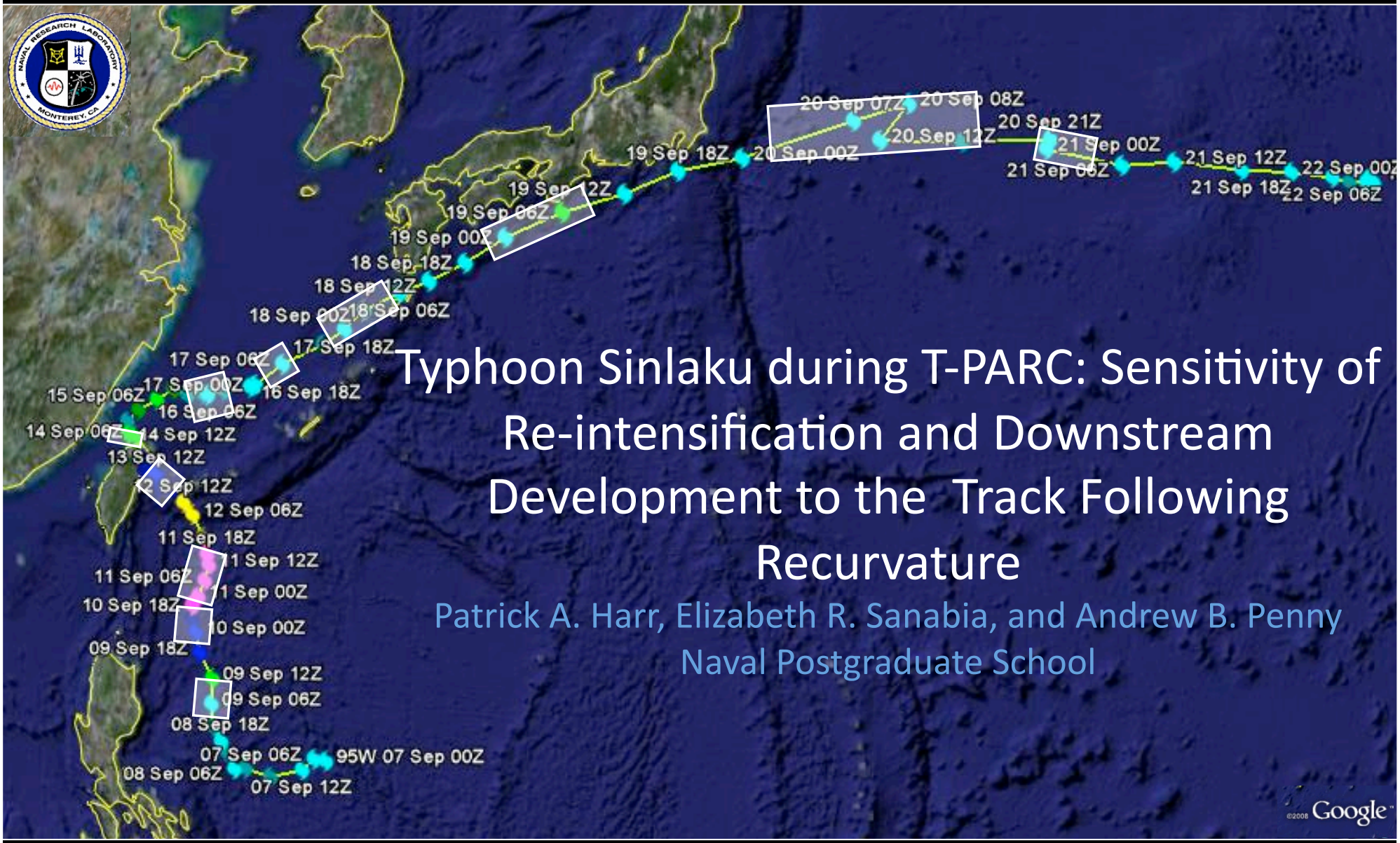
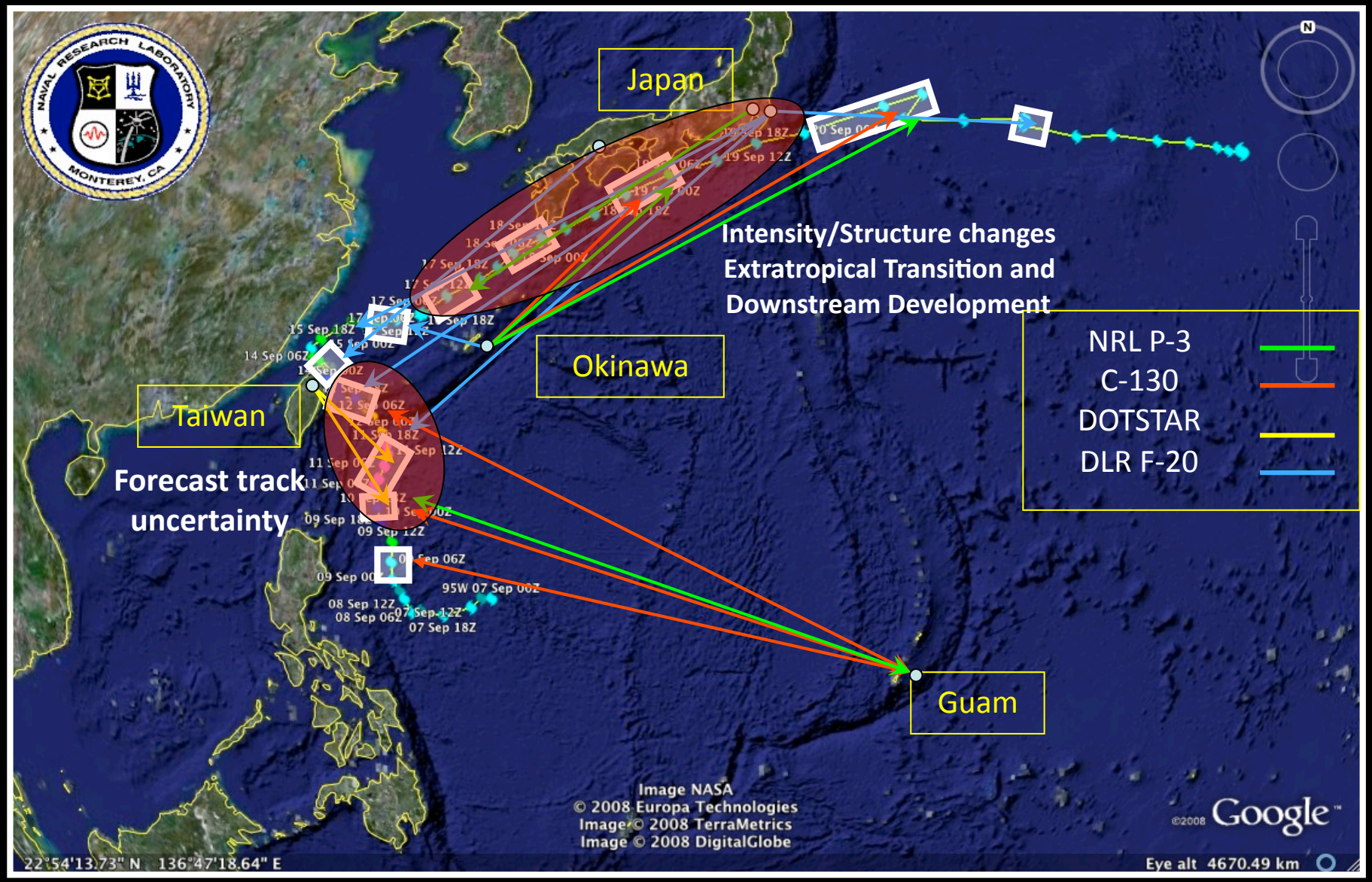


Typhoon Sinlaku during T-PARC: Sensitivity of Re-intensification and Downstream Development to the Track Following Recurvature

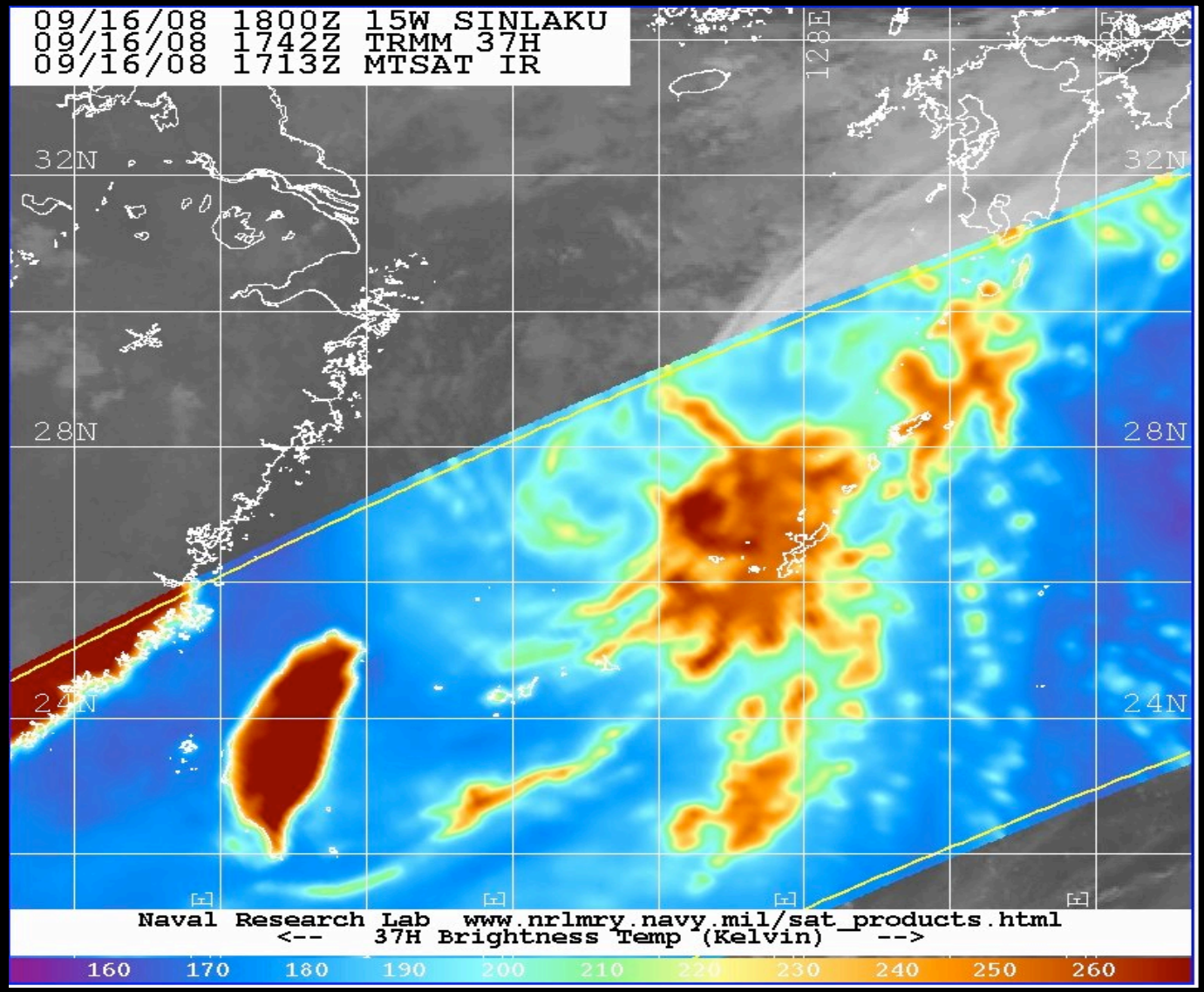
Patrick A. Harr, Elizabeth R. Sanabia, and Andrew B. Penny
Naval Postgraduate School

