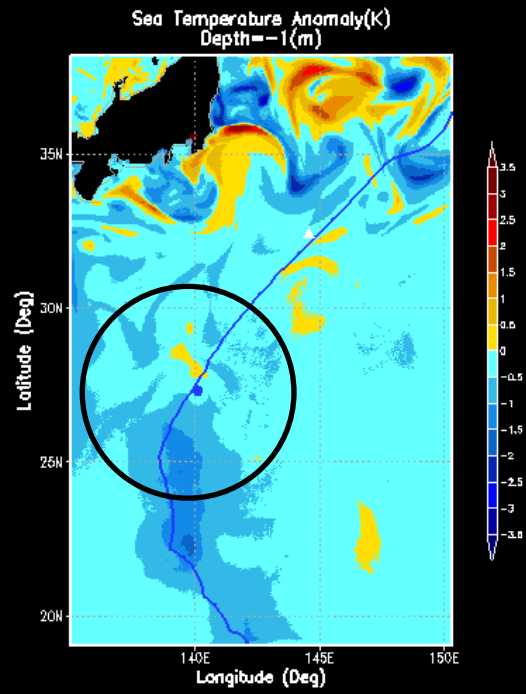

Sea Temperature Anomaly(K)
Depth=-100(m)
26N
24N
22N
20N
Latitude (Deg)
120E
122E
124E
126E
128E
130E
132E

T0914
After 72 hours

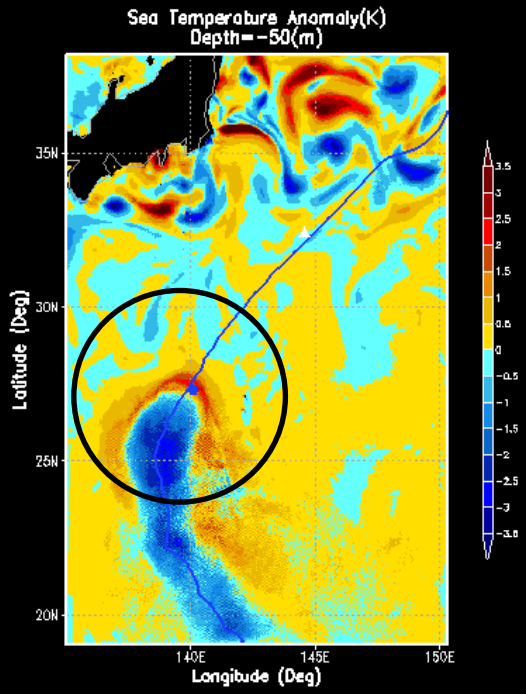
Temperature Anomalies from t=0

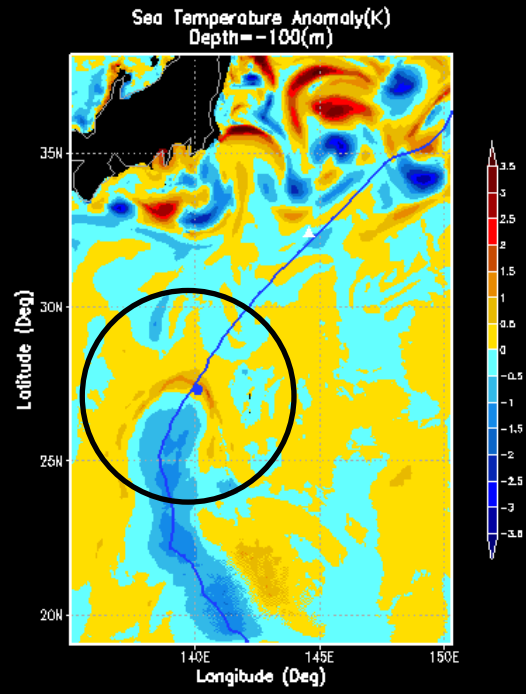
Z=0 (SST)





