

Analysis and Forecasts of a Historic Rain and Flood Event

Richard H. Grumm

National Weather Service State College

and

Jia Xuxuan

Shenyang Central Metrological Observatory

Overview

- ***We will examine a major Flood event***
 - *Significant impact on North Korea*
 - *Devastated crops in mid-August*
- **Ideal to see what happened**
 - *Examine aspects of a major flood → where did it rain*
 - *Analysis and forecast issues can be addressed →*
 - *What did the pattern look like and was it forecast as such?*
- **Ideal application of ensembles**
 - *Precipitation amounts (Probabilities) and timing*
 - *Meteorological setting*
 - *Intensity of key features associated with heavy rainfall.*
 - *Key features associated with heavy rains events*
- **Put features in a context → Climate anomalies of key features**

Slide 2

RHG1

We do not know the truth and are slaves to our analysis of choice/record.

Richard Grumm, 11/11/2007

A few points

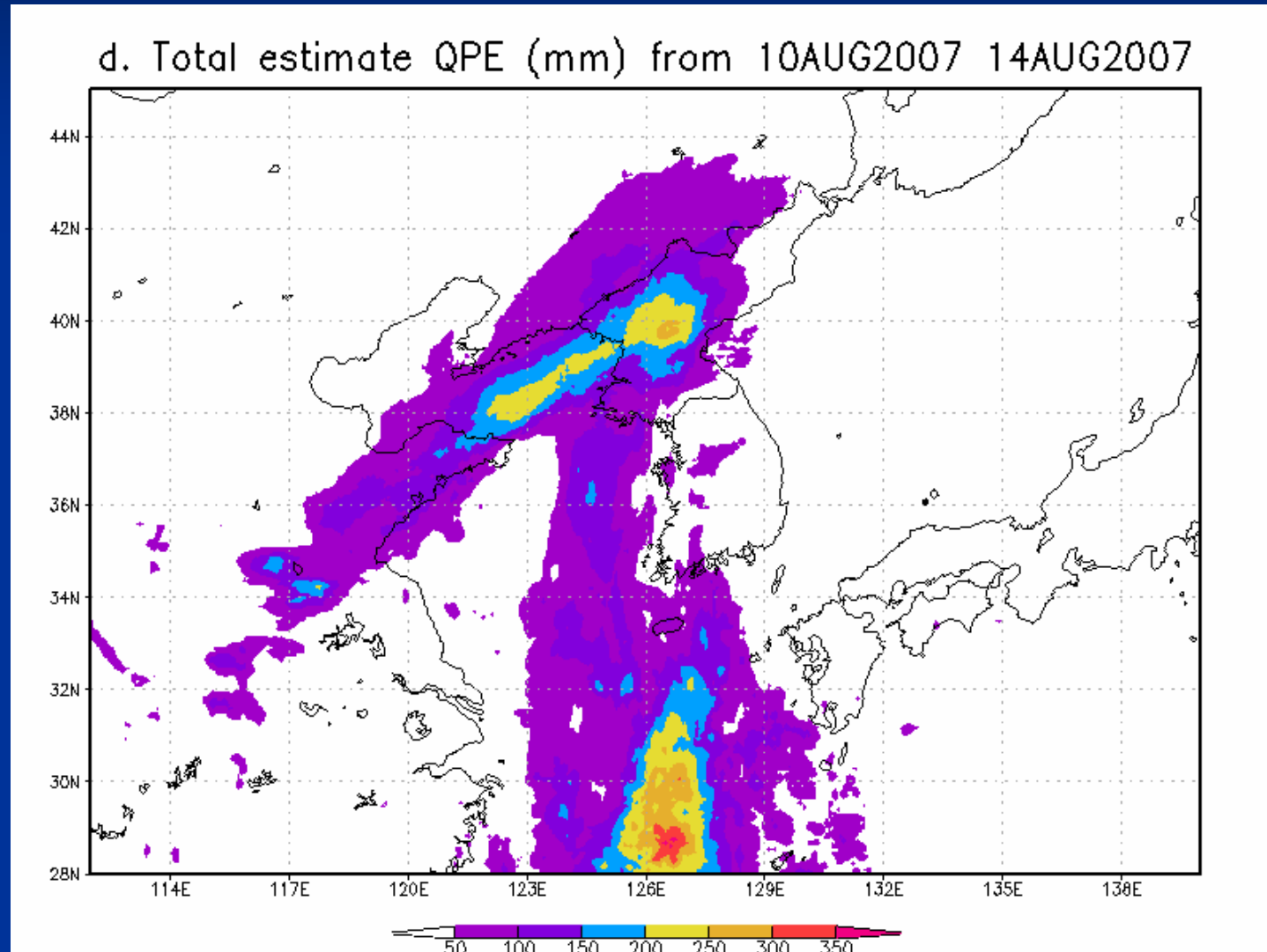
- *Some key characteristics*

- *Anomalously high PW values in affected region*
- *Strong and anomalous low-level southerly winds*
- *Tropical Moisture streams*
- *A pattern often seen in the eastern United States*

- *Blend EPS and Climatic Data can*

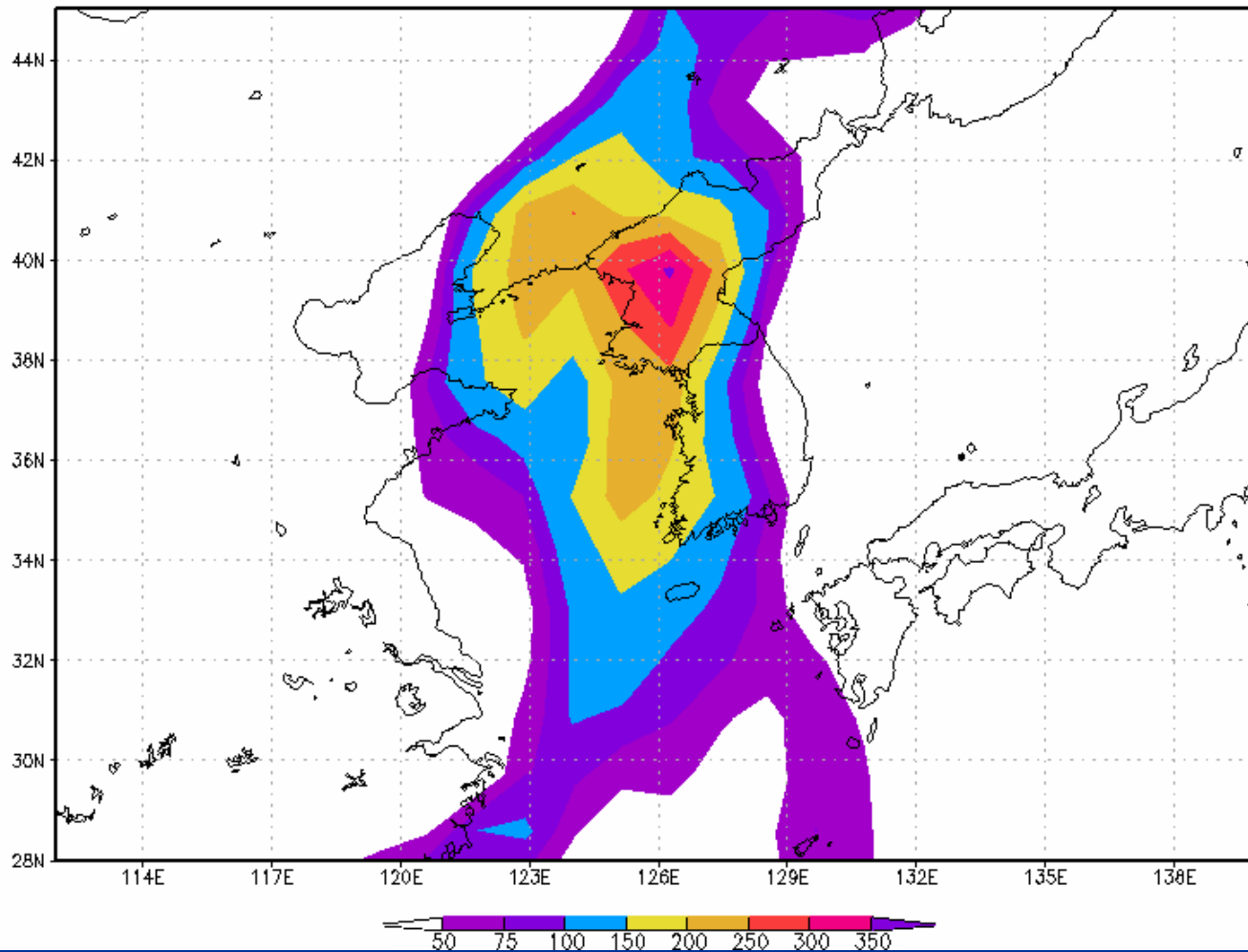
- *Define areas of high confidence → poorman's RMOP*
- *In this case the GEFS was remarkable in the amounts of rain forecast*
- *What would an good mesoscale ensemble have done?*

Estimate Rainfall valid 0000 UTC 10-14 August 2007



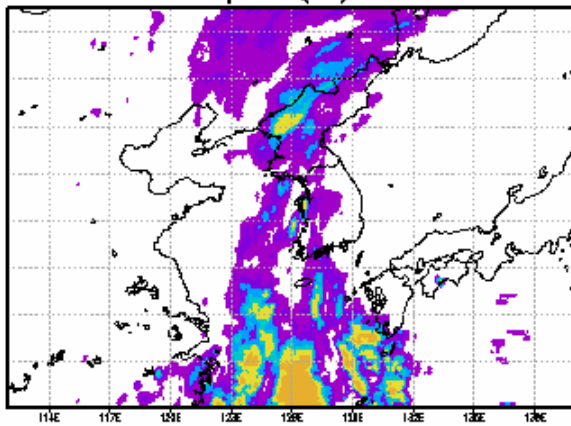
JRA25 Accumulated Rainfall

e. Total estimate QPE (mm) 00Z11AUG2007 to 00Z15AUG2007

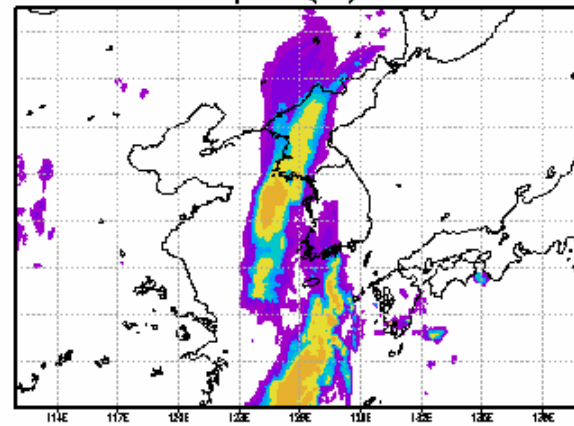


Biggest Days and totals

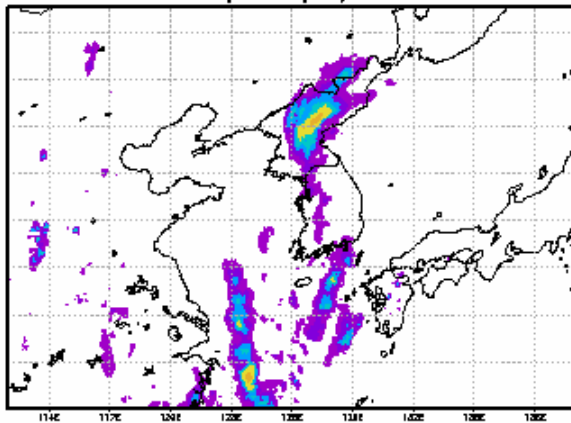
a. CMORPH Precipitation (mm) valid 12AUG2007



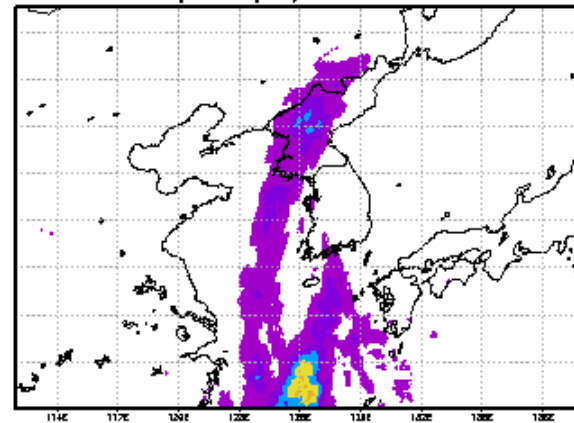
b. CMORPH Precipitation (mm) valid 13AUG2007



c. CMORPH Precipitation (mm) valid 14AUG2007



d. CMORPH Precipitation (mm) valid 12AUG2007-14AUG2007

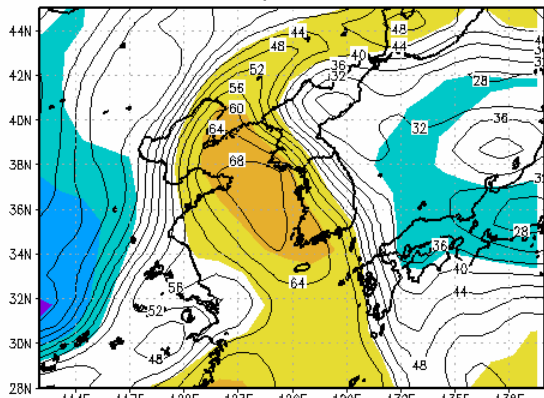


Rainfall Summary

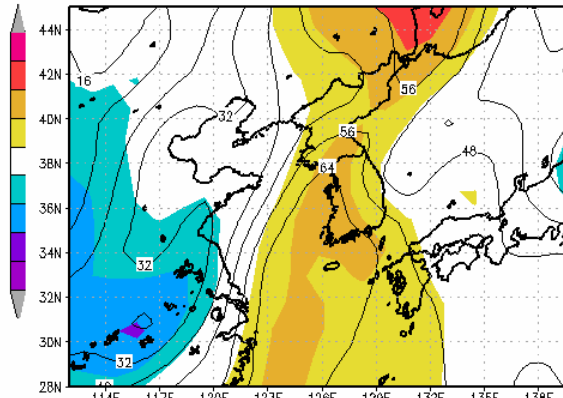
- Period ending 0000 UTC 14 August was a big event
- So was the period ending 0000 UTC on 12 August
- JRA and CMORPH data
 - showed the same affected areas
 - Similar amounts over similar time periods.
 - 350 mm is ~14 inches biggest report was 17in.
- We lack definitive rainfall data!