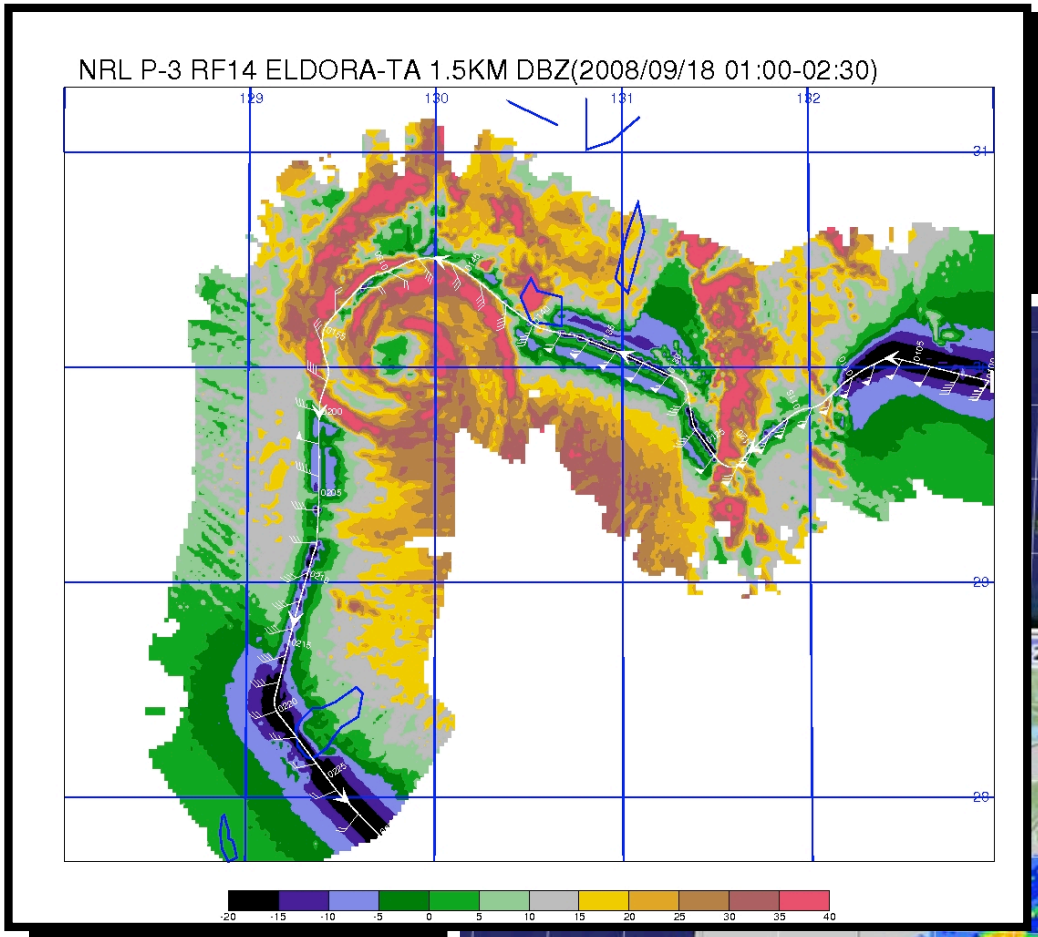
TY Sinlaku T-PARC/TCS-08 aircraft sampling strategy including forward deployment (9-21 Sept 2008)



Tropical Cyclone Intensity/Structure Changes, Extratropical Transition, and Downstream Impacts

TY Sinlaku recurves to move east-northeast under strong westerly shear

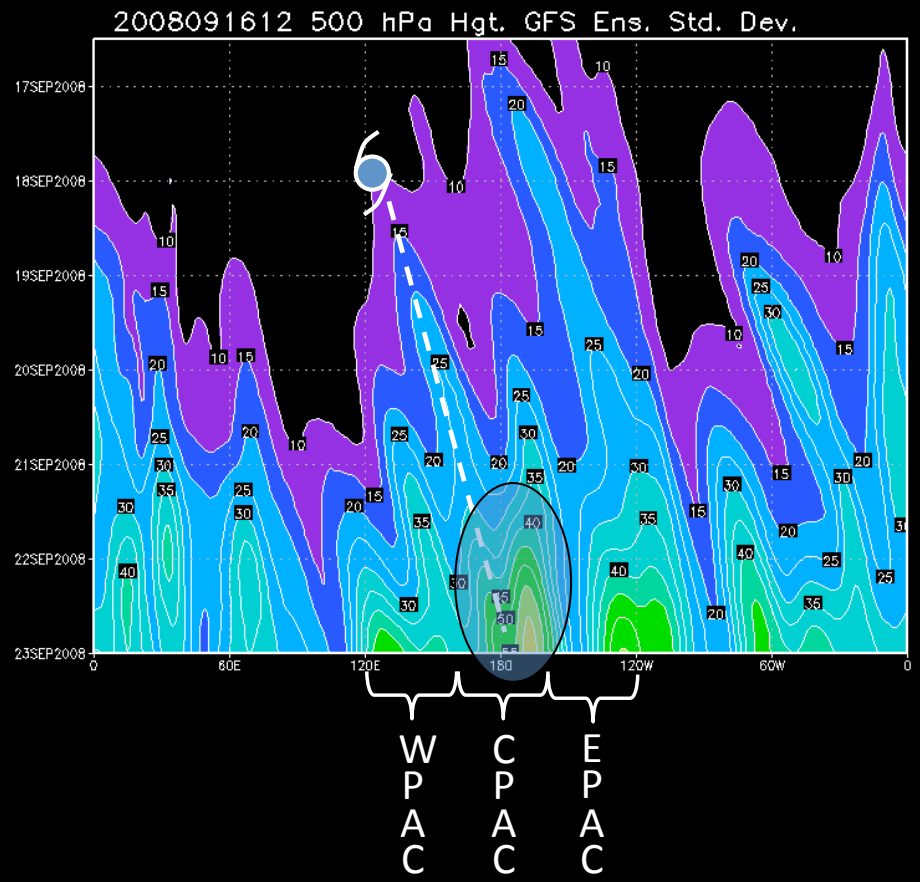




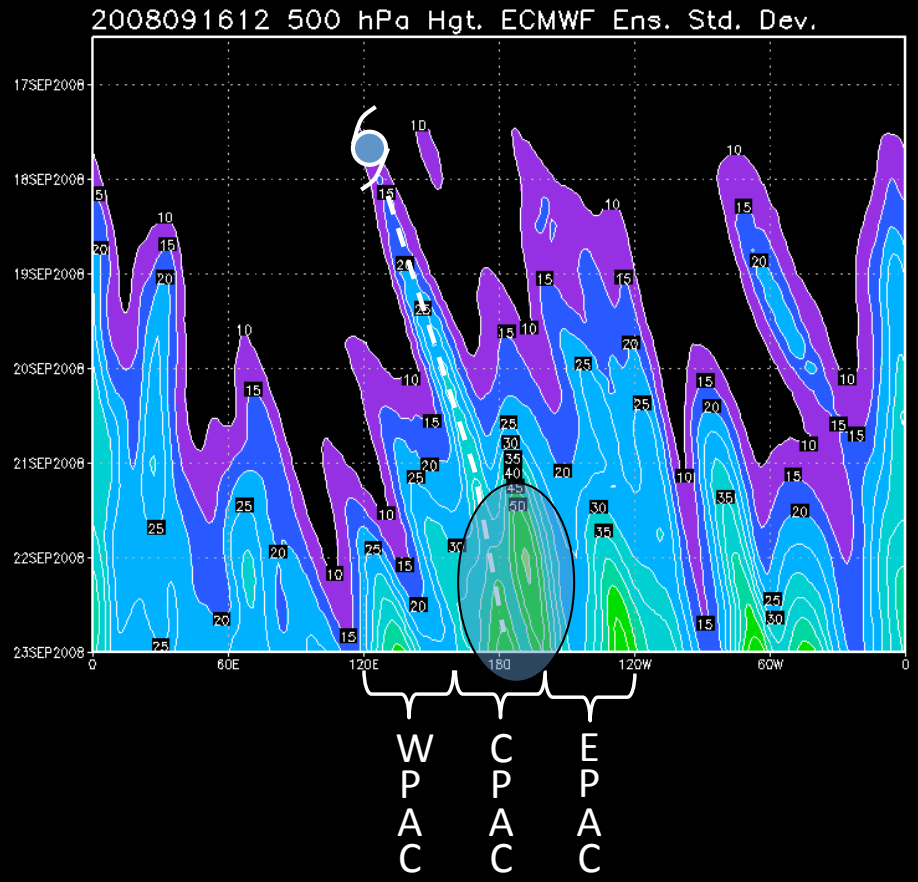
Despite the strong shear, Sinlaku re-intensified to typhoon strength