Z=-1m





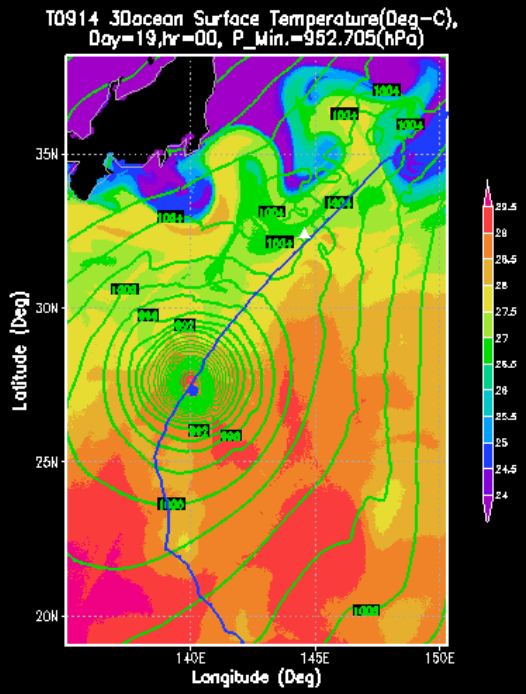
Z=-50m

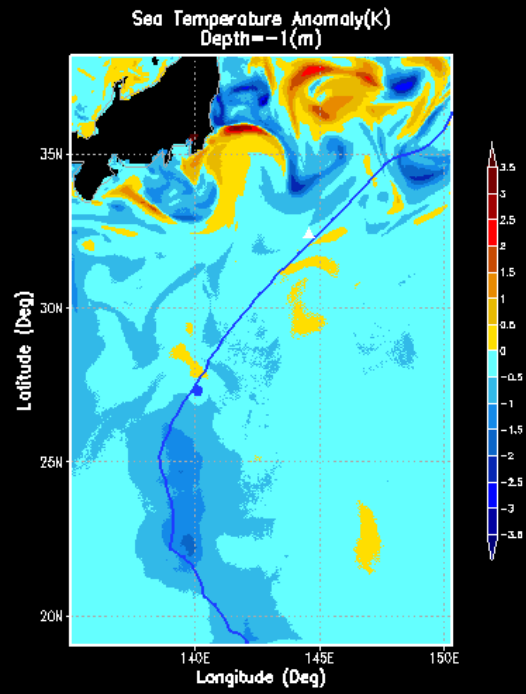
Z=-100m

T0914
After 72 hours

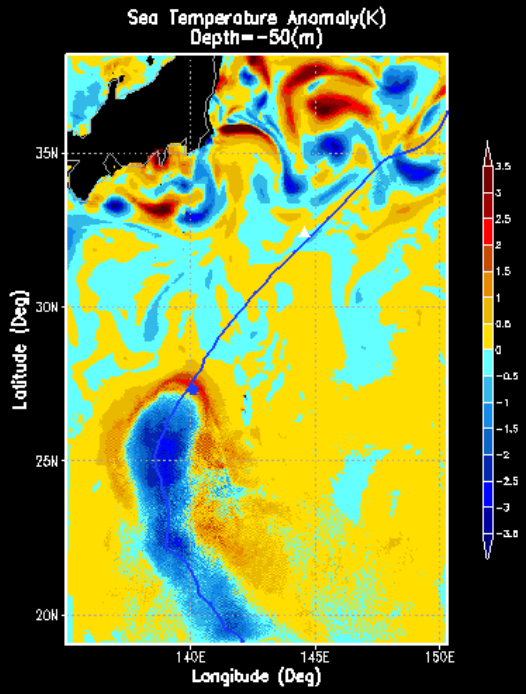
Temperature Anomalies from t=0

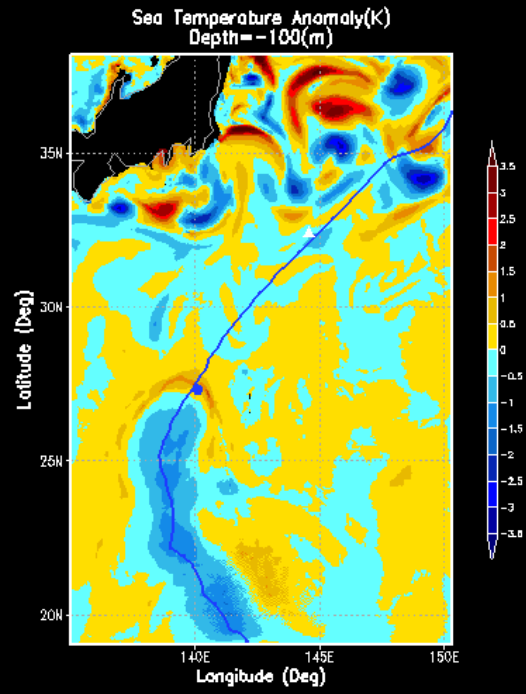
Z=0 (SST)





Z=-1m

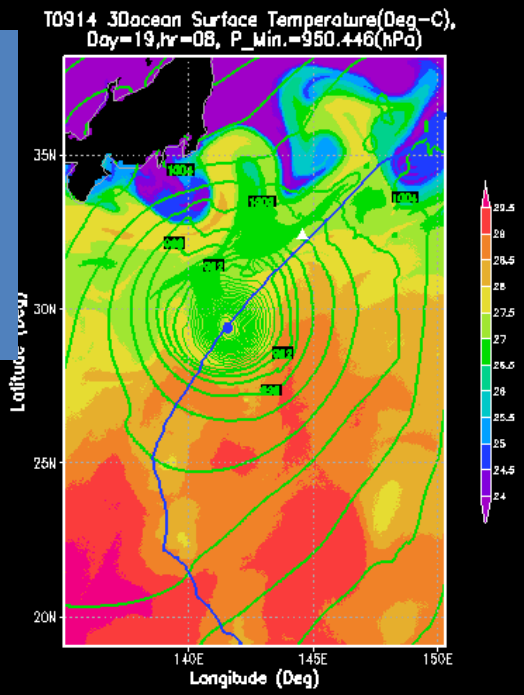




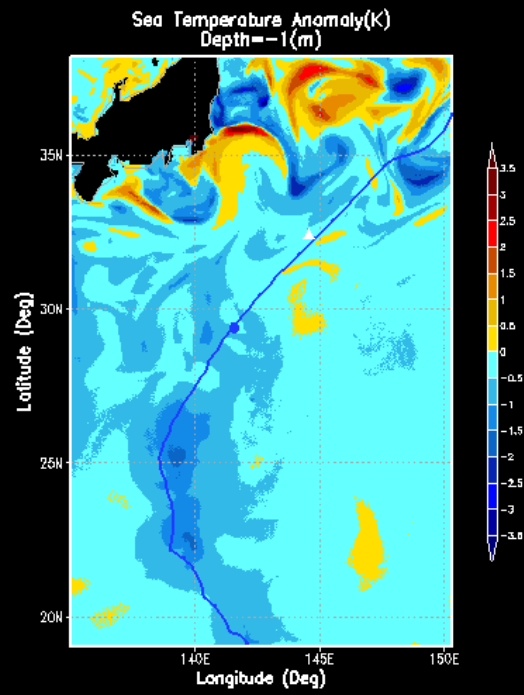
Z=-50m

Z=-100m

T0914
After 80 hours
Pressure
minimum

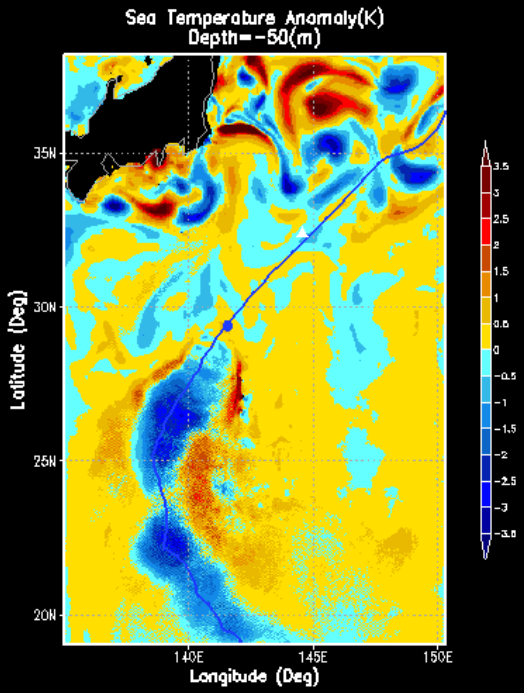


Z=0
(SST)