What the pattern looked like JRA25 perspective

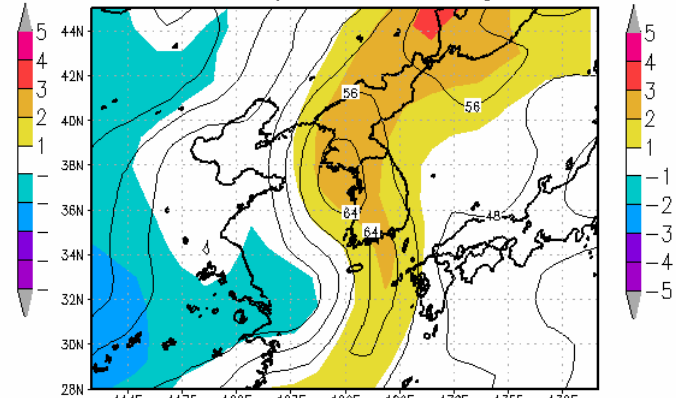
a. JMA 1000 hPa pwatsfc 00Z12AUG2007



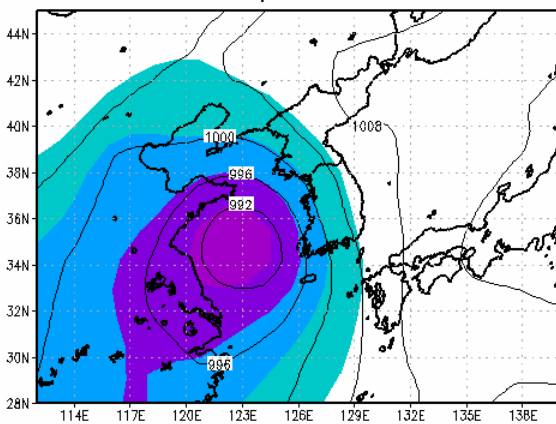
c. JMA sfc pwatsfc 00Z13Aug2007



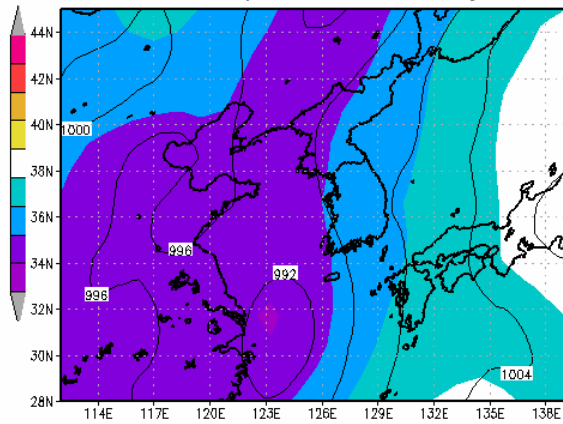
c. JMA sfc pwatsfc 00Z14Aug2007



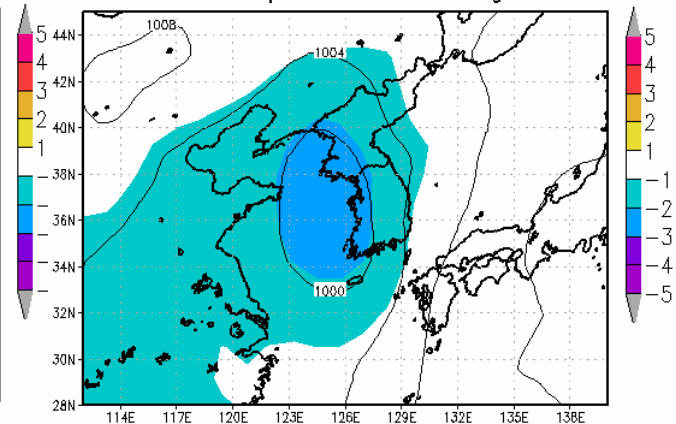
b. JMA 1000 hPa prmslmsl 00Z12AUG2007



d. JMA sfc prmslmsl 00Z13Aug2007

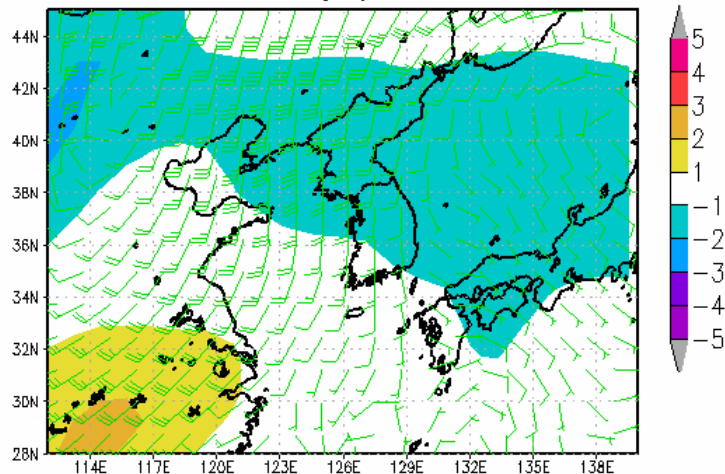


d. JMA sfc prmslmsl 00Z14Aug2007

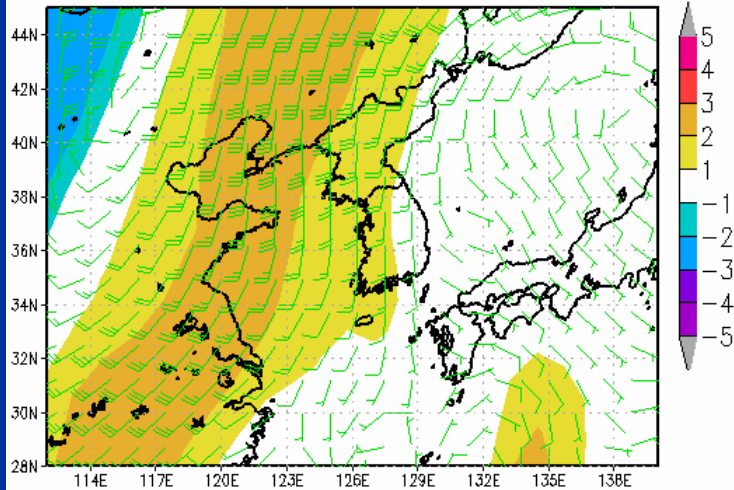


About the Peak → 850 winds too!

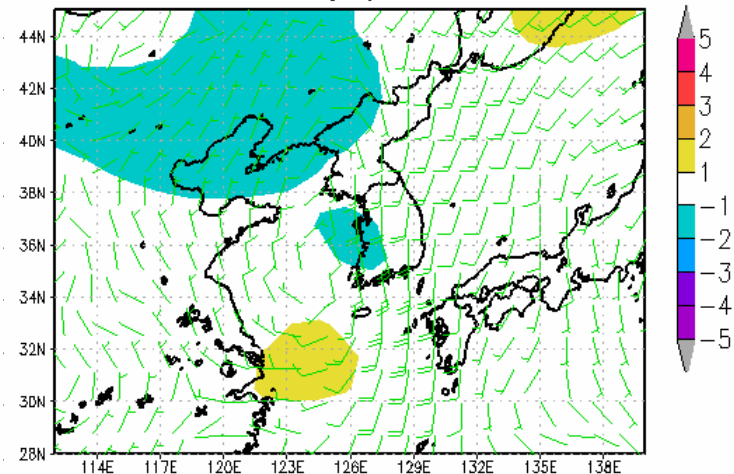
a. JMA 250 hPa ugrdprs 18Z13AUG2007



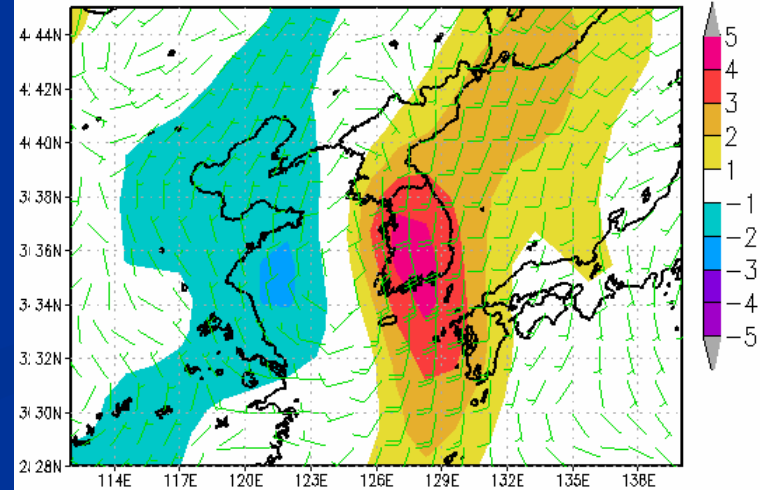
b. JMA 250 hPa ugrdprs 18Z13AUG2007



a. JMA 850 hPa ugrdprs 18Z13AUG2007



b. JMA 850 hPa ugrdprs 18Z13AUG2007



The Pattern

- **Classic quasi-stationary North-South frontal system**
 - *Maddox Synoptic Type*
 - *Similar to US of same pattern (next Slide)*
- **Generalized Pattern**
 - *N-S front*
 - *Above normal PW in warm sector → with tropical connection*
 - *Strong southerly flow into region of heavy rainfall.*

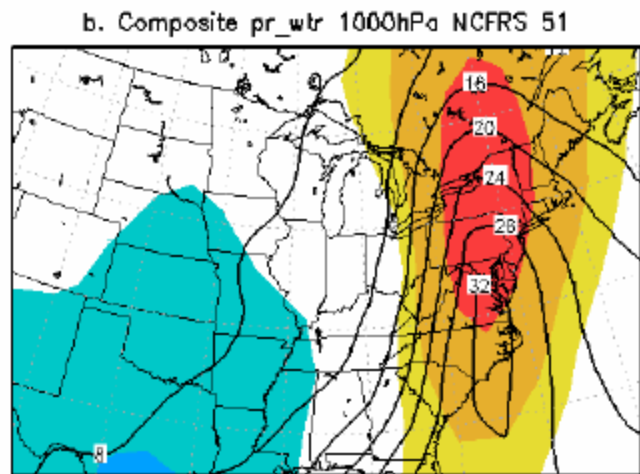
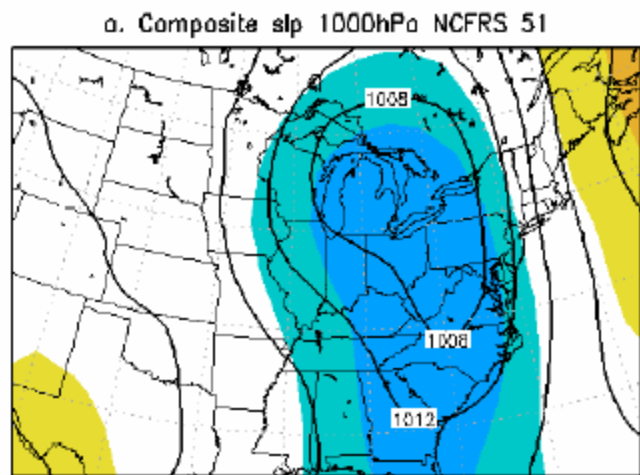


Figure 1. Composite of all cold season Synoptic events showing the a) the composite mean sea-level pressure (hPa) and the mean standardized anomaly and b) the composite precipitable water (mm) and