Predictability Challenges during the ET of TY Sinlaku

GFS

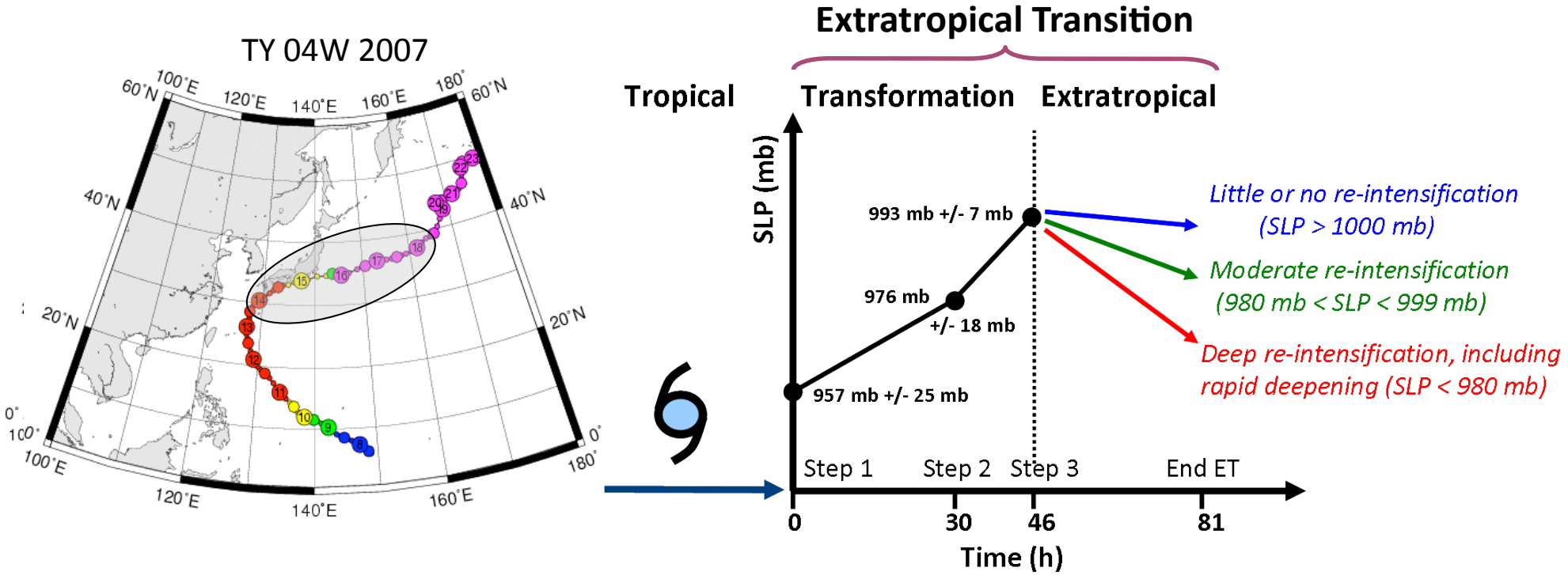


ECMWF



- Compare forecast and analyzed impacts of the ET on NH midlatitudes
- Identify sources of variability downstream of the ET
- Examine physical characteristics of the TC relative to reduced predictability

Extratropical Transition as part of the TC Lifecycle



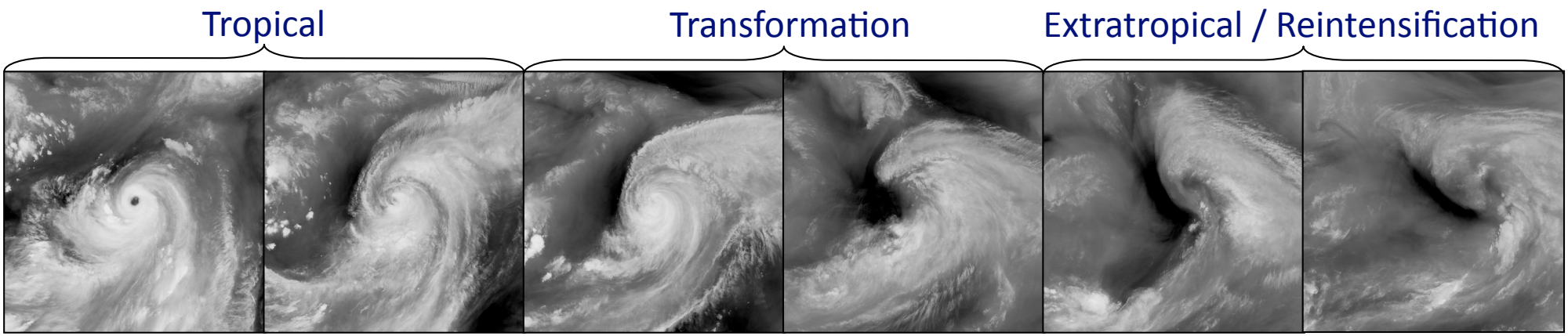
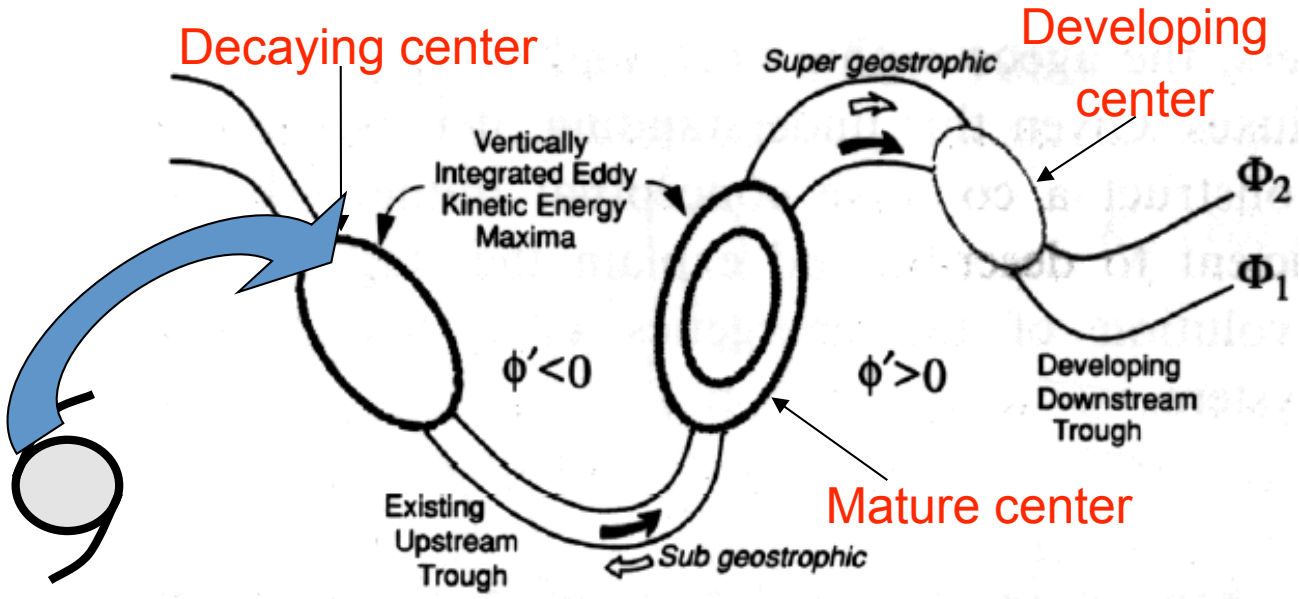


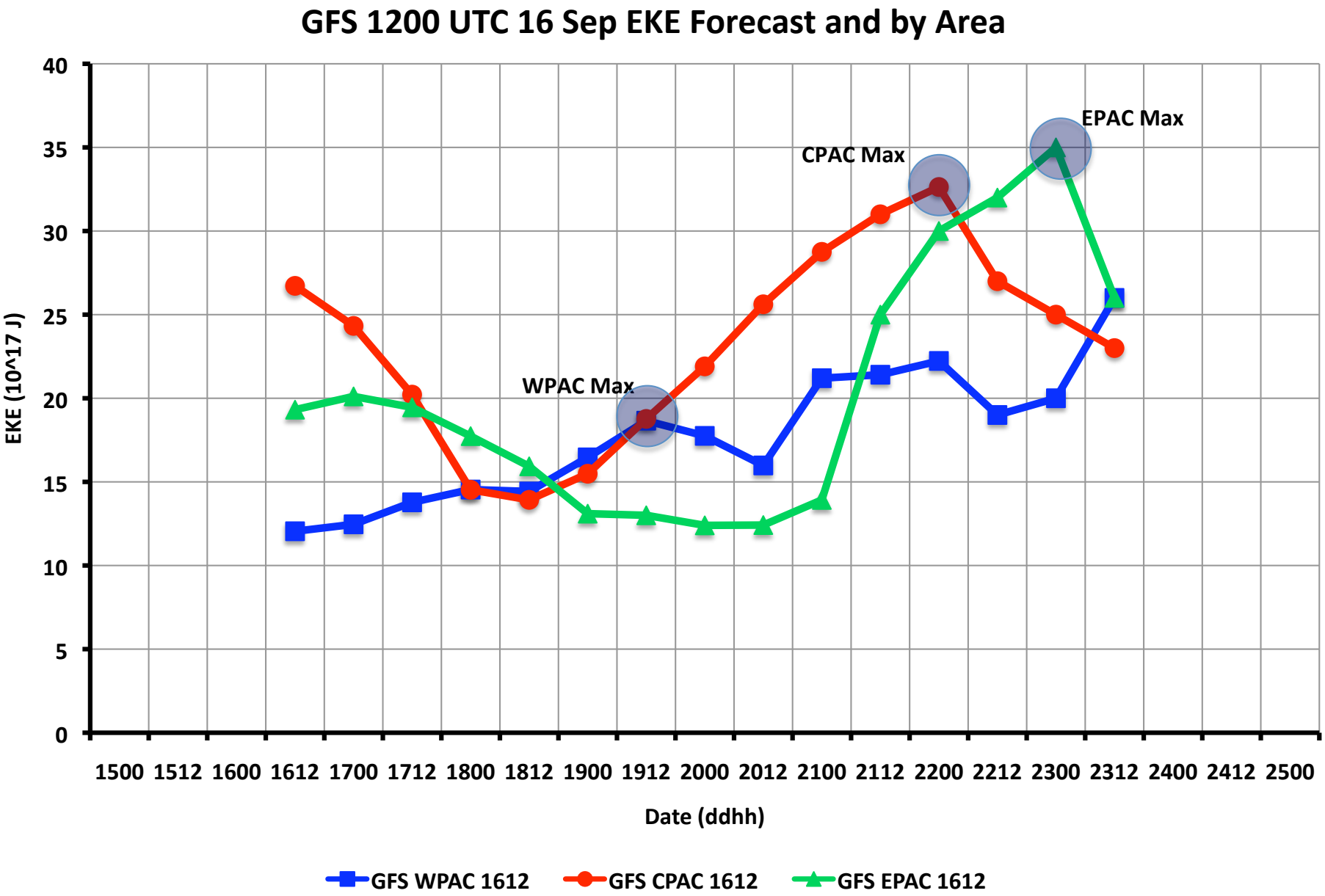
Figure adapted from Klein et al. (2000); TY Man-yi track courtesy Digital Typhoon: http://agora.ex.nii.ac.jp/digital-typhoon/summary/wnp/s/200704.html.en

Downstream Development in the context of a local Eddy Kinetic Energy (EKE) Analysis



The decaying tropical cyclone provides an additional source of EKE that continues to feed the downstream development process.