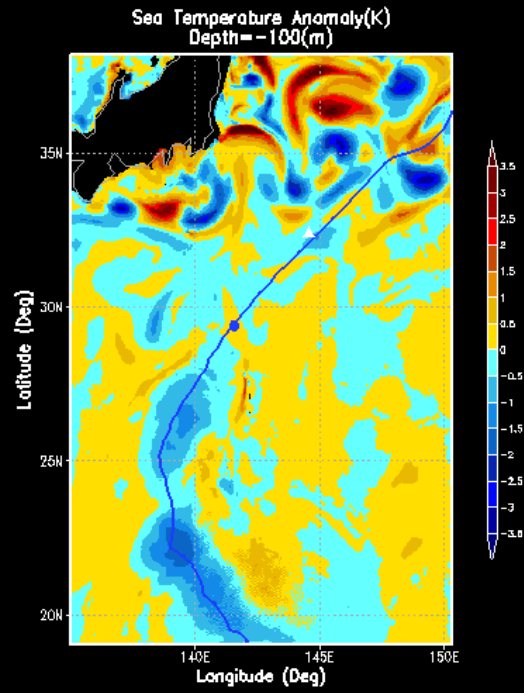


Temperature
Anomalies
from t=0

Z=-1m



Z=-50m



Z=-100m

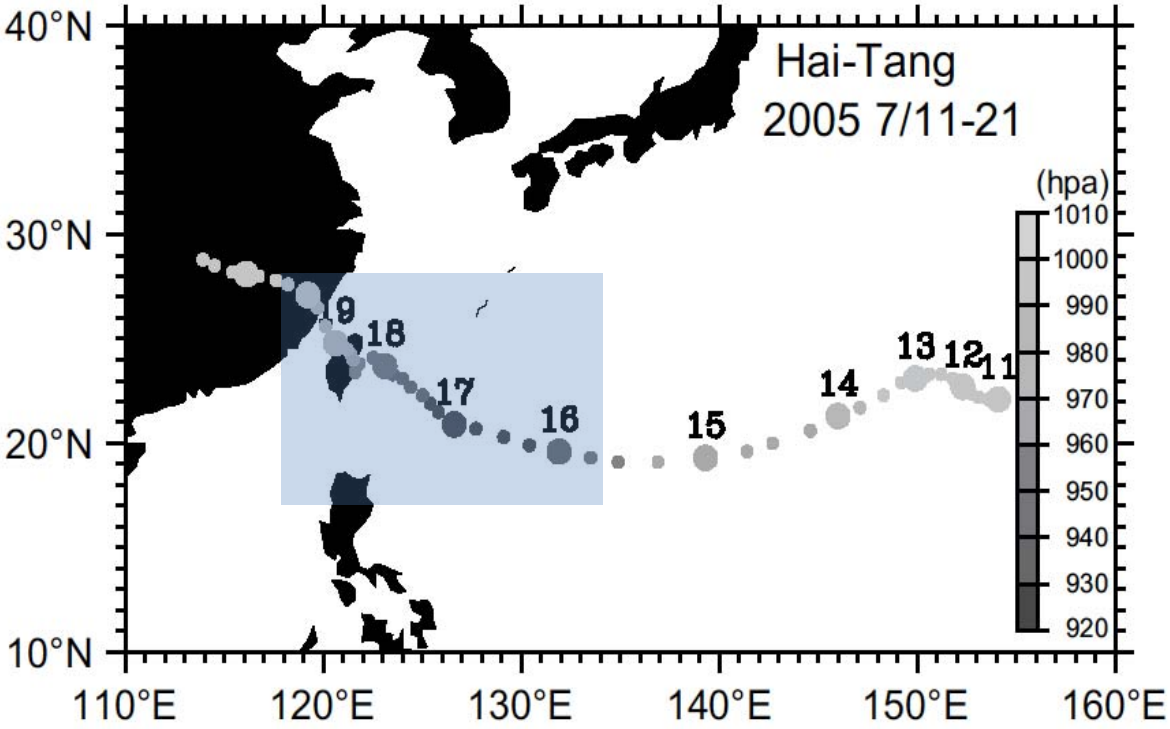
Cloud Resolving Storm Simulator (CReSS)