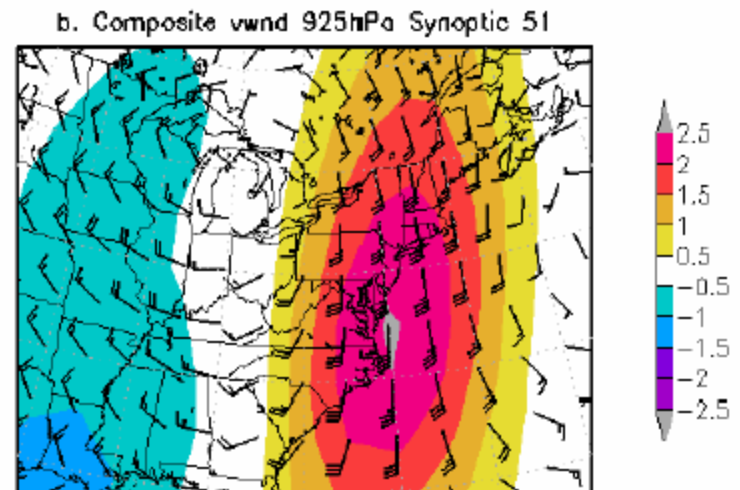
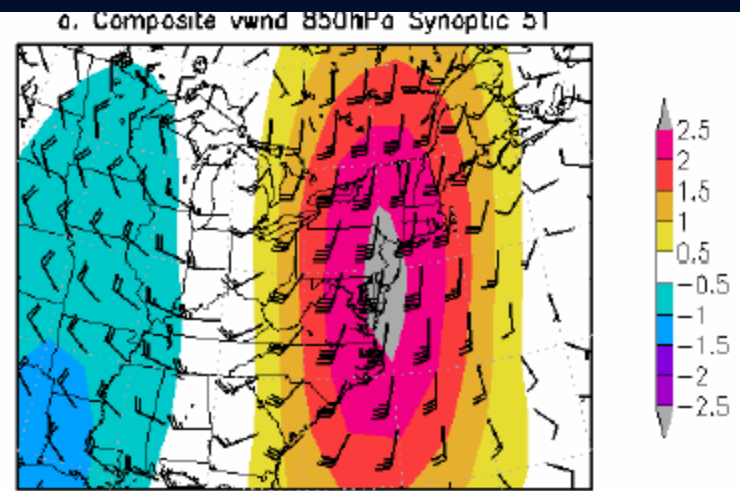
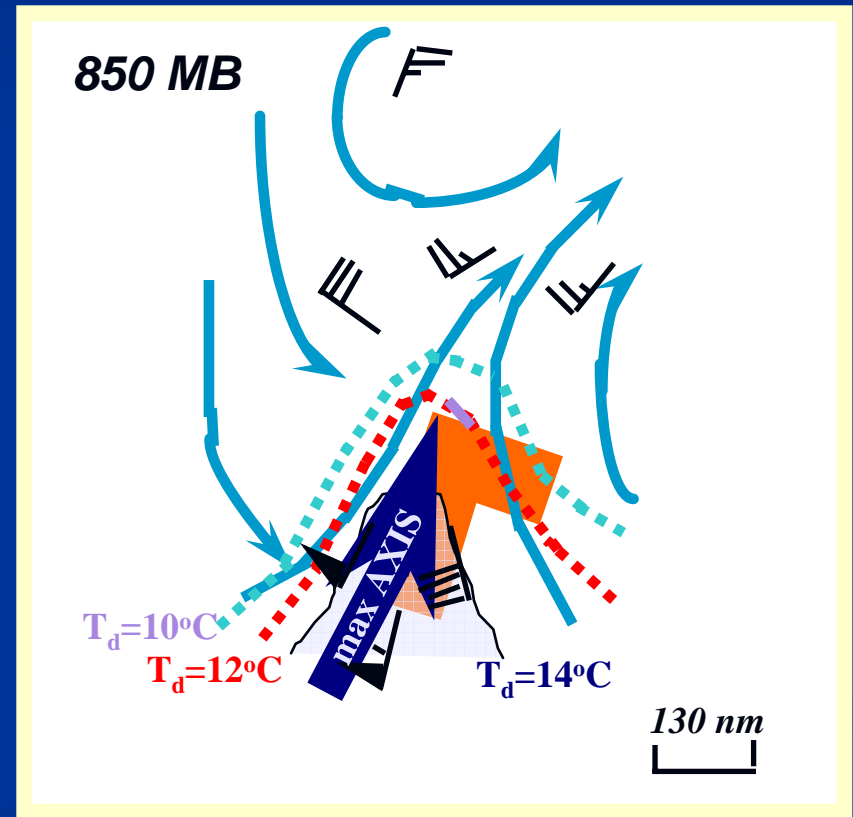
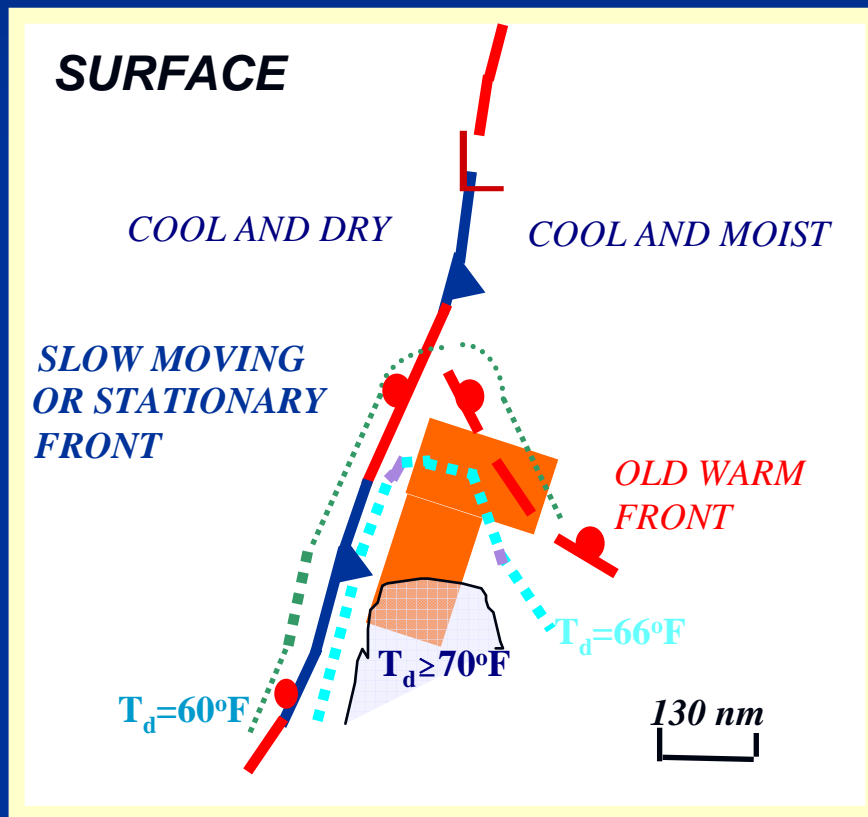


Figure 2 Composite of all cold season Synoptic events showing the a) 850 hPa mean winds and 850 hPa v-wind anomalies and b) 925 hPa winds and v-wind anomalies. Winds are in knots and anomalies in standard deviations from normal.

Synoptic Type schematic



*A POTENT LOW-LEVEL JET
IS PRESENT*

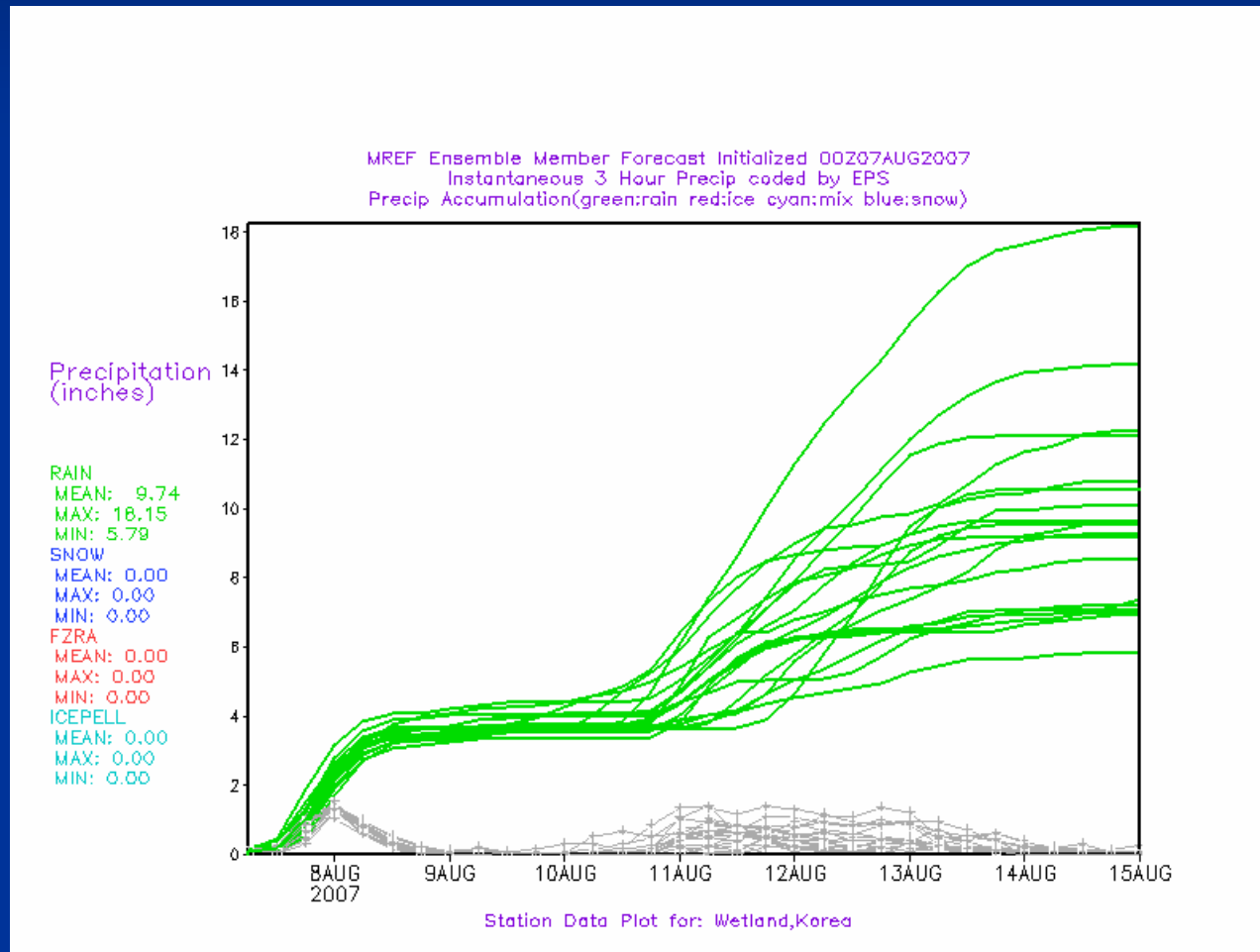
EPS data to Forecast these events

- **Data:** NCEP GEFS data
- **Focus on key features**
 - *Anomalies of key predictants*
 - *Probabilities of QPF over discrete time intervals and values*
 - *SREF and GEFS have history of success with this event type!*
- **Salient points:**
 - *Uncertainty and probabilities are the strengths of ensemble system,*
 - *The future of forecasting is linked to the strengths of the EPS,*
 - *Ensembles add the most value in cases of high uncertainty,*
 - *Never try to chose a member in a high uncertainty event,*
 - *In quiescent weather or areas of high confidence, the ensemble has minimal value*.*
- **Heavy rain we need probabilities of key threshold values!**

EPS Forecasts

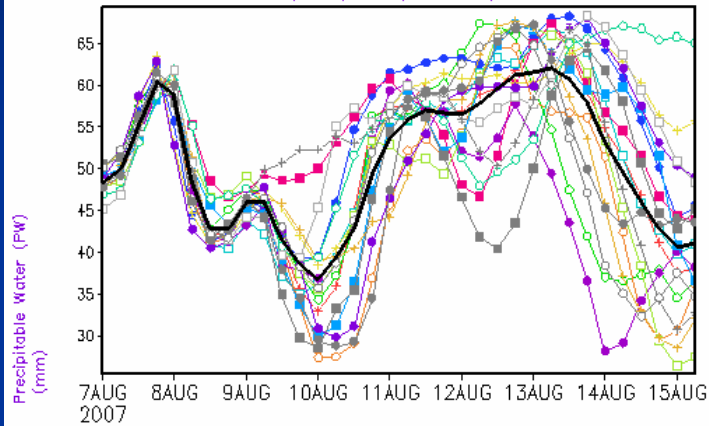
- Plumes showed period of heavy rains
- Patterns were well forecast too
- Probabilities with patterns gave some measure of confidence

7 August GEFS Plume for Central N. Korea....

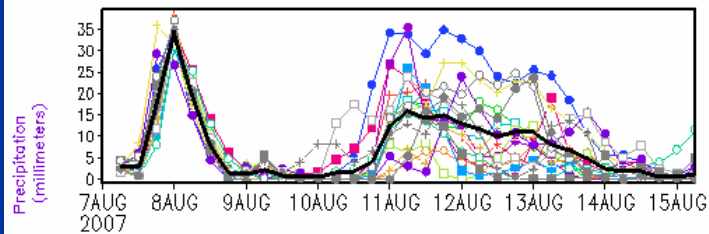


Prolonged high PW forecast

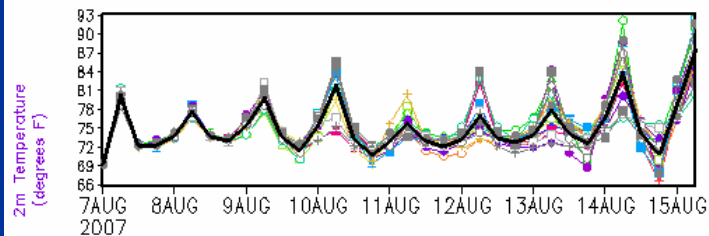
Station Data Plot for: Wetland,Korea
 GEFS-MREF Members Initialized 00Z07AUG2007
 Perturbations (colors) Mean(thick black)