(after Orlanski and Sheldon 1995)


GFS 1200 UTC 16 Sep EKE Forecast and by Area
EKE (10^17 J)
40
35
30
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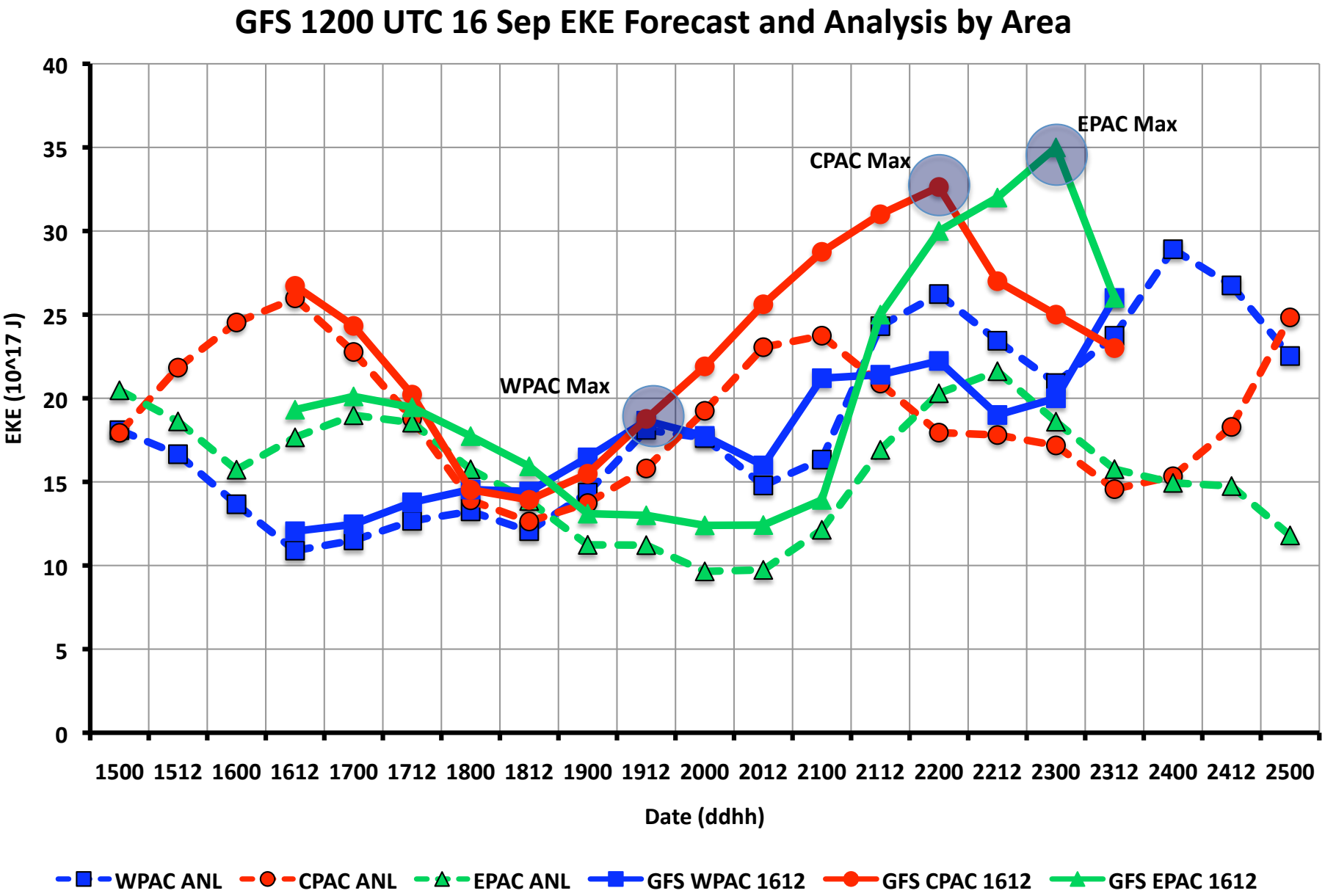
0
1500 1512 1600 1612 1700 1712 1800 1812 1900 1912 2000 2012 2100 2112 2200 2212 2300 2312 2400 2412 2500
Date (ddhh)
WPAC Max
CPAC Max
EPAC Max
GFS WPAC 1612
GFS CPAC 1612
GFS EPAC 1612


GFS 1200 UTC 16 Sep EKE Forecast and Analysis by Area
EKE (10^17 J)
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WPAC Max
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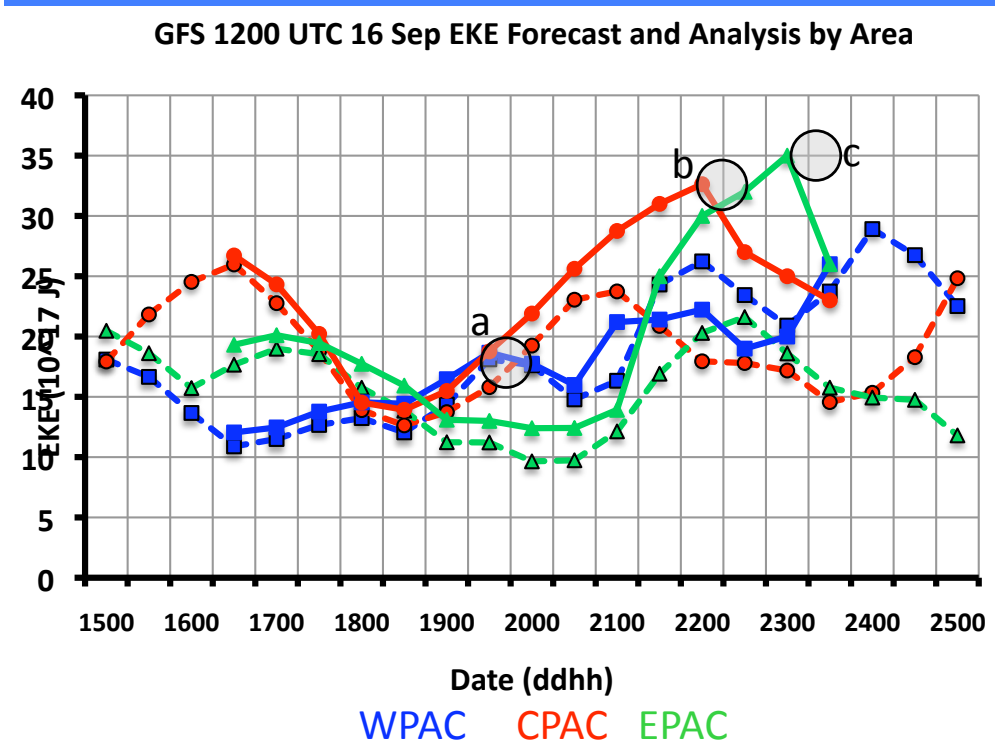
EPAC Max
1500 1512 1600 1612 1700 1712 1800 1812 1900 1912 2000 2012 2100 2112 2200 2212 2300 2312 2400 2412 2500
Date (ddhh)
WPAC ANL
CPAC ANL
EPAC ANL
GFS WPAC 1612
GFS CPAC 1612
GFS EPAC 1612

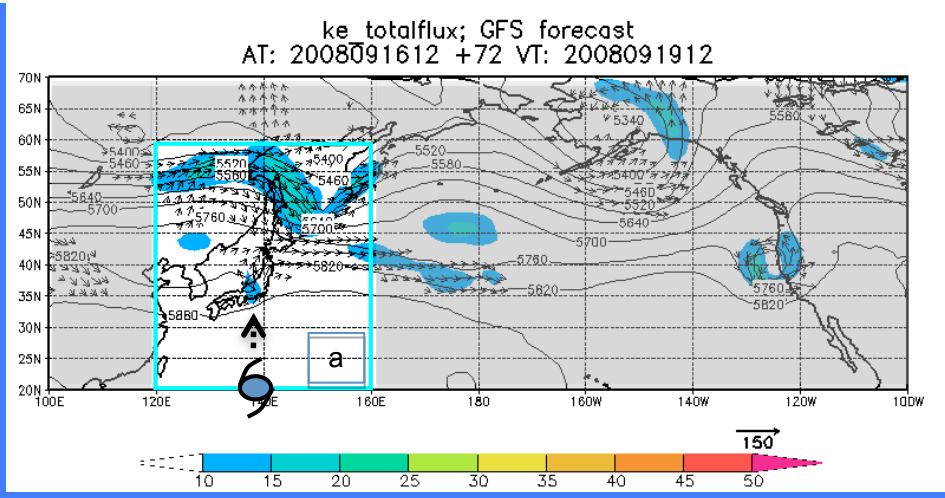
Diagnosing Downstream Development

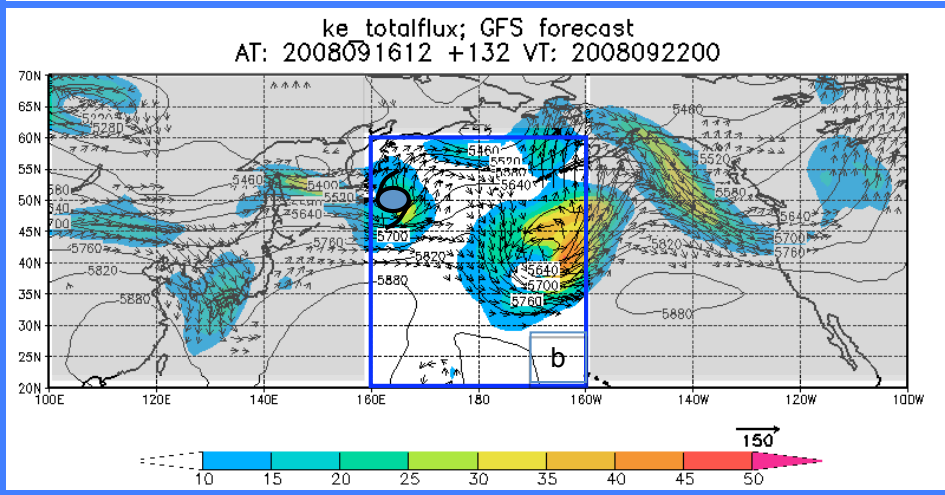
through the downstream propagation of EKE following the TC-midlatitude interaction