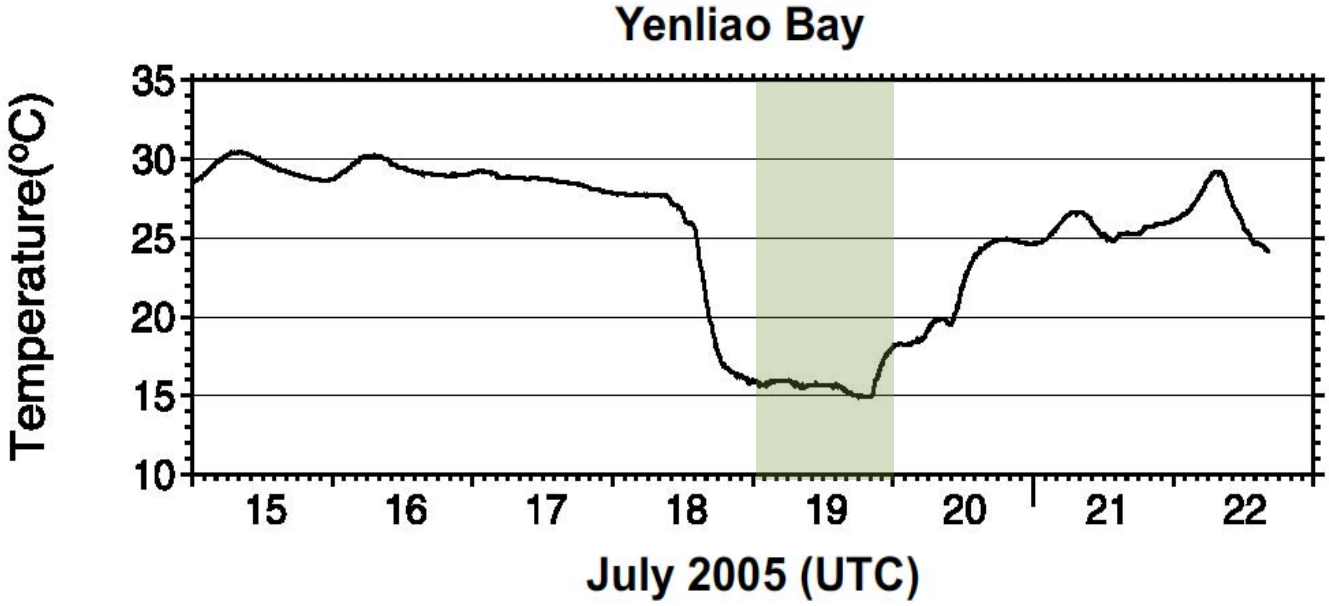
Tsuboki and Sakakibara (2002)
DX = 4km, 380 * 250 * 60 grid
Initial and lateral B. C.:
RANAL from NPD/JMA

NonHydrostatic Ocean model for ES (NHOES)

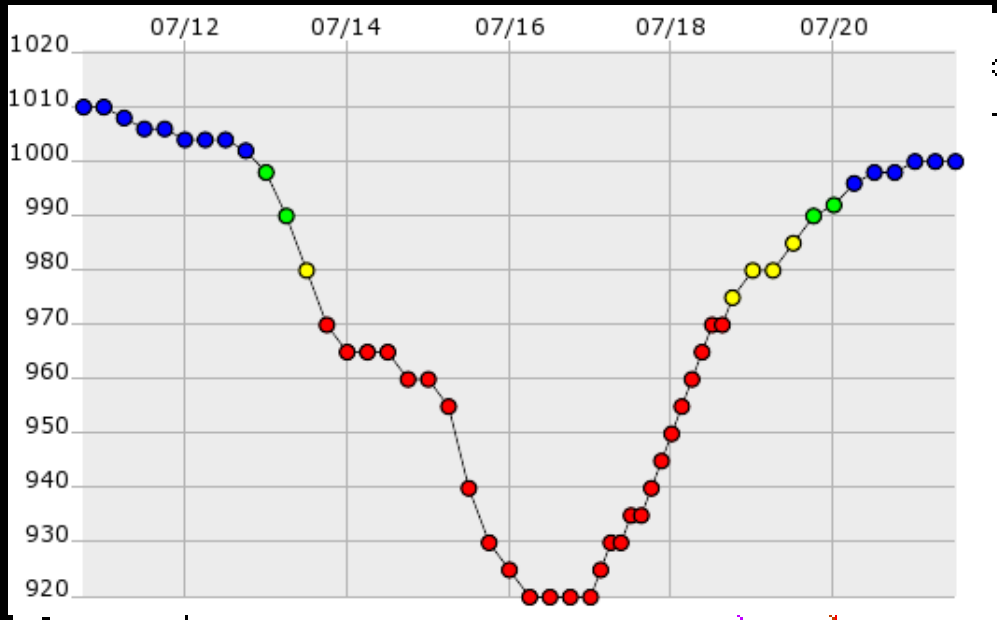
Aiki and Yamagata (2004)
Aiki et al. (2006)
Menesguen et al. (2009)

DX = 1km, DZ = 2 m for top 100 m
1500 * 1000 * 100 grid
Initial and lateral B. C.:
JCOPE2 reanalysis





Morimoto et al. (2009)