Variable: pwatclm LEVEL: 1000

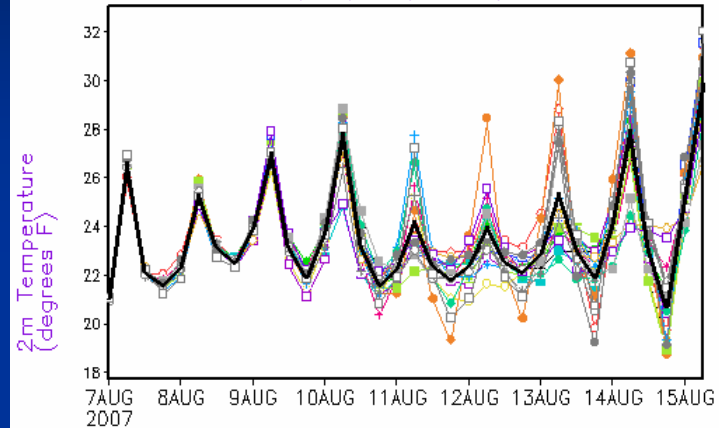


Variable: oooosfc LEVEL: 1000

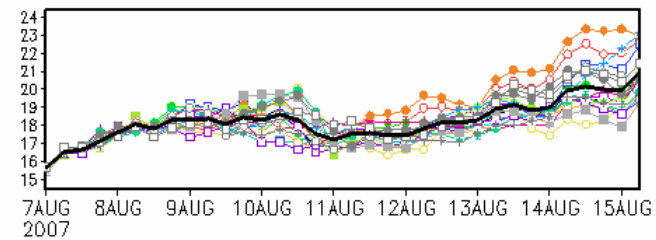


Variable: tmp2m LEVEL: 1000

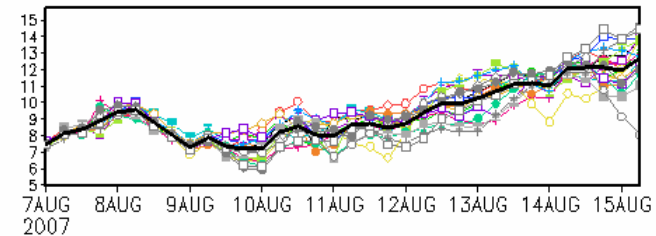
Station Data Plot for: Othersite,Korea
 NCEP-SREF Members Initialized 00Z07AUG2007
 Perturbations (colors) Mean(thick black)



Variable: tmp2m LEVEL: 1000

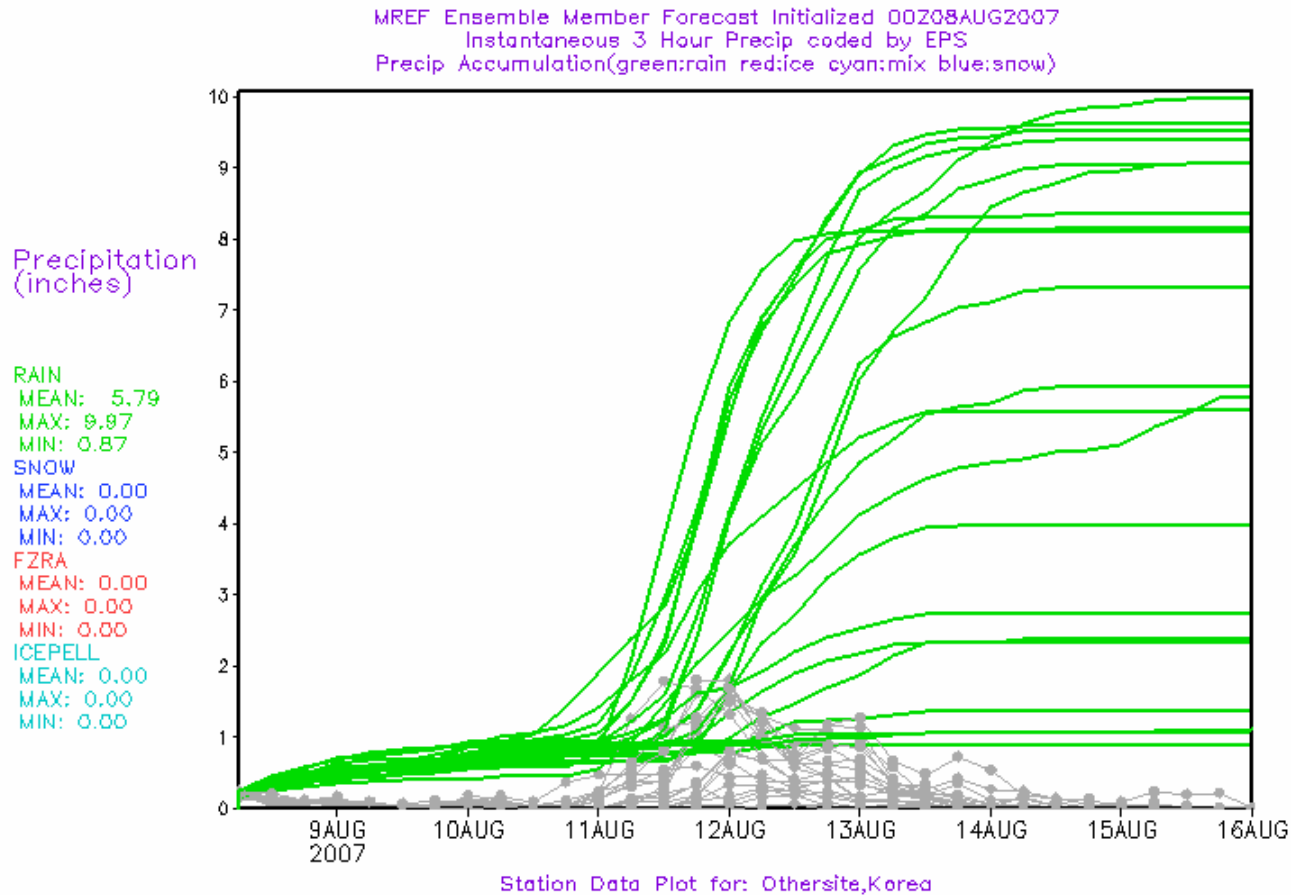


Variable: tmpprs LEVEL: 850

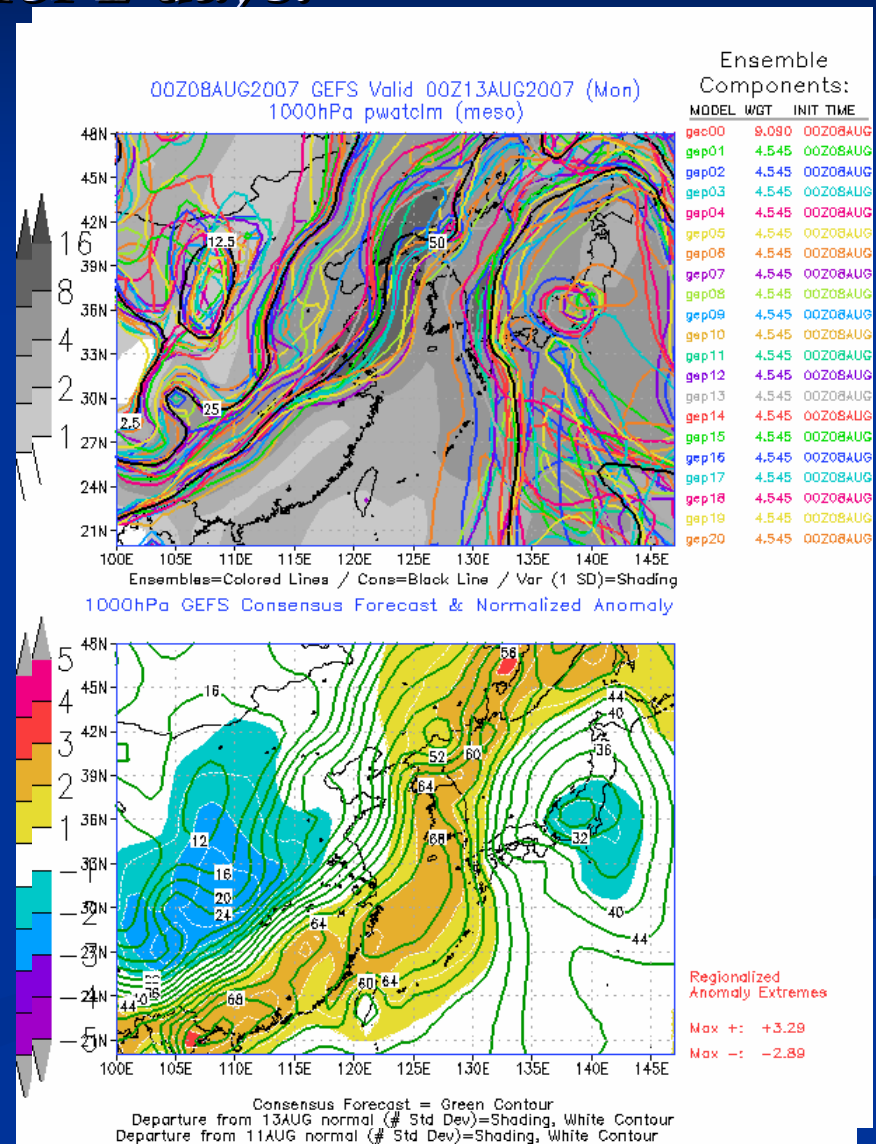
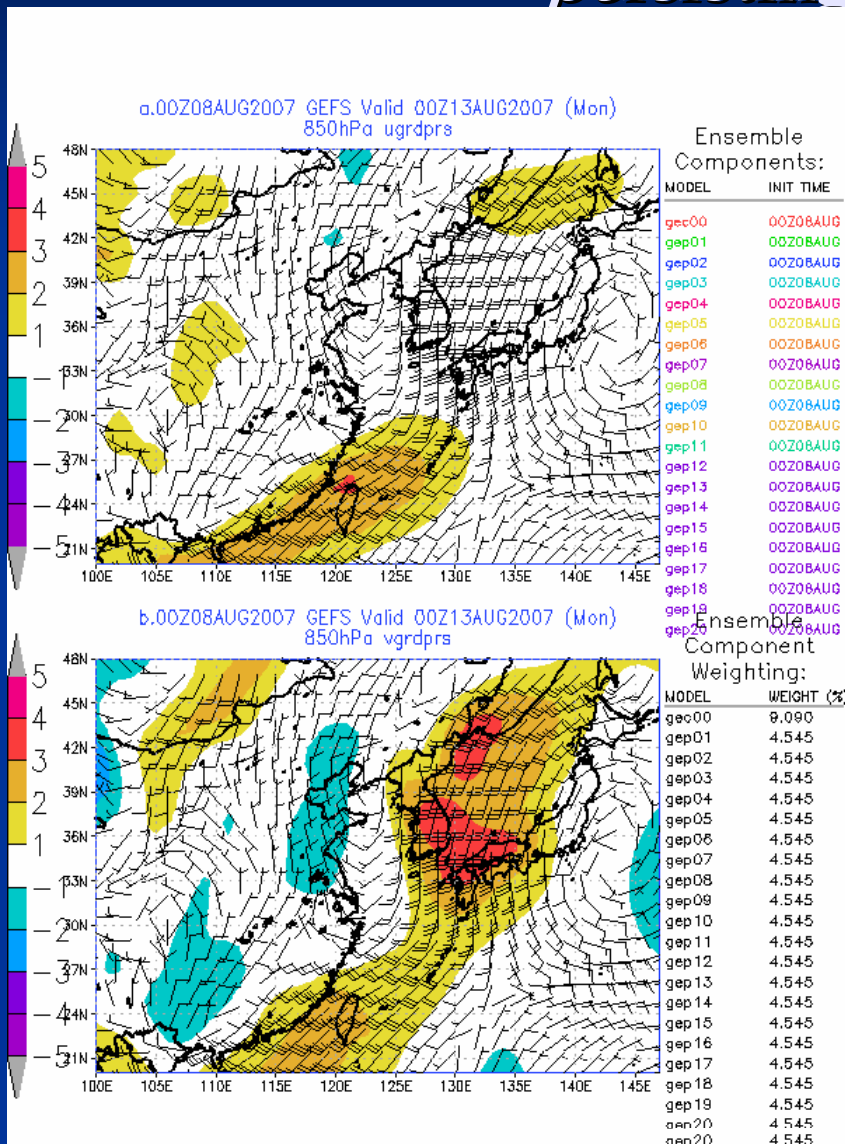


Variable: tmpprs LEVEL: 700

One Day Closer

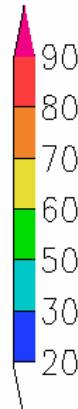
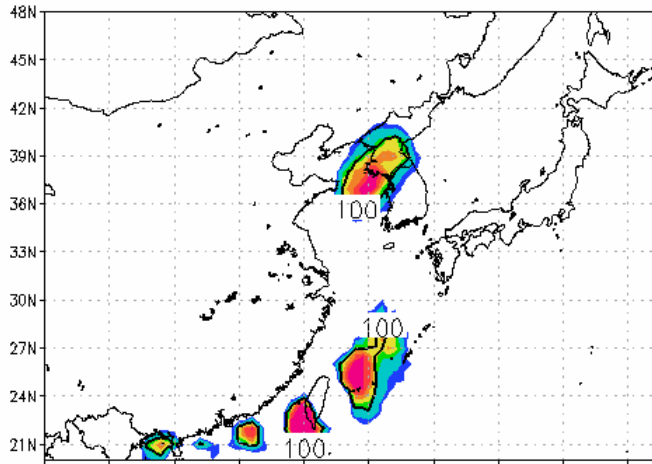