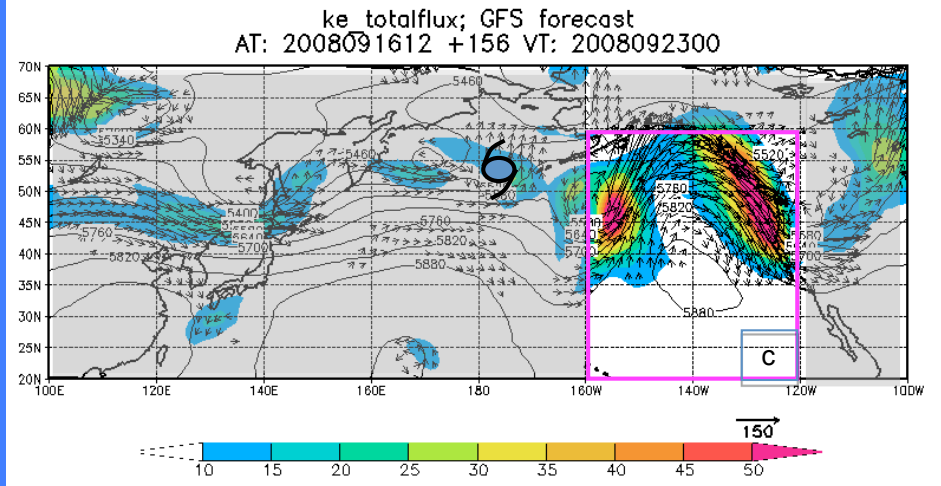
EXAMPLE: GFS Forecast

AT: 1200 UTC 16 Sep 08





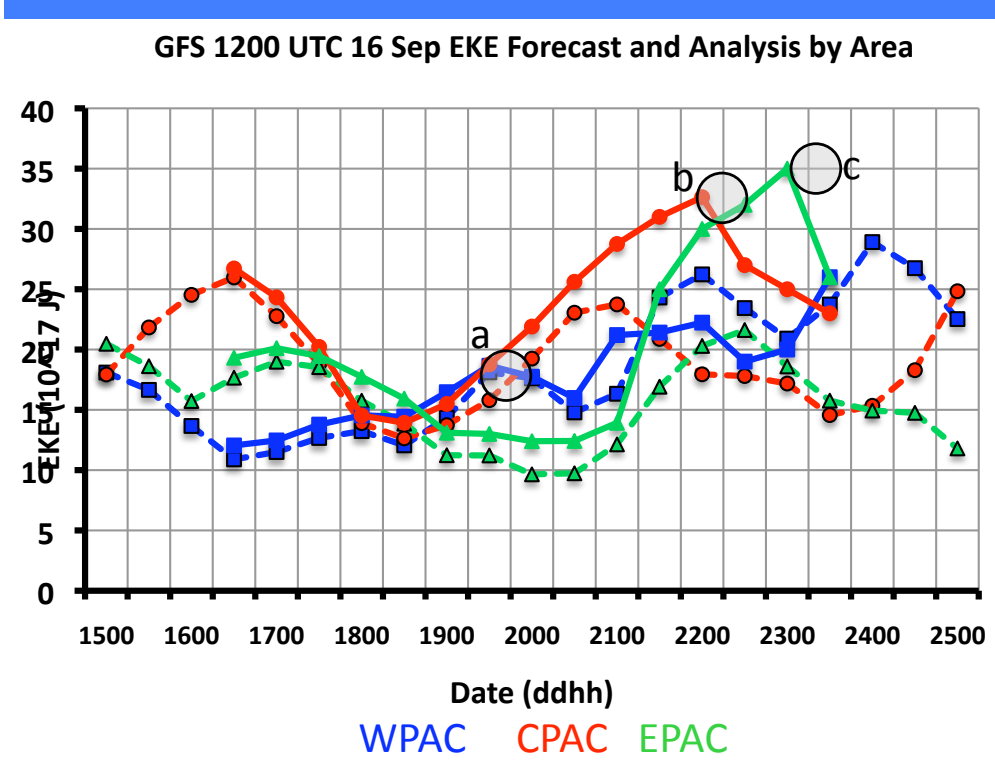


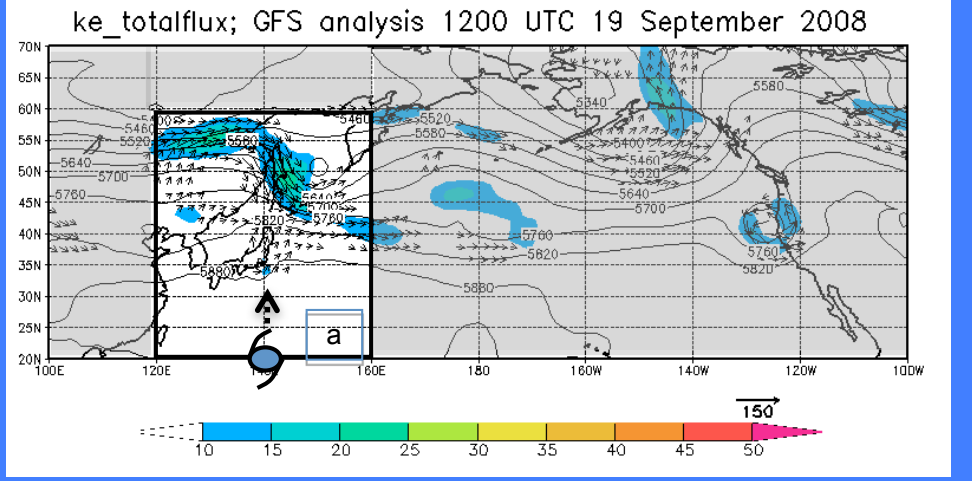


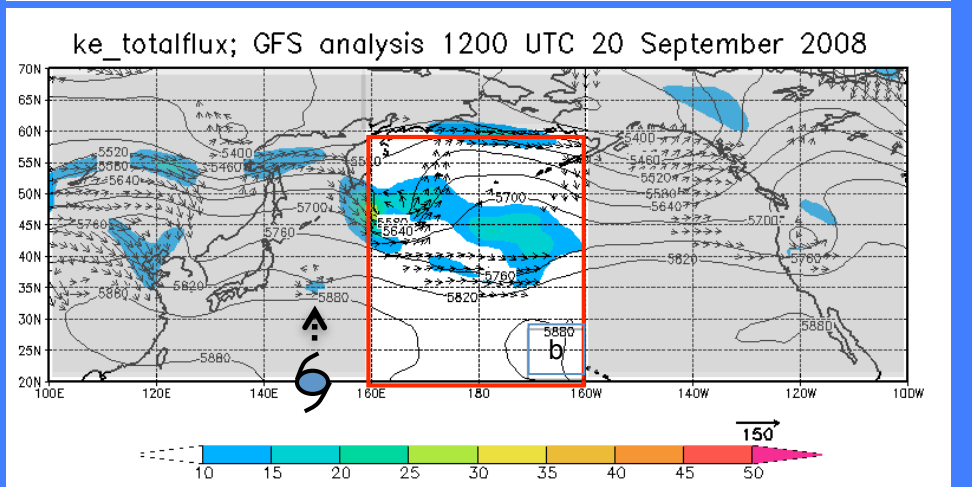
GFS Analysis

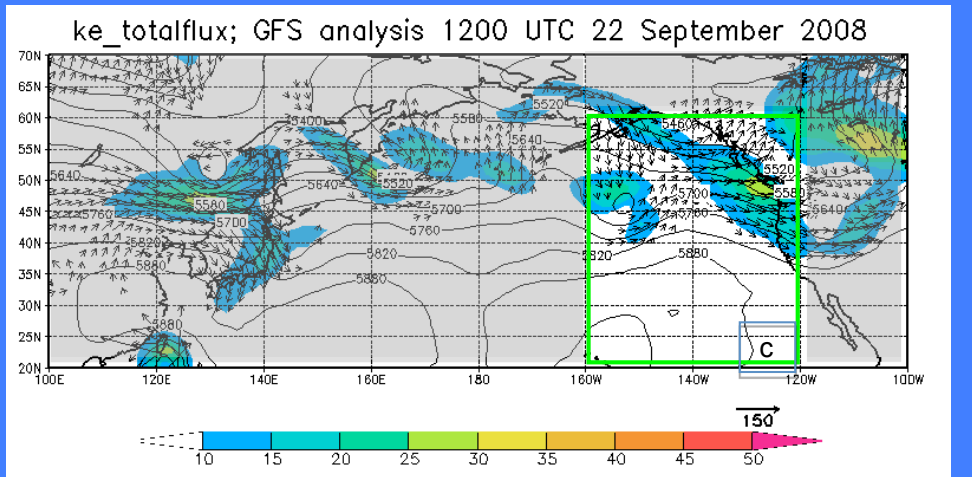
indicates minimal downstream development