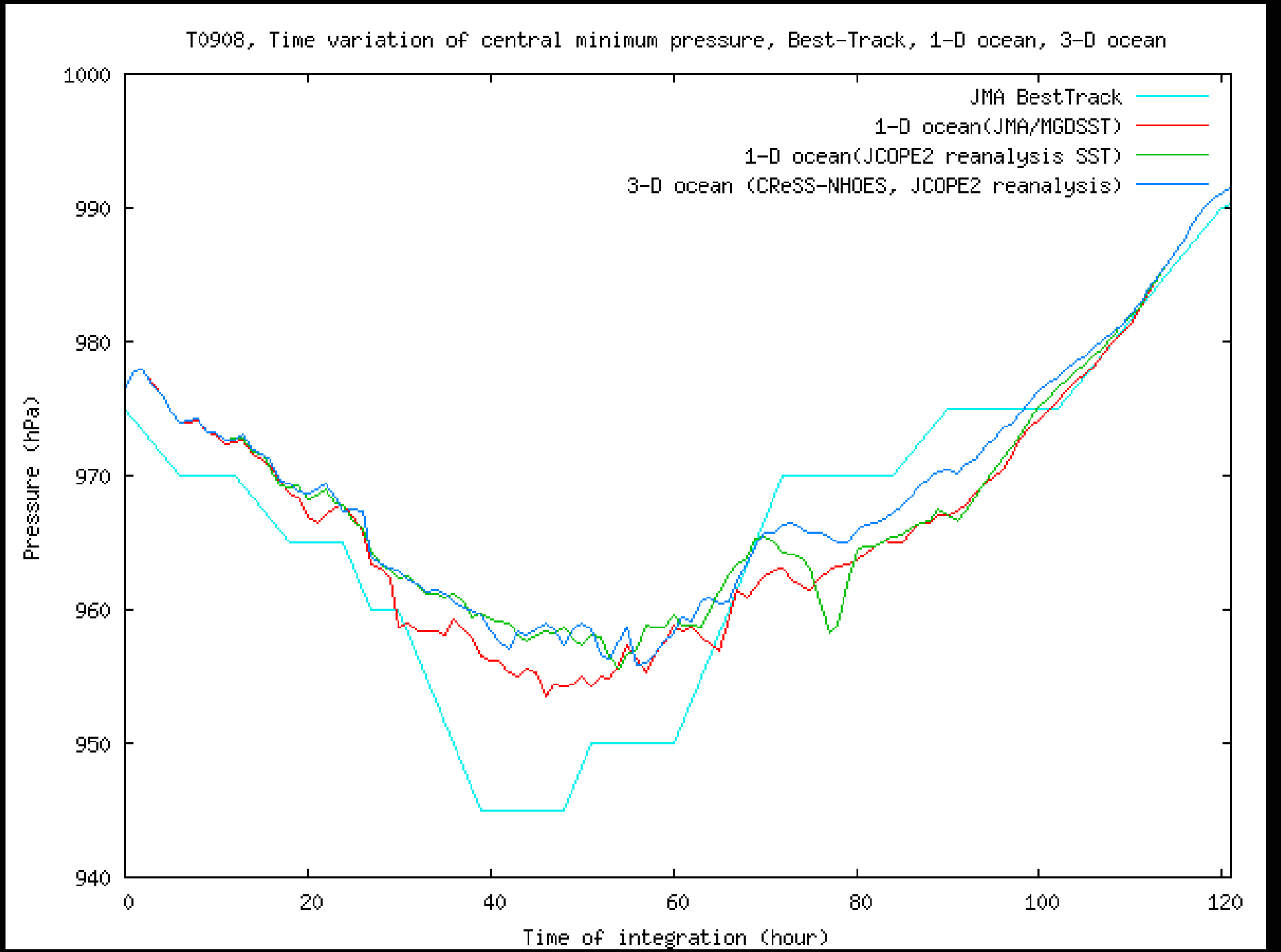
pressure, JMA RANAL, CReSS model results

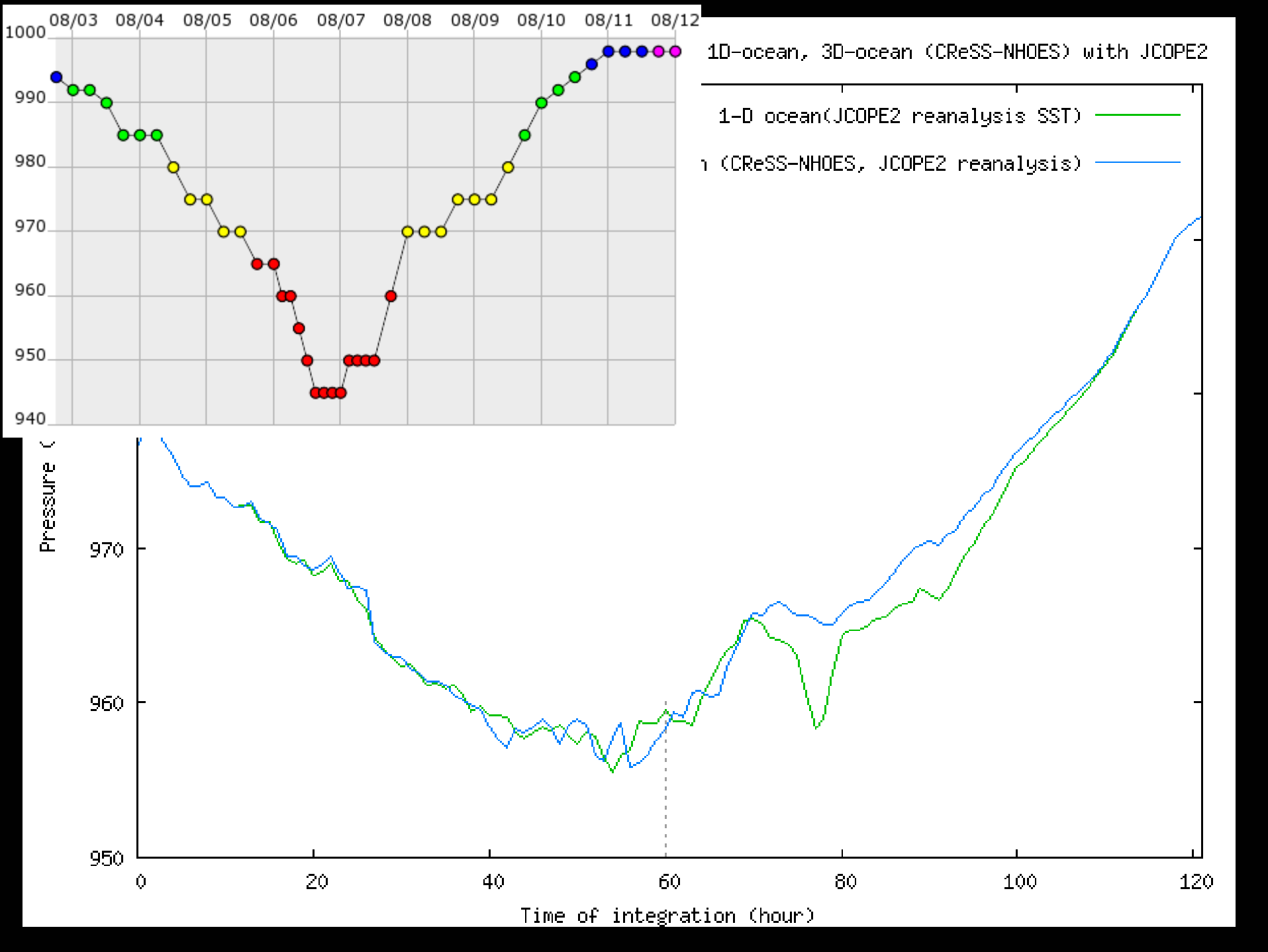
1-D ocean (MGDSST) ---
Fixed SST (MGDSST) ---
JMA RANAL ---