Classic Heavy Rain Pattern → *persisting for 2 days!*

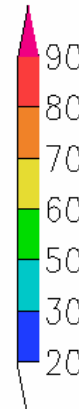
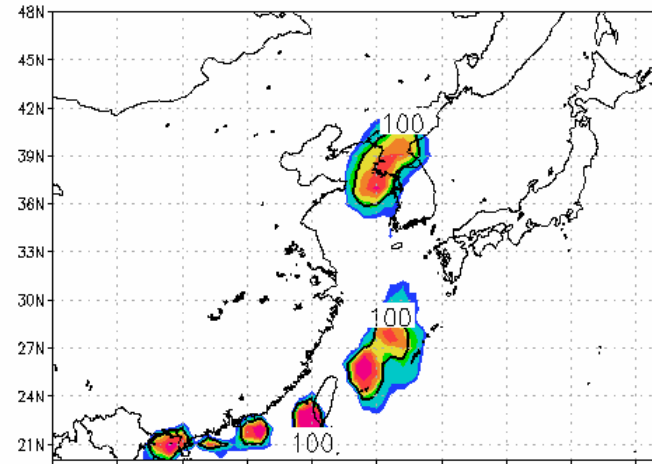


PROB 100mm 48 hrs

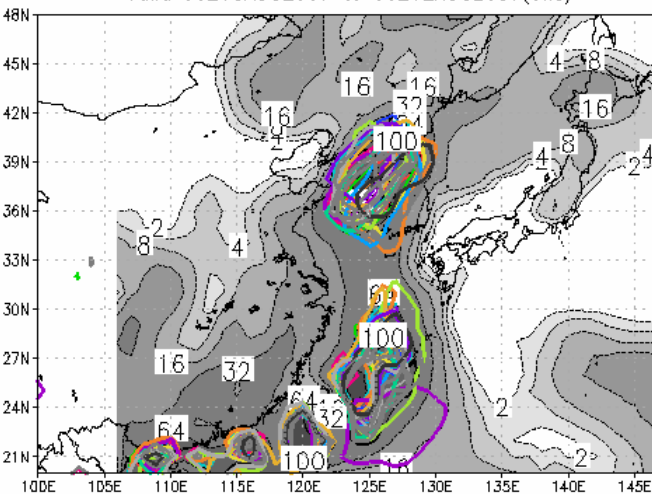
a.00Z08AUG2007 GEFS Prob of 100 apcpsfc in 48-hr
Valid 06Z10AUG2007 to 06Z12AUG2007 Sun



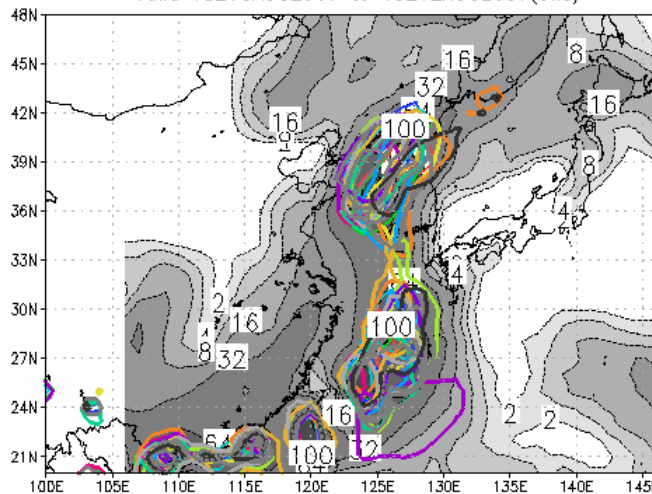
a.00Z08AUG2007 GEFS Prob of 100 apcpsfc in 48-hr
Valid 18Z10AUG2007 to 18Z12AUG2007 Sun



Valid 06Z10AUG2007 to 06Z12AUG2007(ens)



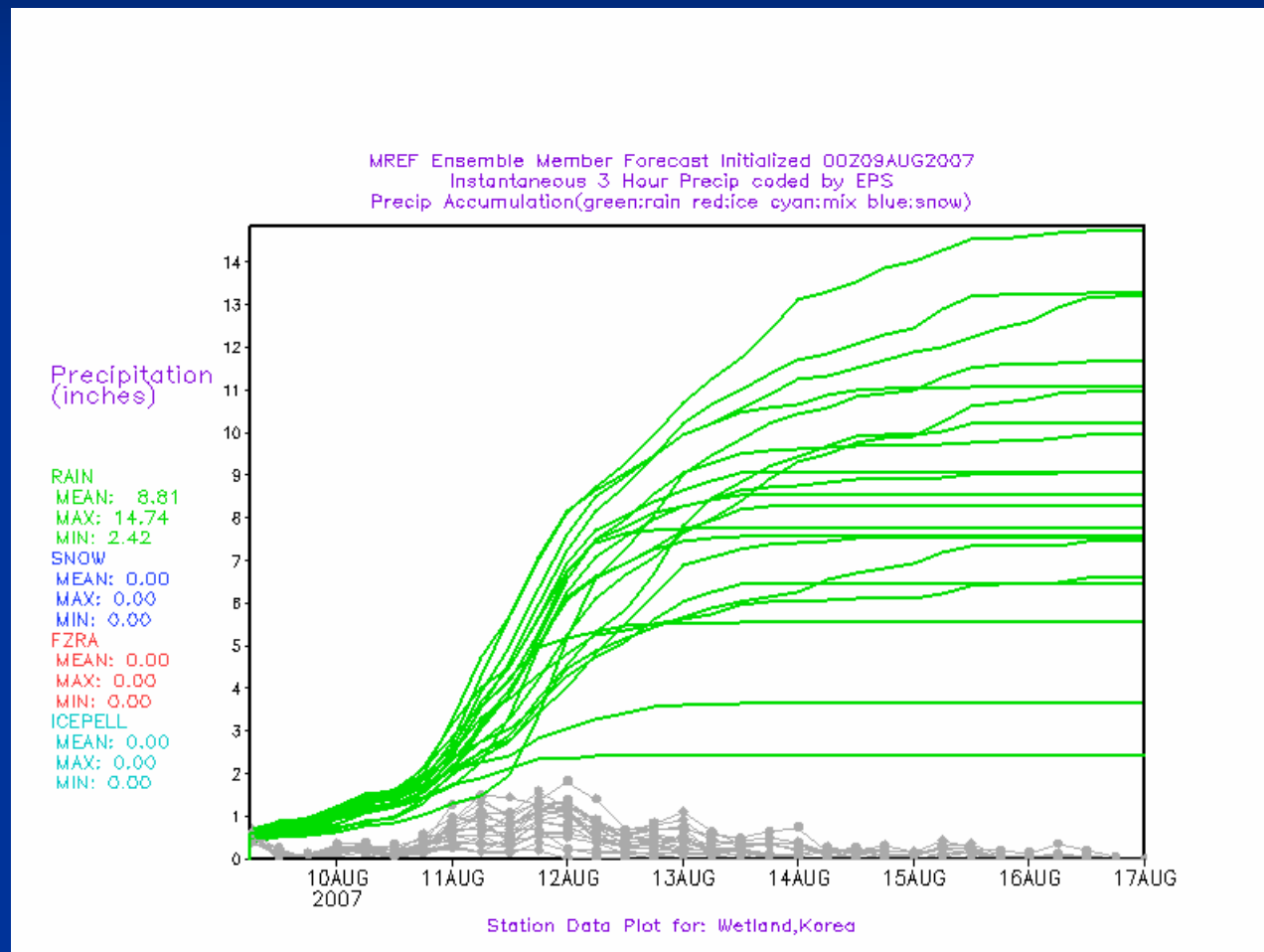
Valid 18Z10AUG2007 to 18Z12AUG2007(ens)



0000 UTC 9 August

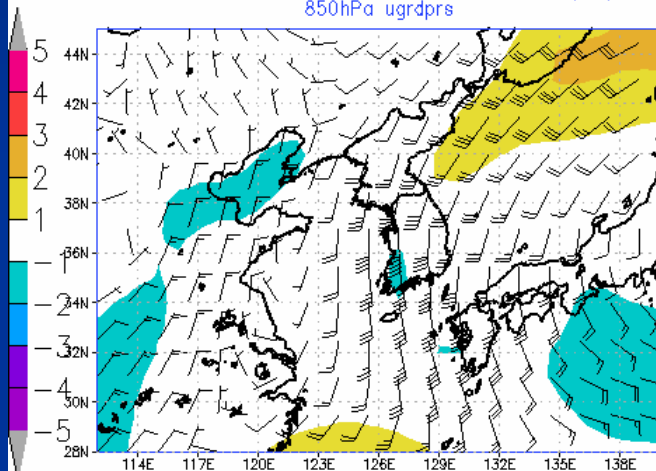
- **GEFS showed a strong signal**
 - *We can see the overall pattern of heavy rainfall*
 - *PW and v-wind anomalies*
- **There was some uncertainty**
 - *Timing and amounts of QPF*
 - *location and intensity of key features*
- **Useful data in the probabilities of QPF values**
 - *Big rain look at 25 mm, 50mm, and 100mm*
 - *We need a good feel for model/ EPS climo → what is an historic event in the model atmosphere?*

9 August → shorter forecasts more rainfall



Strong Low-level winds

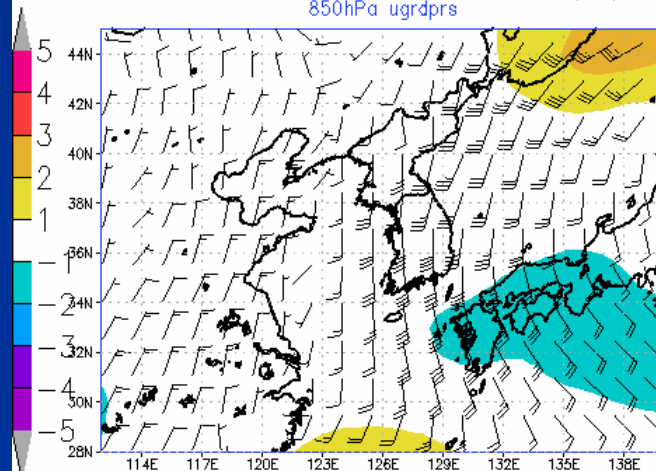
a.06Z09AUG2007 GEFS Valid 18Z11AUG2007 (Sat)
850hPa ugrdprs



Ensemble Components:

MODEL	INIT TIME
gec00	06Z09AUG
gep01	08Z08AUG
gep02	06Z09AUG
gep03	06Z09AUG
gep04	06Z09AUG
gep05	06Z09AUG
gep06	08Z09AUG
gep07	06Z09AUG
gep08	08Z09AUG
gep09	06Z09AUG
gep10	06Z09AUG
gep11	06Z09AUG
gep12	08Z08AUG
gep13	06Z09AUG
gep14	06Z08AUG
gep15	06Z08AUG

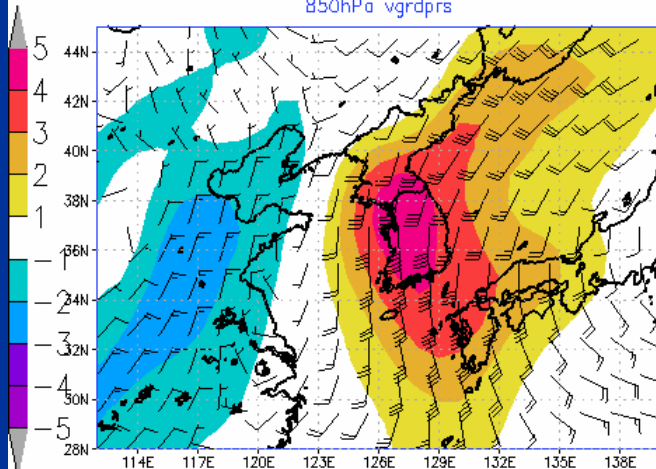
a.06Z09AUG2007 GEFS Valid 06Z12AUG2007 (Sun)
850hPa ugrdprs



Ensemble Components:

MODEL	INIT TIME
gec00	06Z09AUG
gep01	08Z08AUG
gep02	06Z09AUG
gep03	06Z09AUG
gep04	06Z09AUG
gep05	06Z09AUG
gep06	08Z09AUG
gep07	06Z09AUG
gep08	08Z09AUG
gep09	06Z09AUG
gep10	06Z09AUG
gep11	06Z09AUG
gep12	08Z08AUG
gep13	06Z09AUG
gep14	06Z08AUG
gep15	06Z08AUG

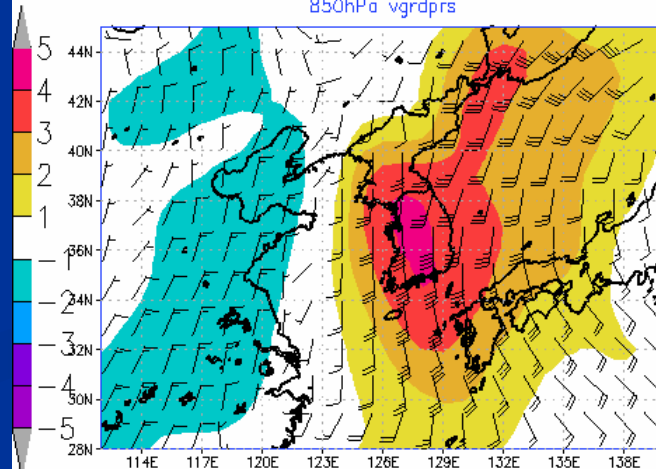
b.06Z09AUG2007 GEFS Valid 18Z11AUG2007 (Sat)
850hPa vgrdprs