1200 UTC 16 Sep 08

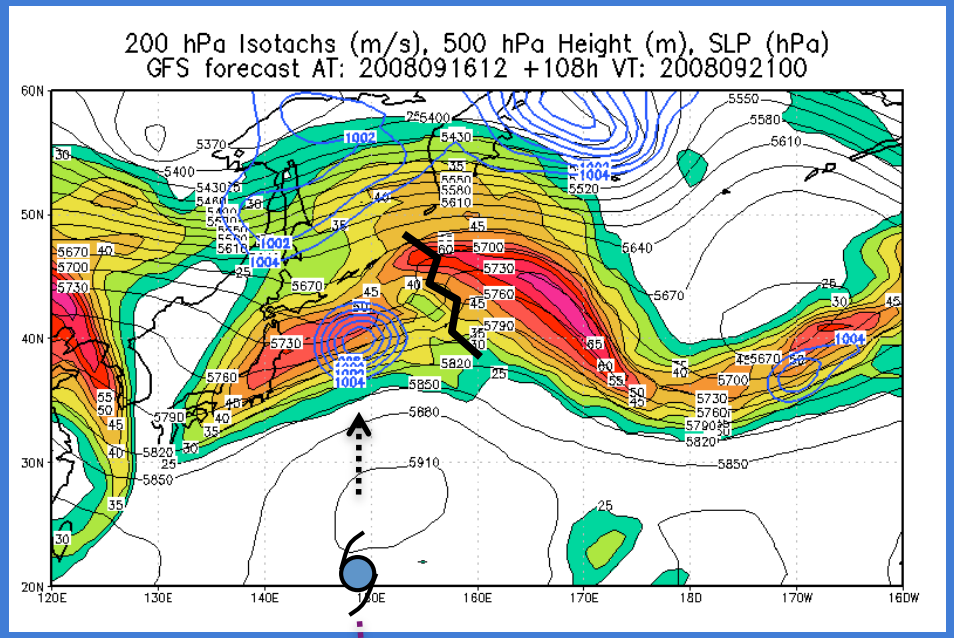


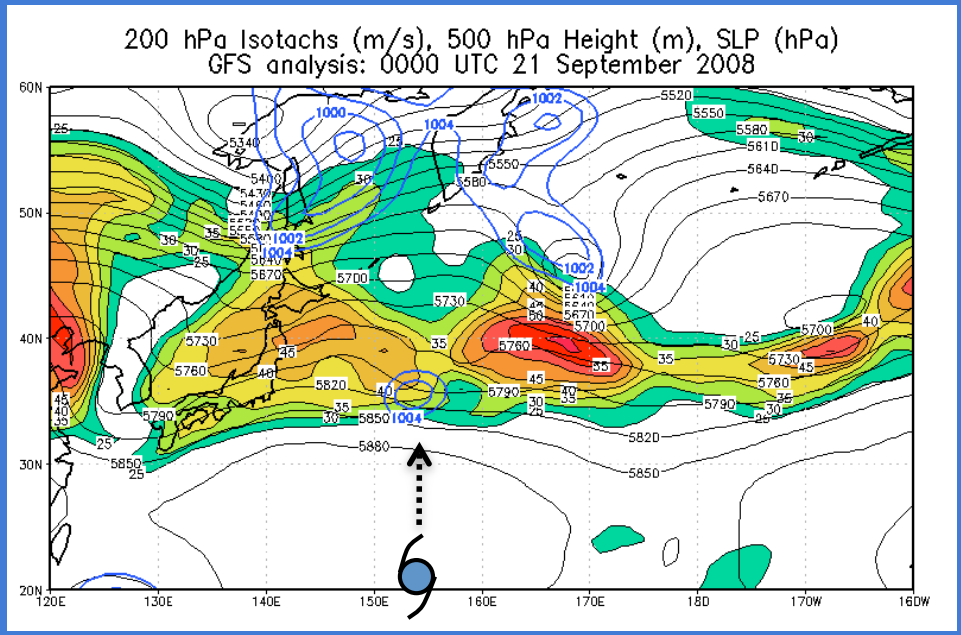


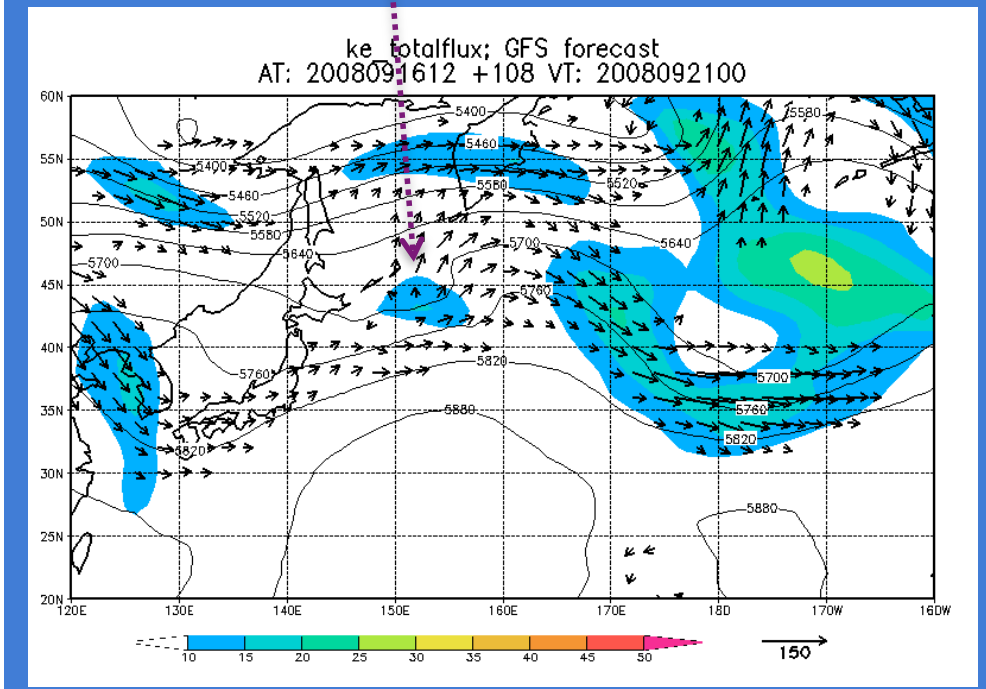


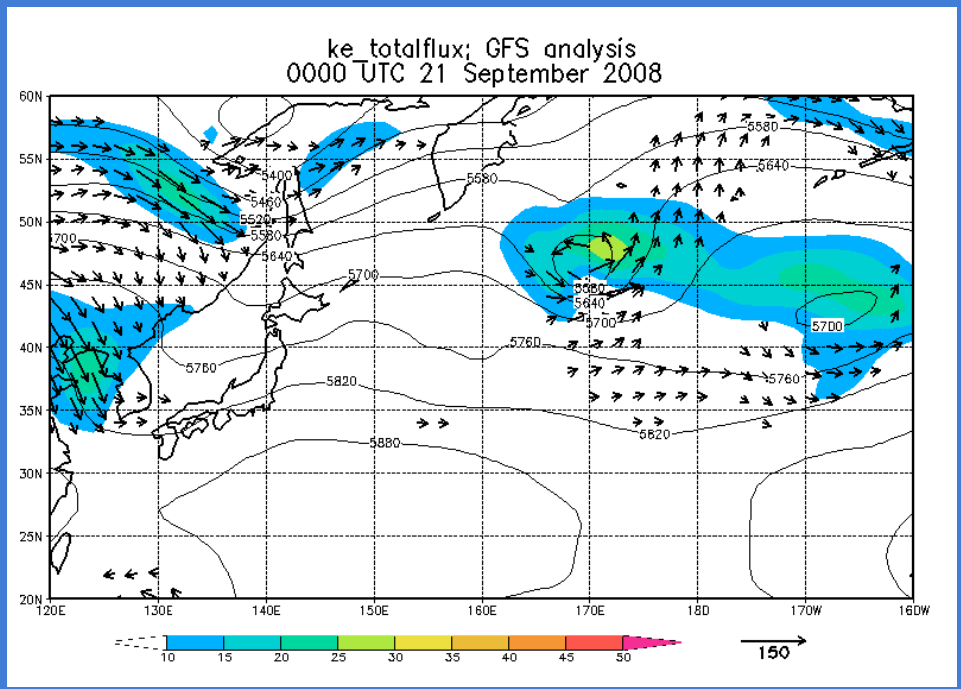


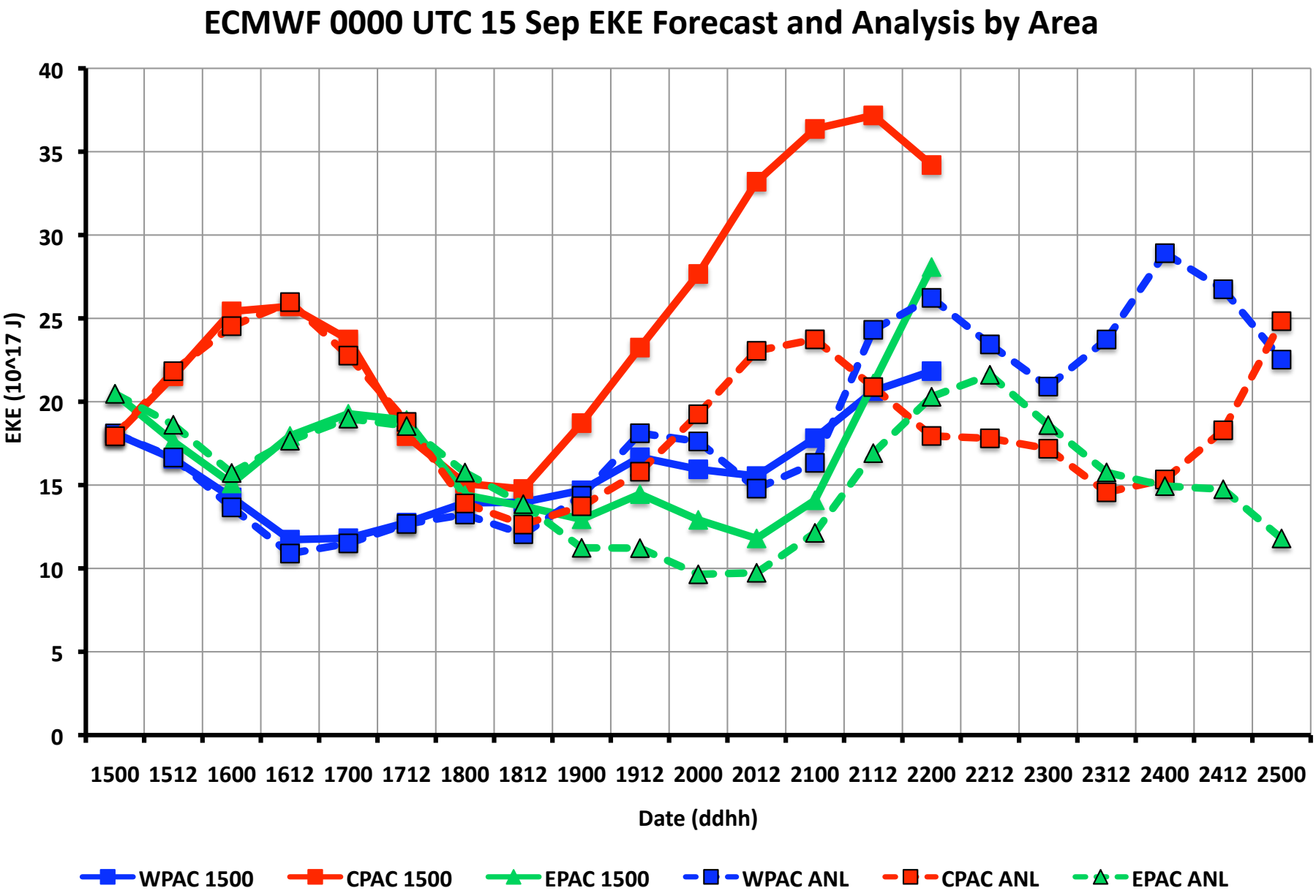
GFS Forecast from 1612 at time of max CPAC EKE