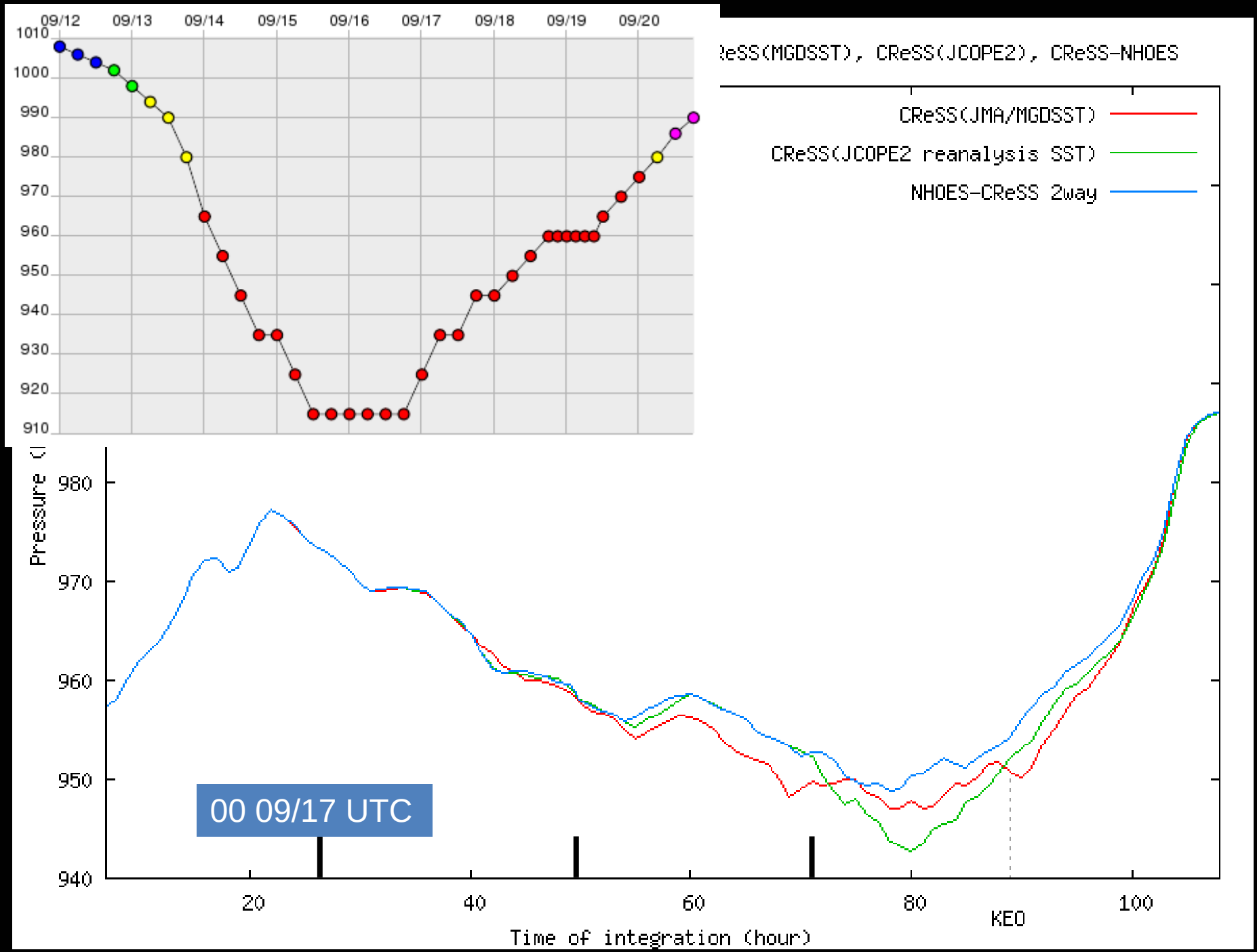
Pressure (hP
970
960
950
940
930
0
20
40
60
80
100
120
140
Time of integration (hour)