Ensemble Component Weighting:

MODEL	WEIGHT (%)
gec00	11.76
gep01	5.882
gep02	5.882
gep03	5.882
gep04	5.882
gep05	5.882
gep06	5.882
gep07	5.882
gep08	5.882
gep09	5.882
gep10	5.882
gep11	5.882
gep12	5.882
gep13	5.882
gep14	5.882
gep15	5.882

b.06Z09AUG2007 GEFS Valid 06Z12AUG2007 (Sun)
850hPa vgrdprs

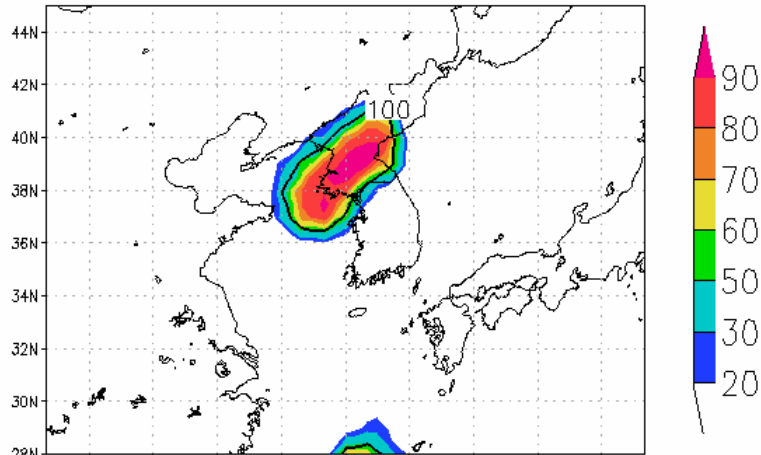


Ensemble Component Weighting:

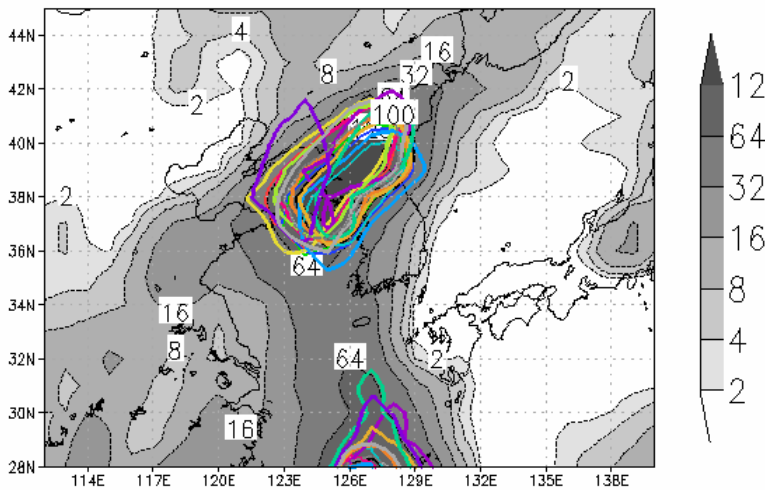
MODEL	WEIGHT (%)
gec00	11.76
gep01	5.882
gep02	5.882
gep03	5.882
gep04	5.882
gep05	5.882
gep06	5.882
gep07	5.882
gep08	5.882
gep09	5.882
gep10	5.882
gep11	5.882
gep12	5.882
gep13	5.882
gep14	5.882
gep15	5.882

48-hour heavy rainfall

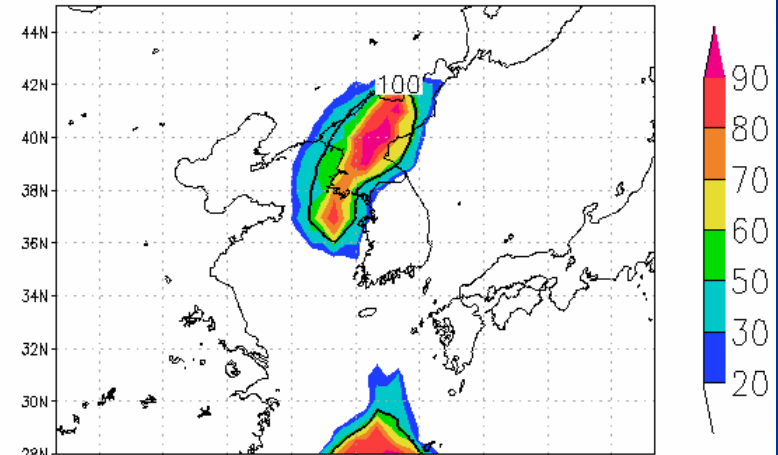
a.00Z02MAR2007 GEFS Prob of 100 apcpsfc in 48-hr
Valid 00Z10AUG2007 to 00Z12AUG2007 Sun



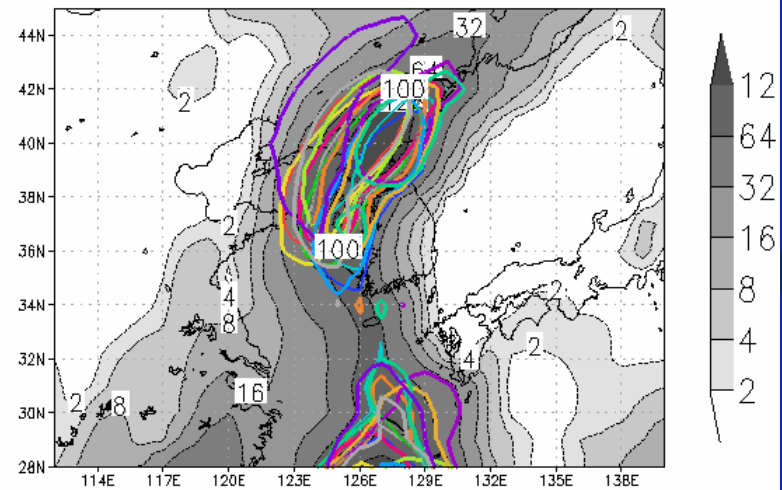
114E, 48-hr 100 apcpsfc GEFS (RFD) 677 (09E) 138E
Valid 00Z10AUG2007 to 00Z12AUG2007(ens)



a.00Z02MAR2007 GEFS Prob of 100 apcpsfc in 48-hr
Valid 00Z11AUG2007 to 00Z13AUG2007 Mon

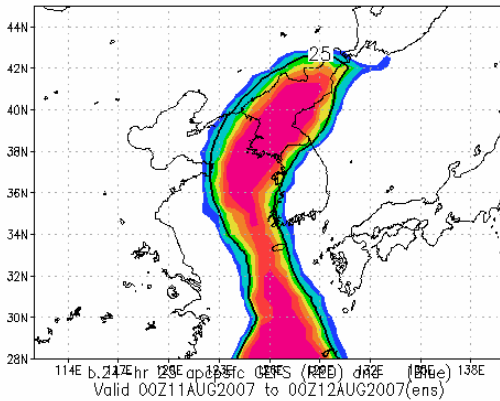


114E, 48-hr 100 apcpsfc GEFS (RFD) 677 (09E) 138E
Valid 00Z11AUG2007 to 00Z13AUG2007(ens)

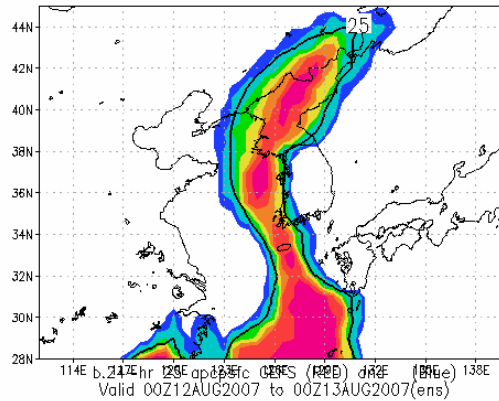


24-hour heavy rainfall

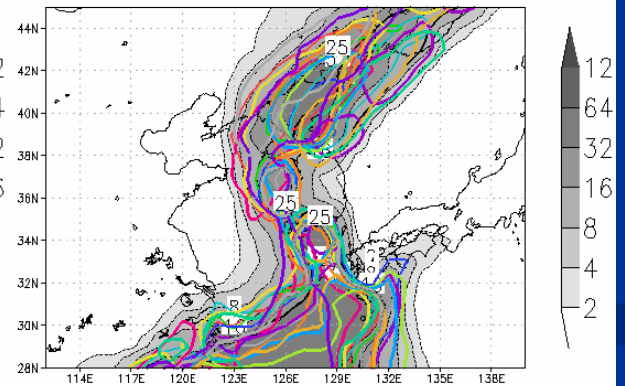
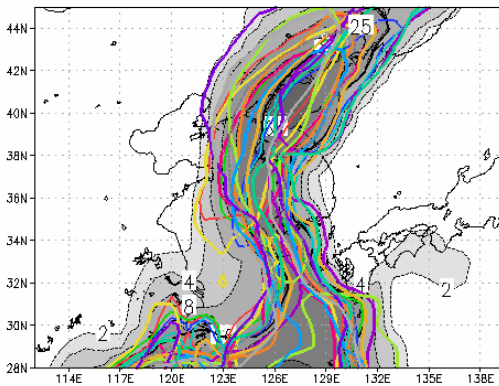
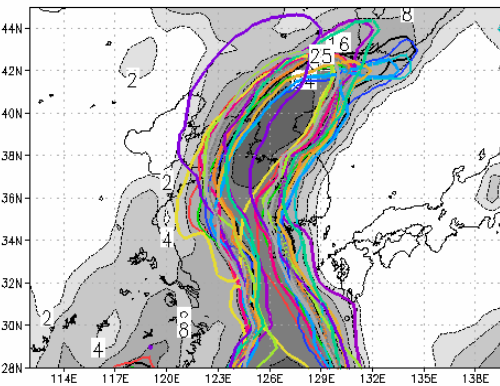
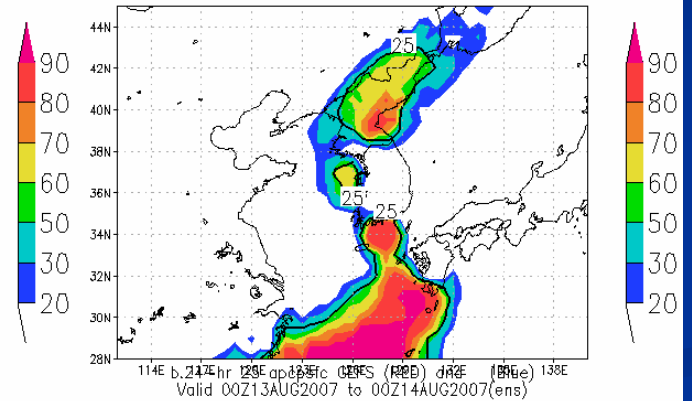
a.00Z02MAR2007 GEFS Prob of 25 apcpssc in 24-hr
Valid 00Z11AUG2007 to 00Z12AUG2007 Sun



a.00Z02MAR2007 GEFS Prob of 25 apcpssc in 24-hr
Valid 00Z12AUG2007 to 00Z13AUG2007 Mon



a.00Z02MAR2007 GEFS Prob of 25 apcpssc in 24-hr
Valid 00Z13AUG2007 to 00Z14AUG2007 Tue

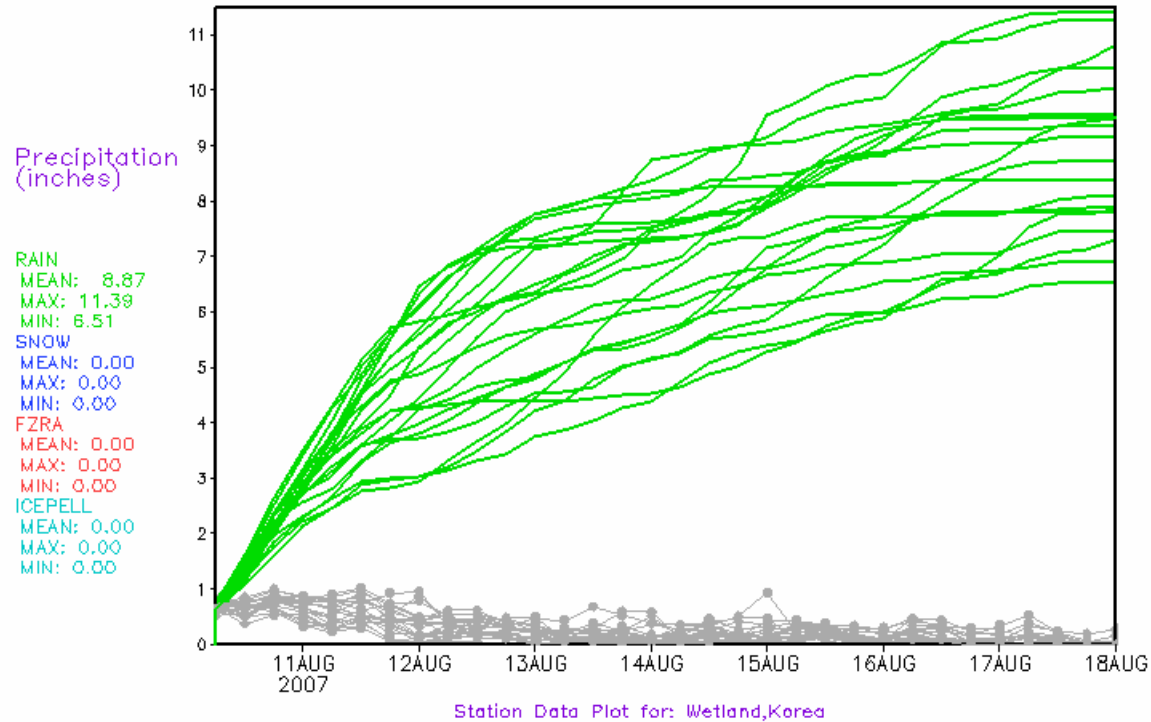


0000 UTC 10 August

- **GEFS showed a strong signal**
 - *We can see the overall pattern of heavy rainfall*
 - *PW and v-wind anomalies*
- **There was some uncertainty**
 - *Timing and amounts of QPF*
 - *location and intensity of key features*
- **Useful data in the probabilities of QPF values**
 - *Big rain look at 25 mm, 50mm, and 100mm*
 - *We need a good feel for model/ EPS climo → what is an historic event in the model atmosphere?*