ECMWF 0000 UTC 15 Sep EKE Forecast and Analysis by Area
EKE (10^17 J)
40
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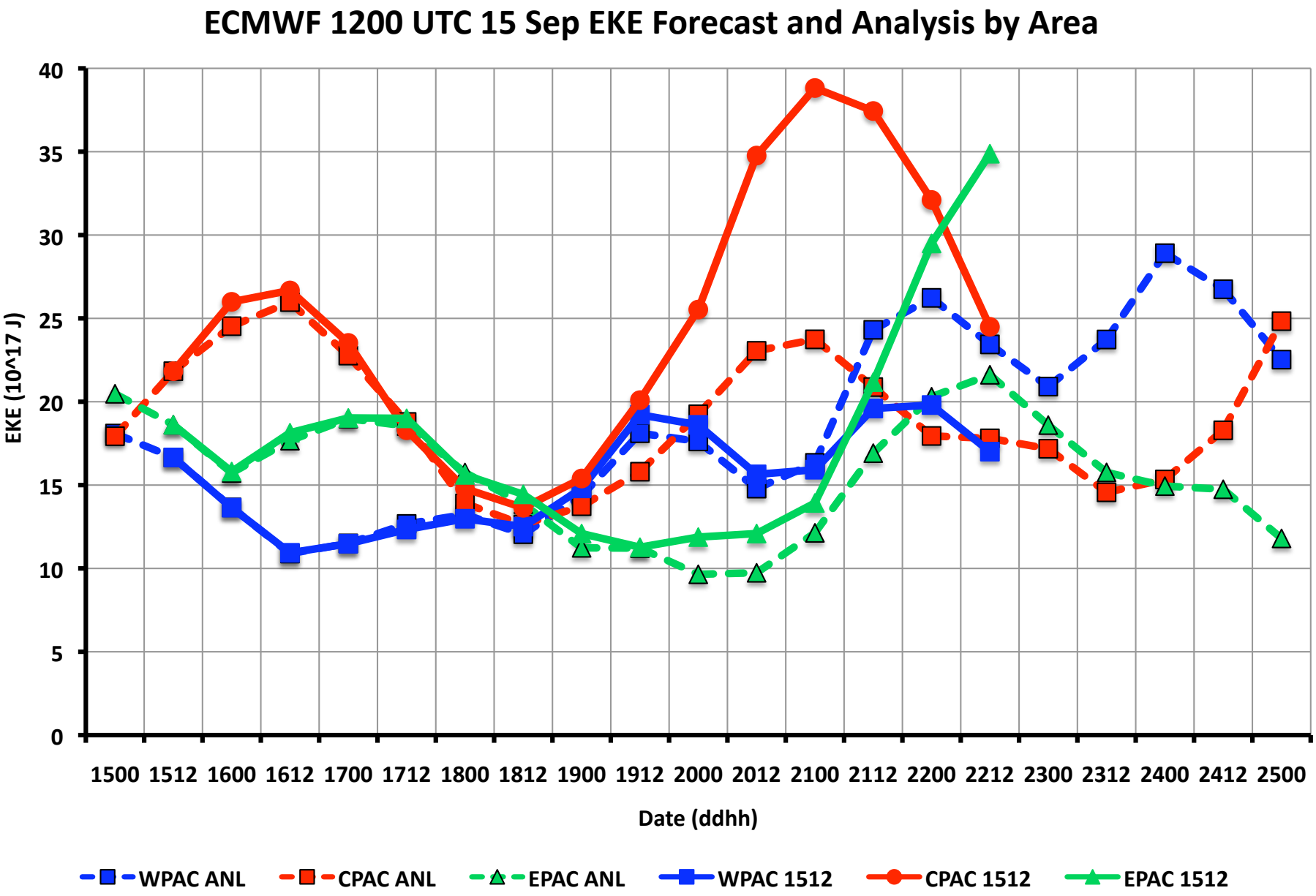
1500 1512 1600 1612 1700 1712 1800 1812 1900 1912 2000 2012 2100 2112 2200 2212 2300 2312 2400 2412 2500
Date (ddhh)
WPAC 1500
CPAC 1500
EPAC 1500
WPAC ANL
CPAC ANL
EPAC ANL


ECMWF 1200 UTC 15 Sep EKE Forecast and Analysis by Area
EKE (10^17 J)
40
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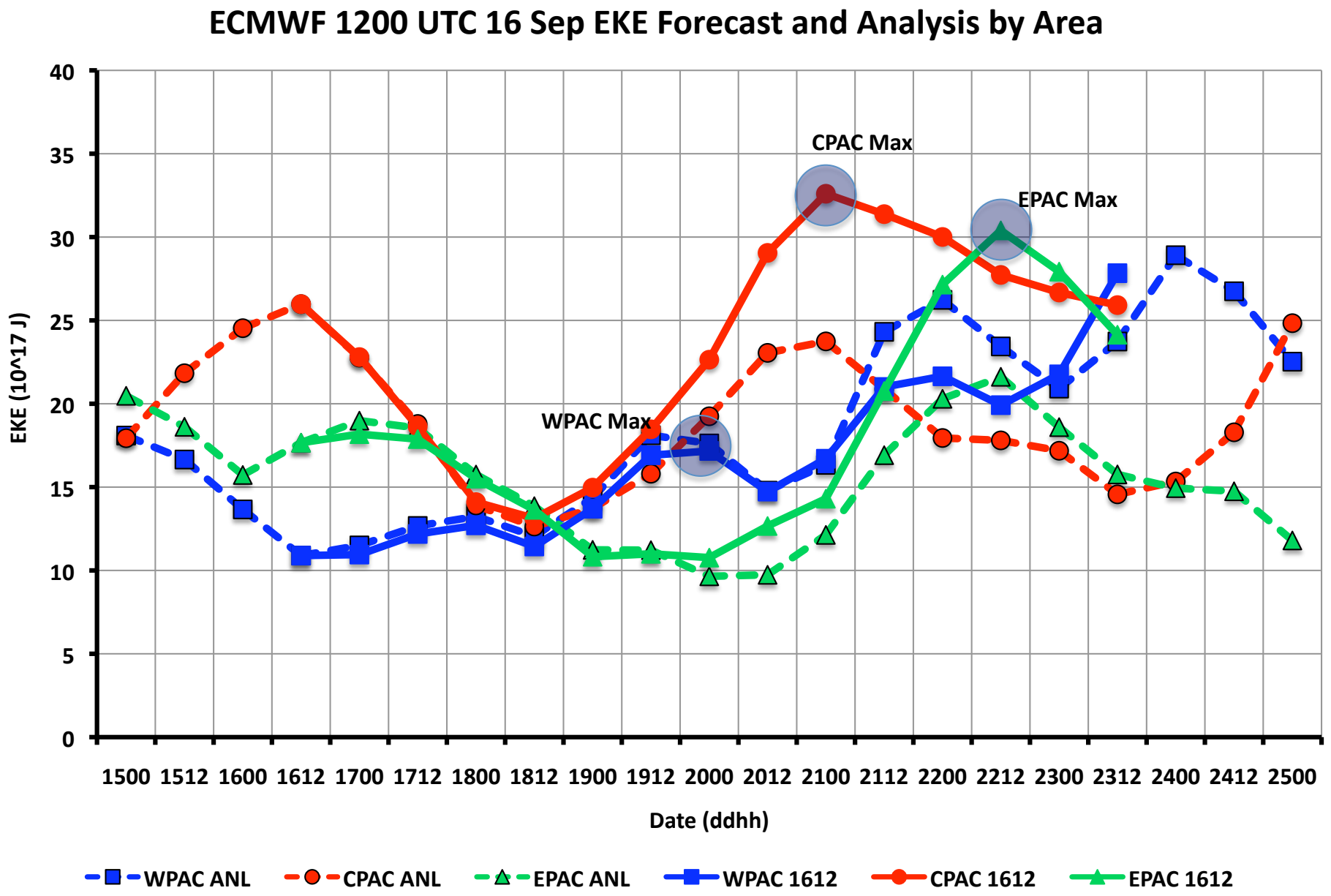
1500 1512 1600 1612 1700 1712 1800 1812 1900 1912 2000 2012 2100 2112 2200 2212 2300 2312 2400 2412 2500
Date (ddhh)
WPAC ANL
CPAC ANL
EPAC ANL
WPAC 1512
CPAC 1512
EPAC 1512