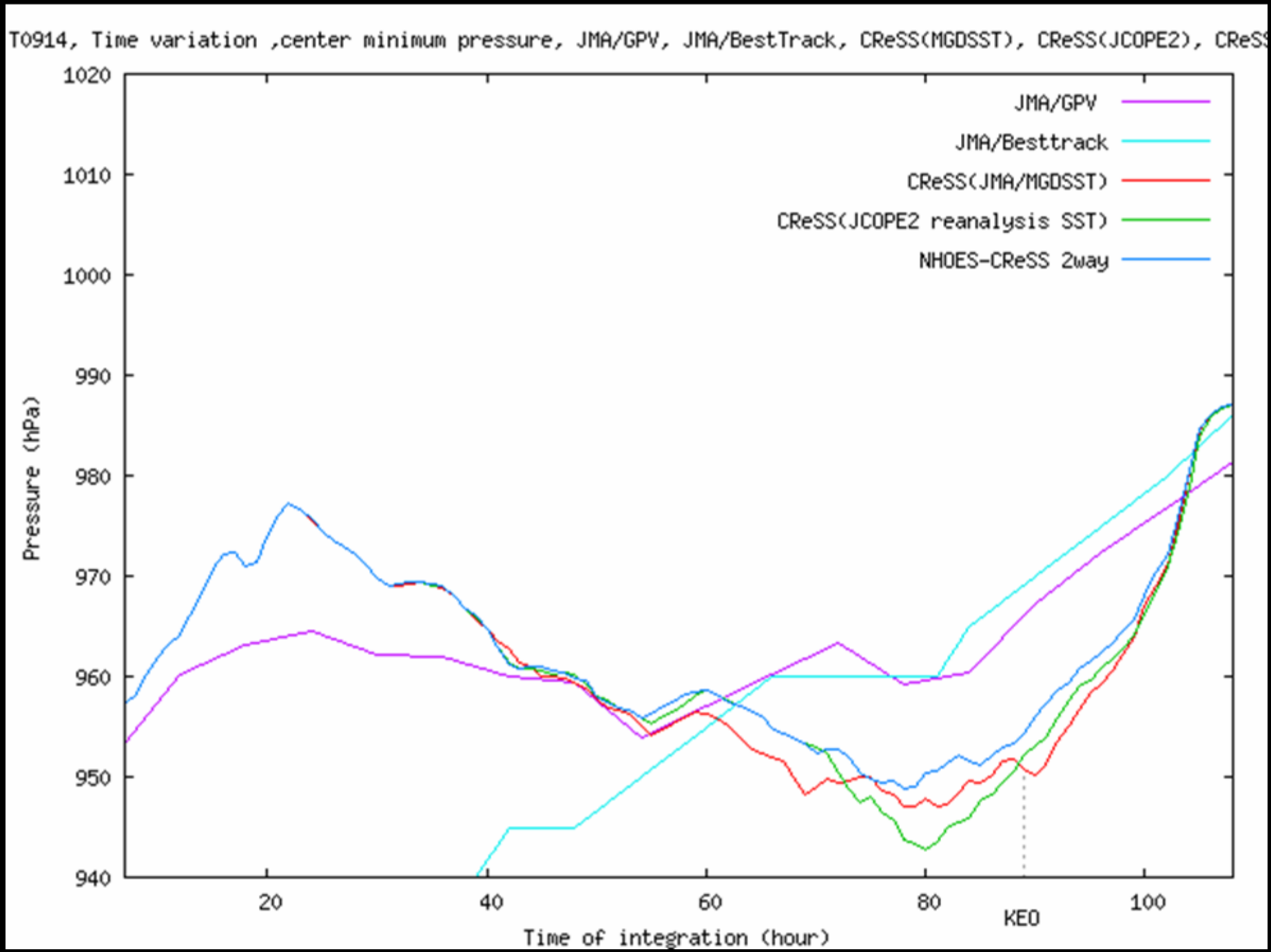
00Z 07/15
07/16

約7hPa抑制


T0908, Time variation of central minimum pressure, Best-Track, 1-D ocean, 3-D ocean
JMA BestTrack
1-D ocean(JMA/MGDSST)
1-D ocean(JCOPE2 reanalysis SST)
3-D ocean (CReSS-NHOES, JCOPE2 reanalysis)
Pressure (hPa)
1000
990
980
970
960
950
940
0
20
40
60
80
100
120
Time of integration (hour)