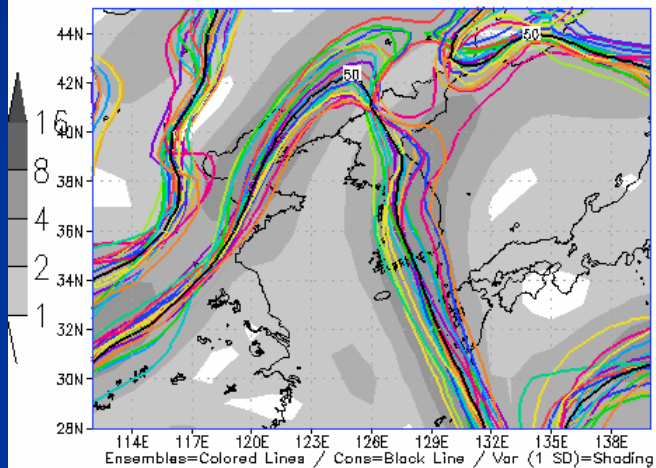
Plume Diagram

MREF Ensemble Member Forecast Initialized 00Z10AUG2007
Instantaneous 3 Hour Precip coded by EPS
Precip Accumulation(green:rain red:ice cyan:mix blue:snow)



High PW N-S frontal Zone

00Z10AUG2007 GEFS Valid 12Z11AUG2007 (Sat)
1000hPa pwatclm (meso)

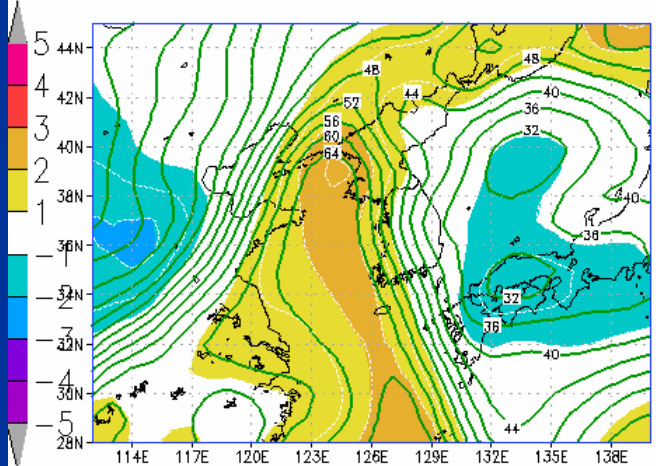


Ensemble Components:

MODEL	WGT	INIT TIME
gep00	9.090	00Z10AUG
gep01	4.545	00Z10AUG
gep02	4.545	00Z10AUG
gep03	4.545	00Z10AUG
gep04	4.545	00Z10AUG
gep05	4.545	00Z10AUG
gep06	4.545	00Z10AUG
gep07	4.545	00Z10AUG
gep08	4.545	00Z10AUG
gep09	4.545	00Z10AUG
gep10	4.545	00Z10AUG
gep11	4.545	00Z10AUG
gep12	4.545	00Z10AUG
gep13	4.545	00Z10AUG
gep14	4.545	00Z10AUG
gep15	4.545	00Z10AUG
gep16	4.545	00Z10AUG
gep17	4.545	00Z10AUG
gep18	4.545	00Z10AUG
gep19	4.545	00Z10AUG
gep20	4.545	00Z10AUG

Ensembles=Colored Lines / Cons=Black Line / Var (1 SD)=Shading

1000hPa GEFS Consensus Forecast & Normalized Anomaly



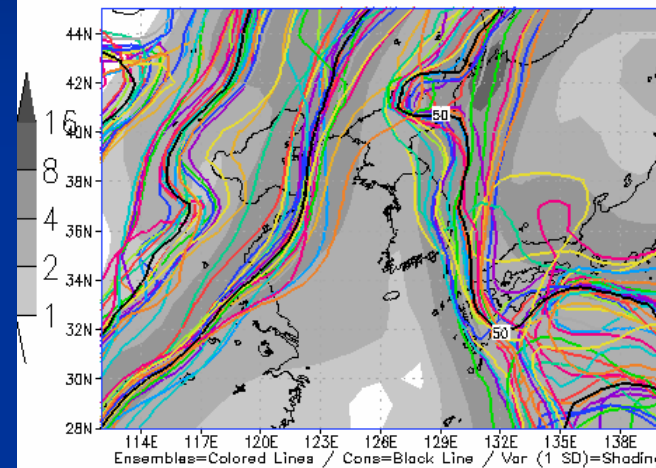
Regionalized Anomaly Extremes

Max +: +2.59

Max -: -2.12

Consensus Forecast = Green Contour
Departure from 11AUG normal (# Std Dev)=Shading, White Contour

00Z10AUG2007 GEFS Valid 12Z12AUG2007 (Sun)
1000hPa pwatclm (meso)

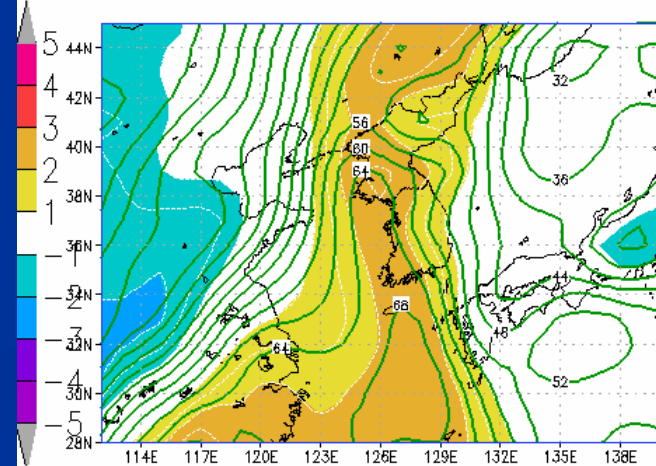


Ensemble Components:

MODEL	WGT	INIT TIME
gep00	9.090	00Z10AUG
gep01	4.545	00Z10AUG
gep02	4.545	00Z10AUG
gep03	4.545	00Z10AUG
gep04	4.545	00Z10AUG
gep05	4.545	00Z10AUG
gep06	4.545	00Z10AUG
gep07	4.545	00Z10AUG
gep08	4.545	00Z10AUG
gep09	4.545	00Z10AUG
gep10	4.545	00Z10AUG
gep11	4.545	00Z10AUG
gep12	4.545	00Z10AUG
gep13	4.545	00Z10AUG
gep14	4.545	00Z10AUG
gep15	4.545	00Z10AUG
gep16	4.545	00Z10AUG
gep17	4.545	00Z10AUG
gep18	4.545	00Z10AUG
gep19	4.545	00Z10AUG
gep20	4.545	00Z10AUG

Ensembles=Colored Lines / Cons=Black Line / Var (1 SD)=Shading

1000hPa GEFS Consensus Forecast & Normalized Anomaly



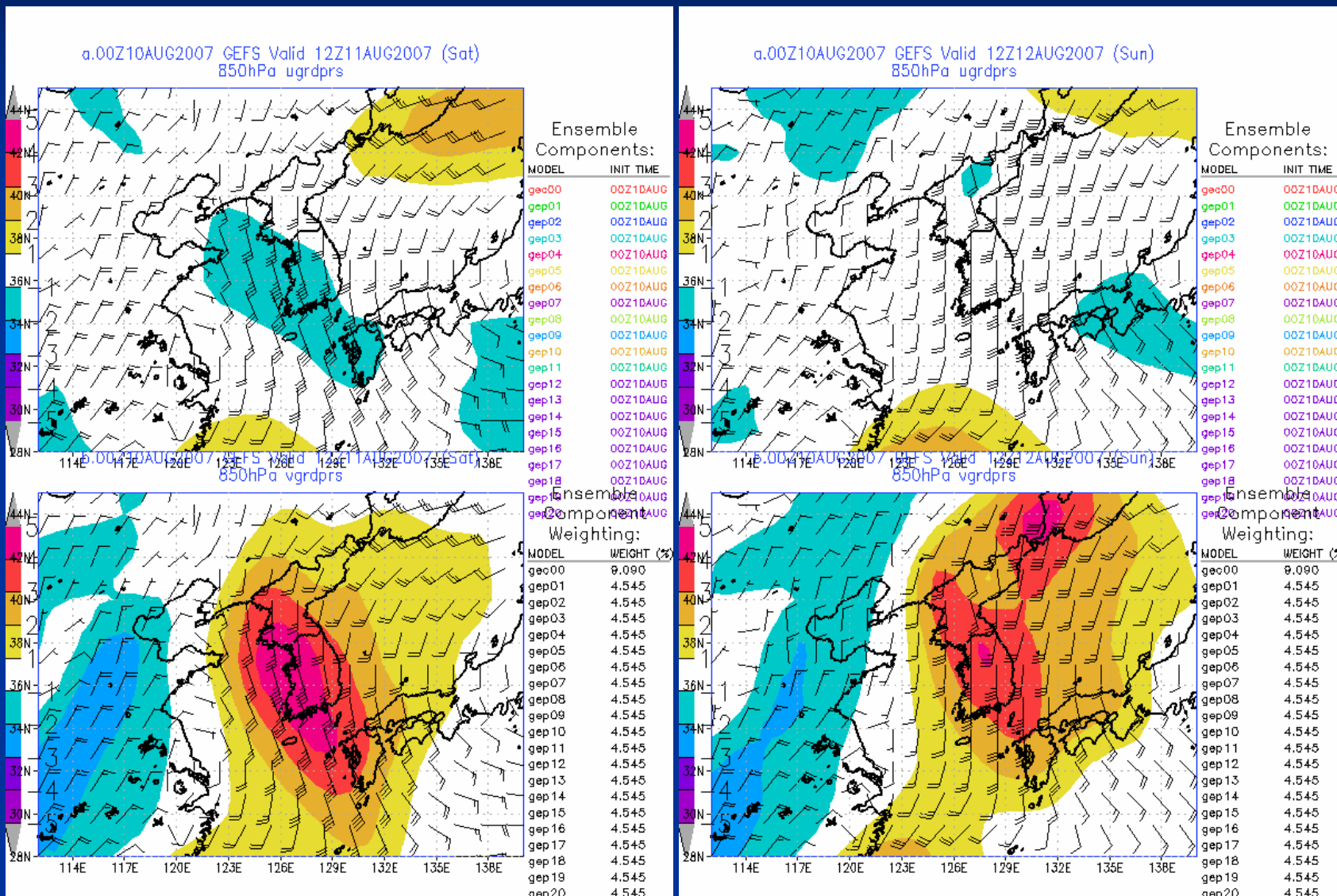
Regionalized Anomaly Extremes

Max +: +2.81

Max -: -2.29

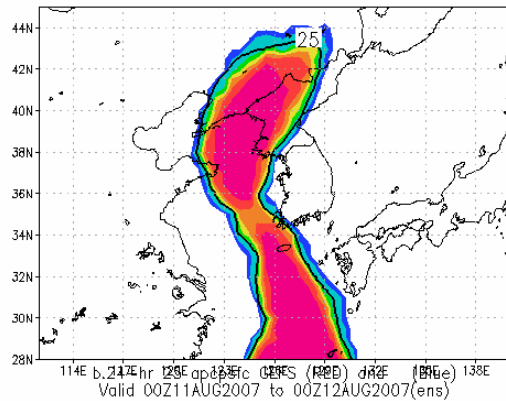
Consensus Forecast = Green Contour
Departure from 12AUG normal (# Std Dev)=Shading, White Contour

Low-level winds

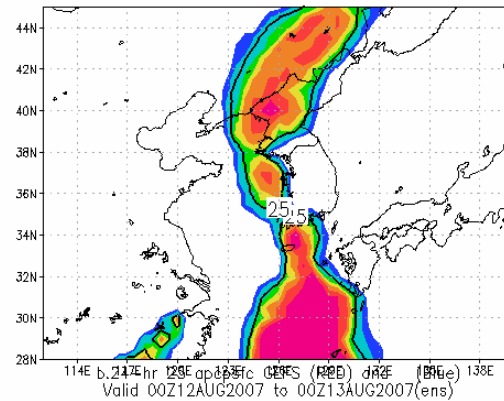


Heavy rain over 24 hour periods

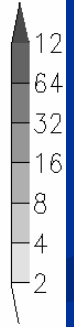
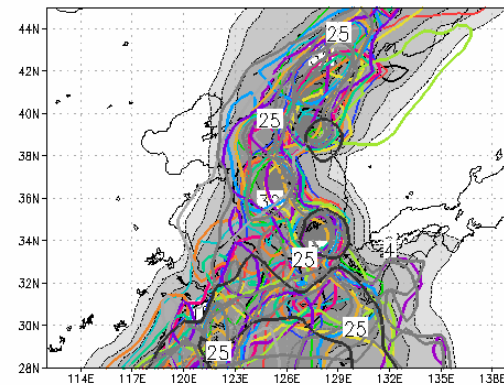
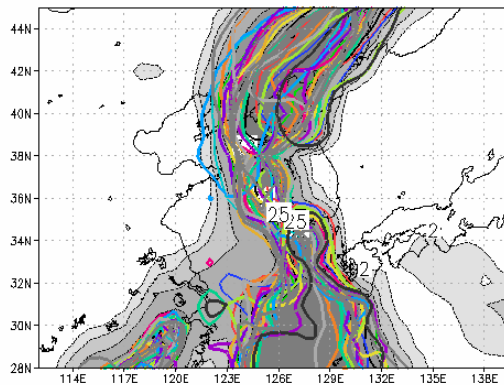
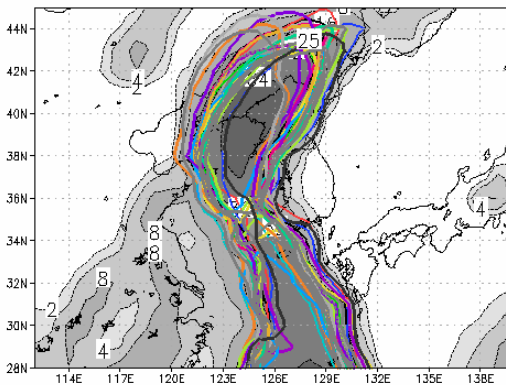
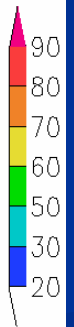
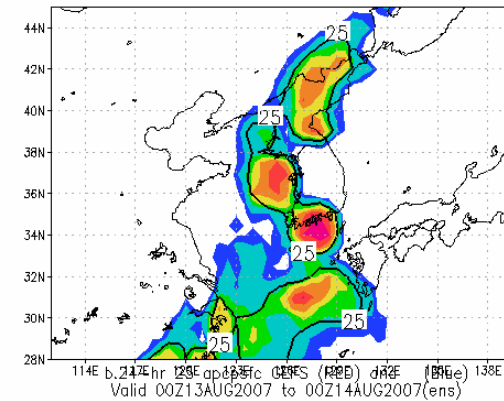
a.00Z10AUG2007 GEFS Prob of 25 apcpfc in 24-hr
Valid 00Z11AUG2007 to 00Z12AUG2007 Sun



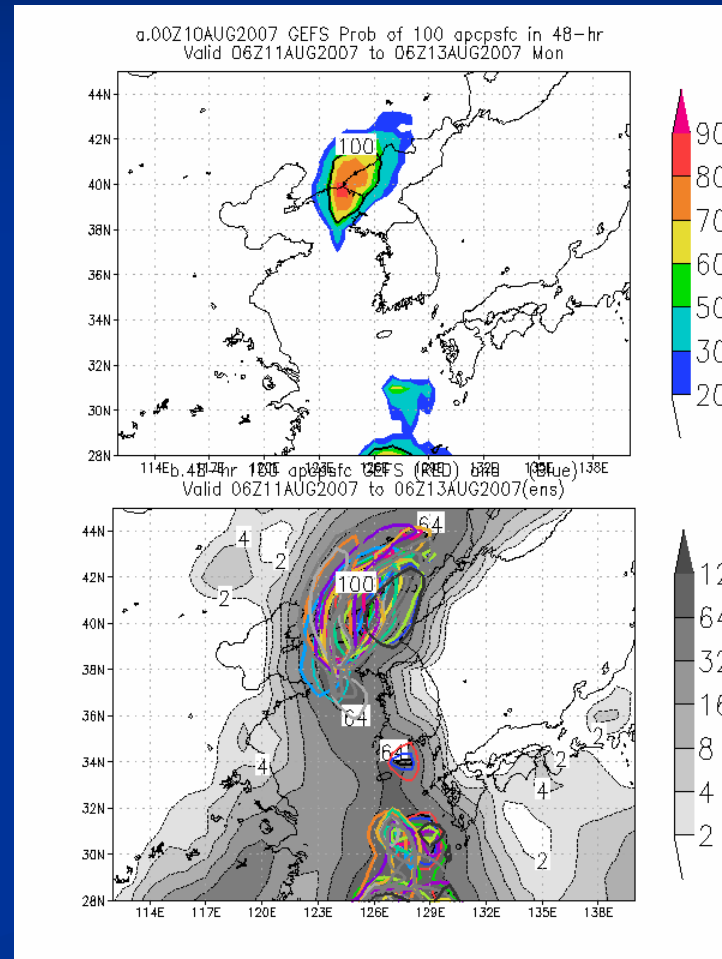
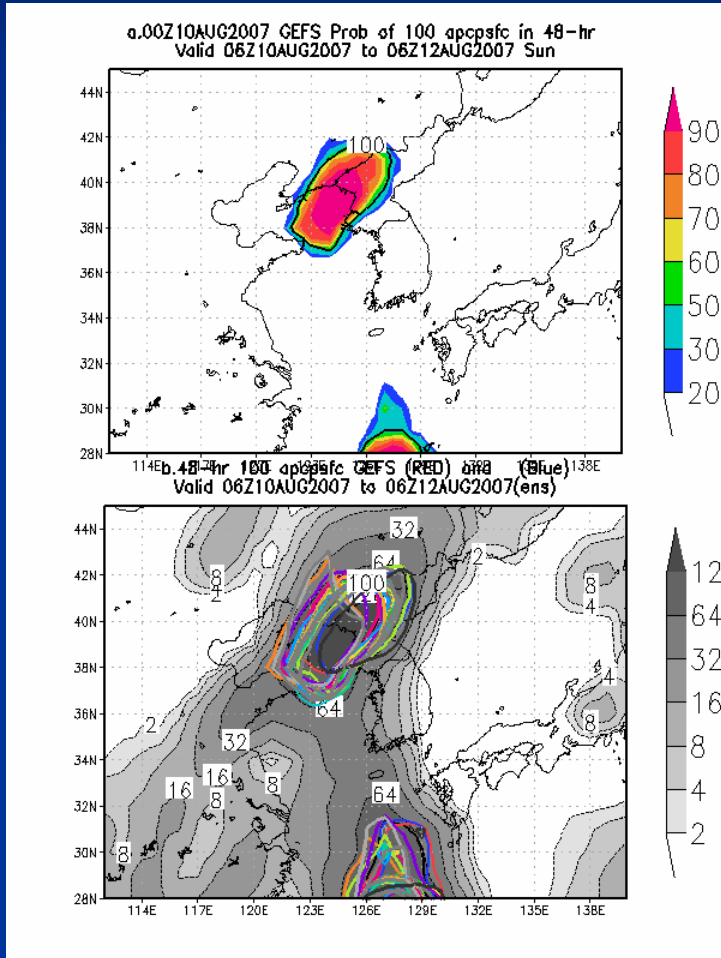
a.00Z10AUG2007 GEFS Prob of 25 apcpfc in 24-hr
Valid 00Z12AUG2007 to 00Z13AUG2007 Mon



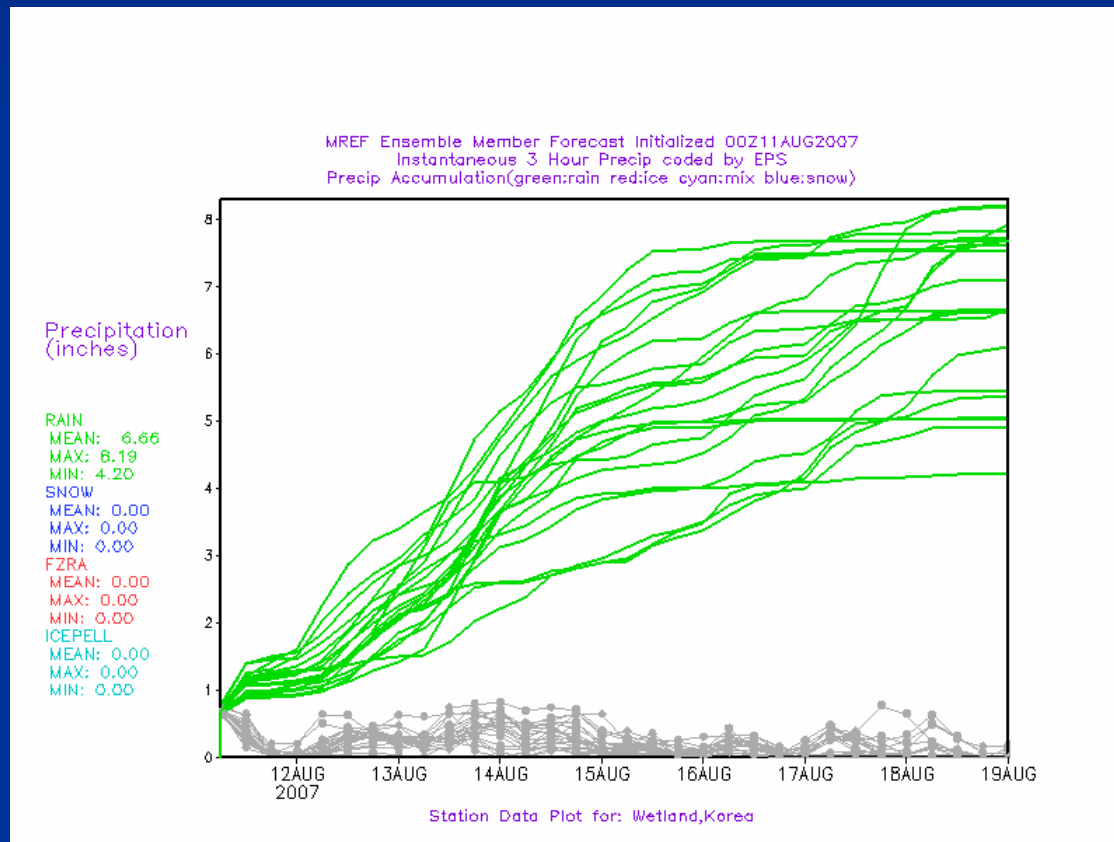
a.00Z10AUG2007 GEFS Prob of 25 apcpfc in 24-hr
Valid 00Z13AUG2007 to 00Z14AUG2007 Tue



48-hour QPF



11 August already raining.... Same signal as earlier forecasts



Review

- We examined a major Flood event over North Korea
 - *Devastated crops in mid-August*
 - *Did it have other implications?*
- **This historic case was used to**
 - *Examine aspects of a major flood events and*
 - *Issues related to both the analysis and forecast of such significant events*
 - *We do not really know the ground truth and each analysis gives us a different answers*
 - *The forecasts were quite good*
- **It was an Ideal application of ensembles**
 - *Precipitation amounts (Probabilities) and timing*
 - *Meteorological setting → Features associated with significant flood events.*
- **The event seemed to put the features in a context → Climate anomalies of key features associated with heavy rainfall.**

Acknowledgements

- *NCEP for the data GEFS and GEFS bias corrected*
- *CPC for the CMOPRH data*
- *Robert Hart and Jeremy Ross of climatic anomalies and anomalies data base.*

Wet Reference

- Doswell, C.A. III, H. E. Brooks and R.A. Maddox, 1996: Flash Flood forecasting: An ingredients-based methodology. *Wea. Forecasting*, **11**, 560-581.
- Harneck, R. P., Apffel, K., and Cermak, J. R., 1999. Heavy precipitation events in New Jersey: Attendant upper air conditions. *Wea. Forecasting*, **14**: 933-954.
- Heideman, K. F., and Fritsch, J. M., 1988. Forcing mechanisms and other characteristics of significant summertime precipitation. *Wea. Forecasting*, **3**: 115-30.
- Konrad, C. E., 1997. Synoptic-scale features associated with warm season heavy rainfall over the interior southeastern United States. *Wea. Forecasting*, **12**: 557-571.
- Konrad, C. E., 2001. The heaviest precipitation events over the eastern United States: Considerations of scale. *Journal of Hydrometeorology* **2**: 309-325.
- Konrad, C. E., Perry, B. and Smith, A. B., 2005. Regional Variations in the Synoptic patterns Associated with Warm Season Heavy Rainfall Across the Eastern United States. *Intl. J. Climatol.*
- Received for review.
- Maddox, R. A., C. F. Chappell, and Hoxit, L. R., 1979. Synoptic and meso-scale aspects of flash flood events. *Bull. Amer. Meteor. Soc.*, **60**: 115-123.
- Smith, A. B., 2005. The Location of Heaviest Rainfall Relative to Frontal Boundaries during the Warm Season. Master's Thesis, University of North Carolina at Chapel Hill.
- Winkler, J. A., 1988. Climatological characteristics of summer-time extreme rainstorms in Minnesota. *Ann. Assoc. Am. Geogr.*, **78**: 57-73.