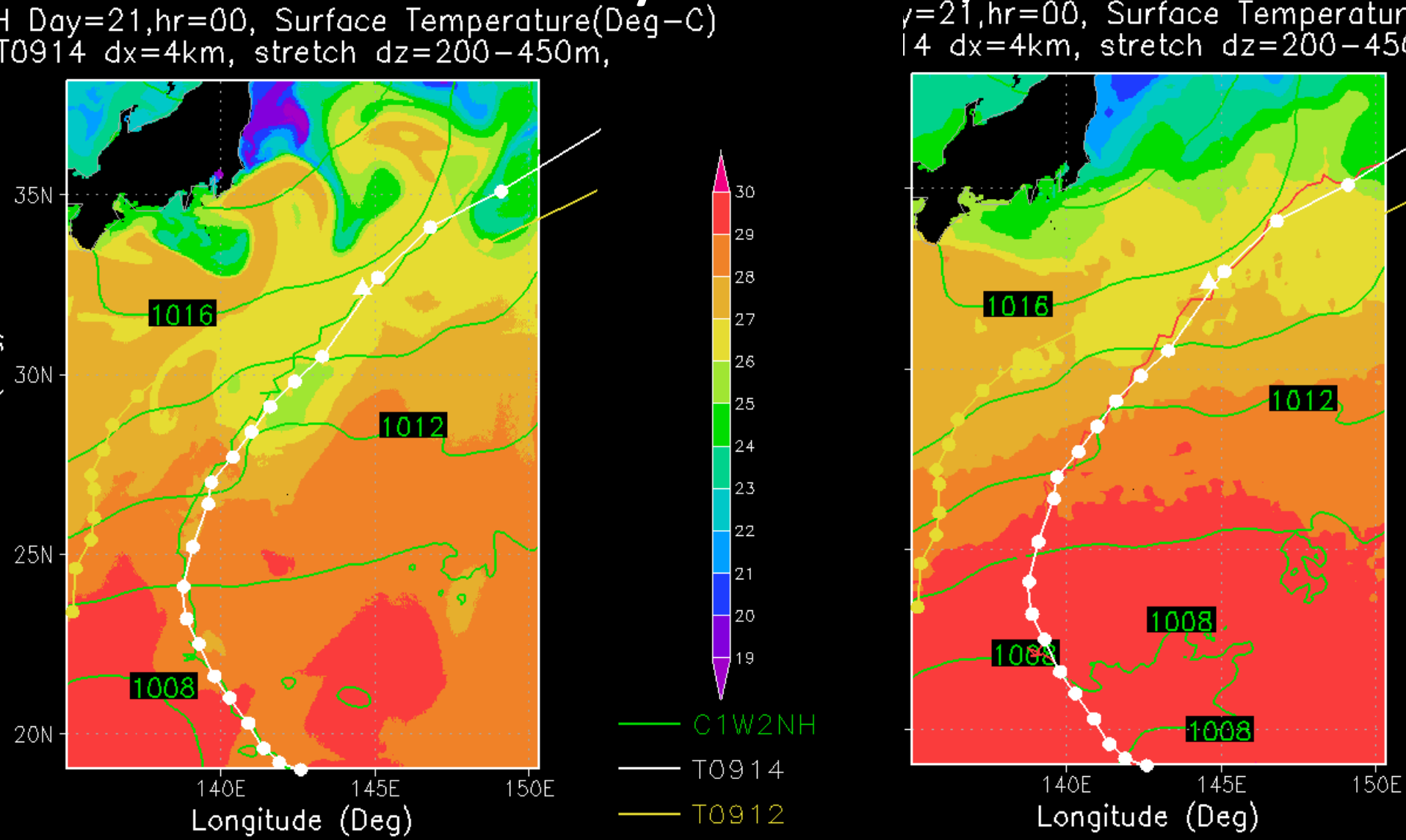

08/03
08/04
08/05
08/06
08/07
08/08
08/09
08/10
08/11
08/12
1000
990
980
970
960
950
940
1D-ocean, 3D-ocean (CReSS-NHOES) with JCOPE2
1-D ocean(JCOPE2 reanalysis SST)
(CReSS-NHOES, JCOPE2 reanalysis)
Pressure
970
960
950
0
20
40
60
80
100
120
Time of integration (hour)


09/12
09/13
09/14
09/15
09/16
09/17
09/18
09/19
09/20
1010
1000
990
980
970
960
950
940
930
920
910
eSS(MGDSST), CReSS(JCOPE2), CReSS-NHOES
CReSS(JMA/MGDSST)
CReSS(JCOPE2 reanalysis SST)
NHOES-CReSS 2way
Pressure (
980
970
960
950
940
00 09/17 UTC
20
40
60
80
100
KEO
Time of integration (hour)


T0914, Time variation ,center minimum pressure, JMA/GPV, JMA/BestTrack, CReSS(MGDSST), CReSS(JCOPE2), CReSS
JMA/GPV
JMA/Besttrack
CReSS(JMA/MGDSST)
CReSS(JCOPE2 reanalysis SST)
NHOES-CReSS 2way
Pressure (hPa)
1020
1010
1000
990
980
970
960
950
940
20
40
60
80
100
KEO
Time of integration (hour)

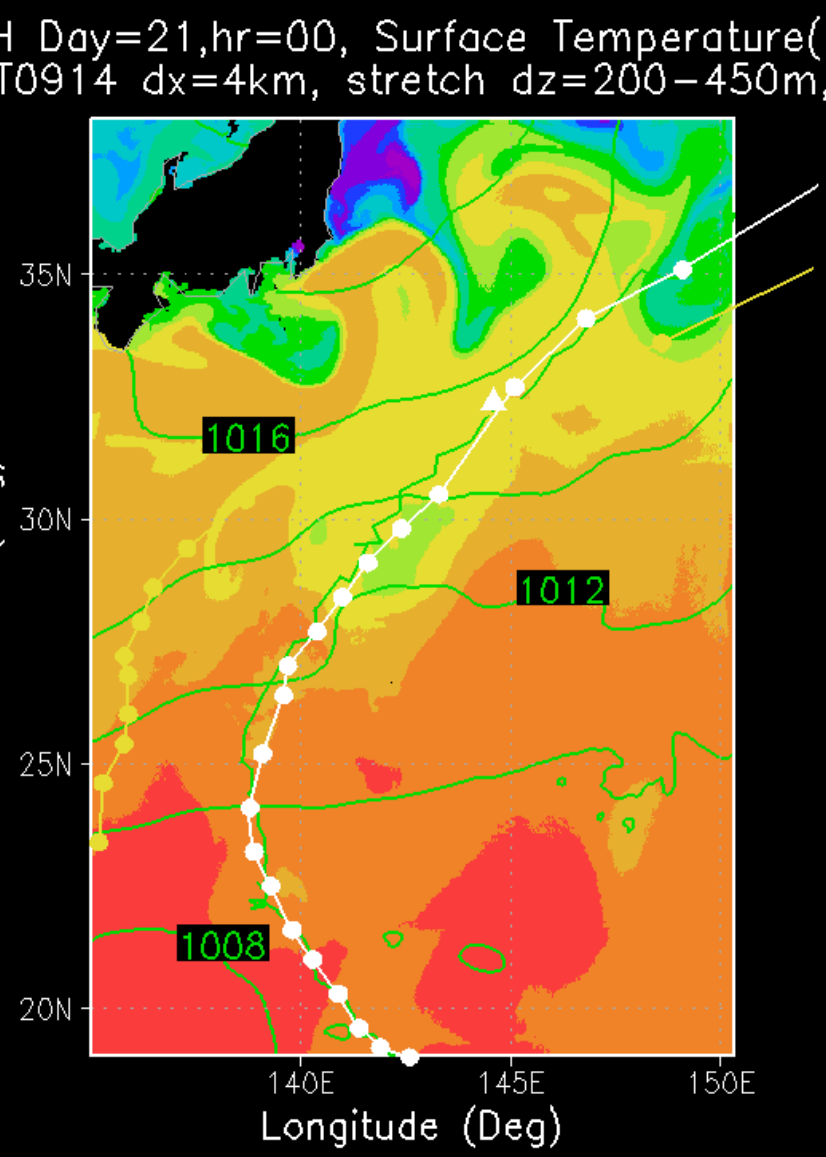
Difference in SST dataset

JCOPE2 Reanalysis JMA/MGDSST



T0914: Difference in SST distribution

1-D ocean



3-D ocean