ECMWF 1200 UTC 16 Sep EKE Forecast and Analysis by Area
EKE (10^17 J)
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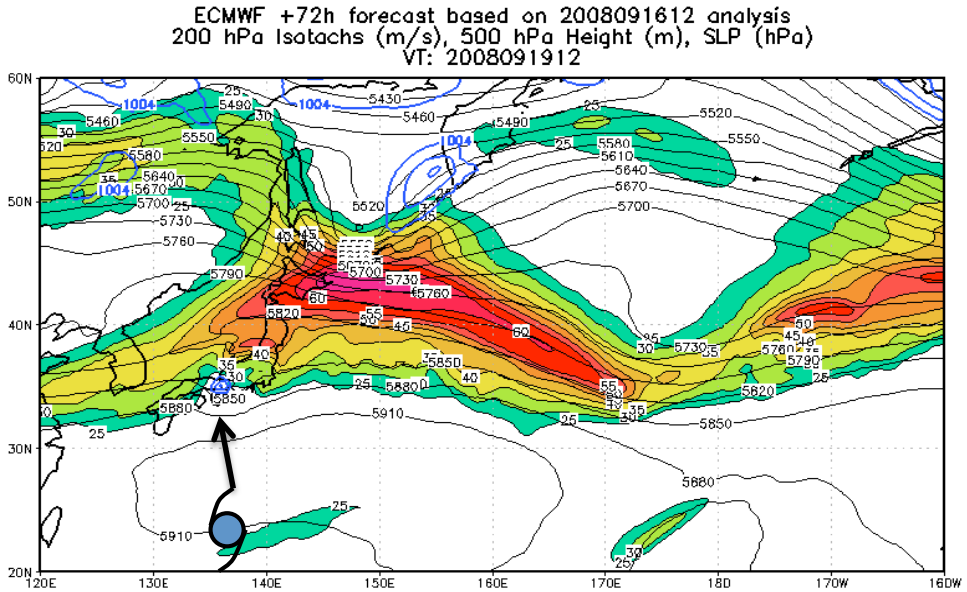
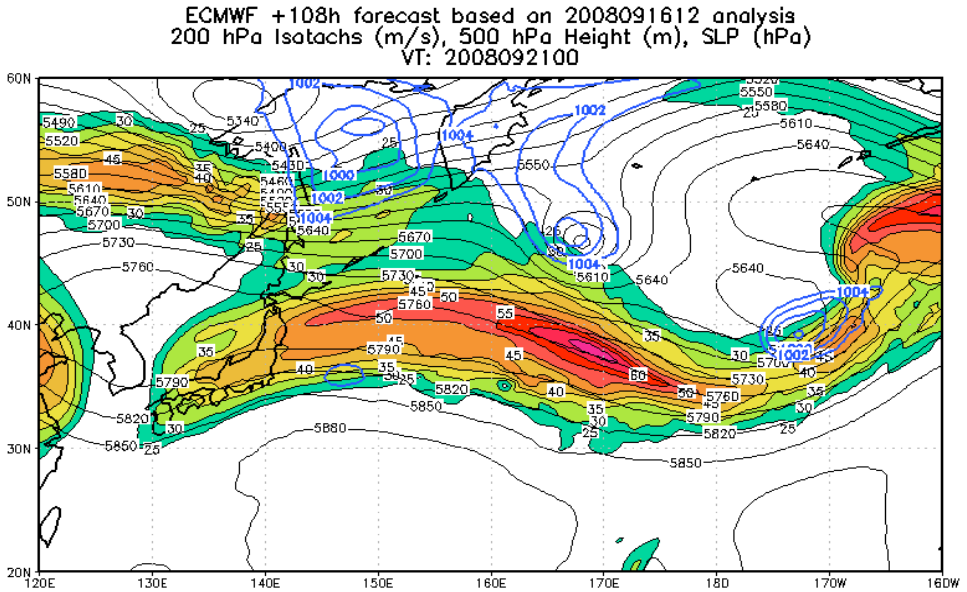
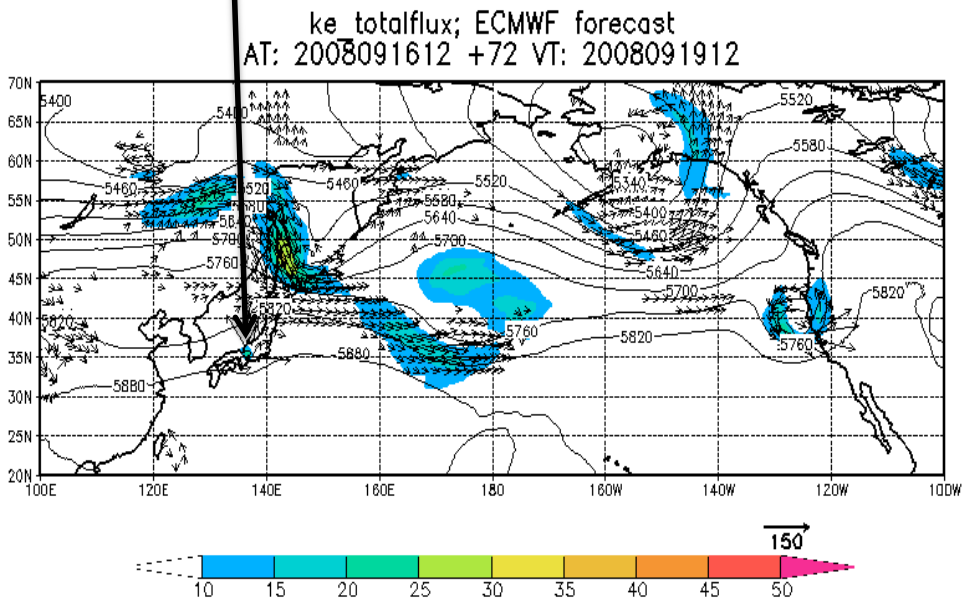
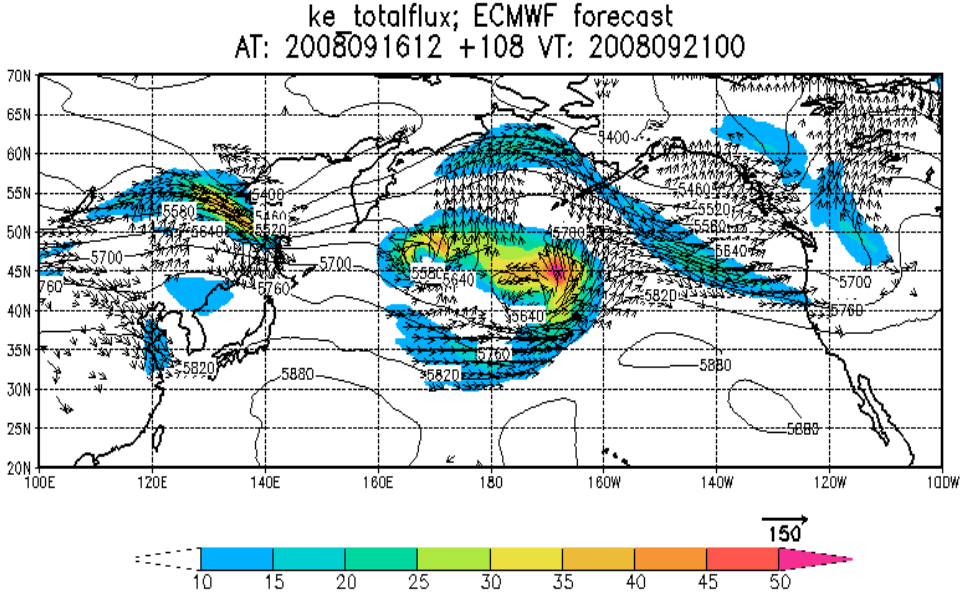
CPAC Max
EPAC Max
WPAC Max
1500 1512 1600 1612 1700 1712 1800 1812 1900 1912 2000 2012 2100 2112 2200 2212 2300 2312 2400 2412 2500
Date (ddhh)
WPAC ANL
CPAC ANL
EPAC ANL
WPAC 1612
CPAC 1612
EPAC 1612

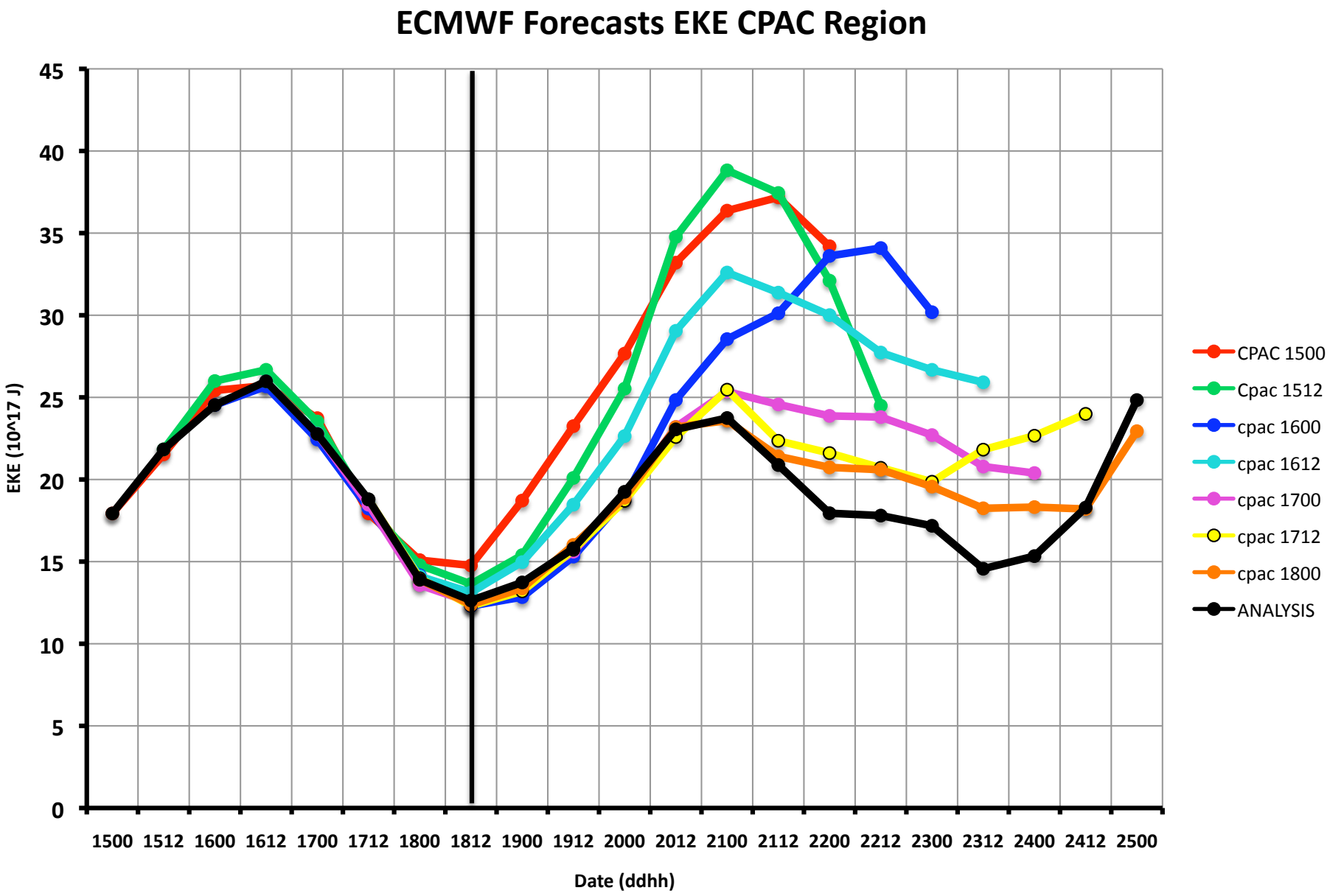
ECMWF Forecast from 1612 at time of max CPAC EKE










ECMWF Forecasts EKE CPAC Region
EKE (10^17 J)
45
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35
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1500 1512 1600 1612 1700 1712 1800 1812 1900 1912 2000 2012 2100 2112 2200 2212 2300 2312 2400 2412 2500
Date (ddhh)
CPAC 1500
Cpac 1512
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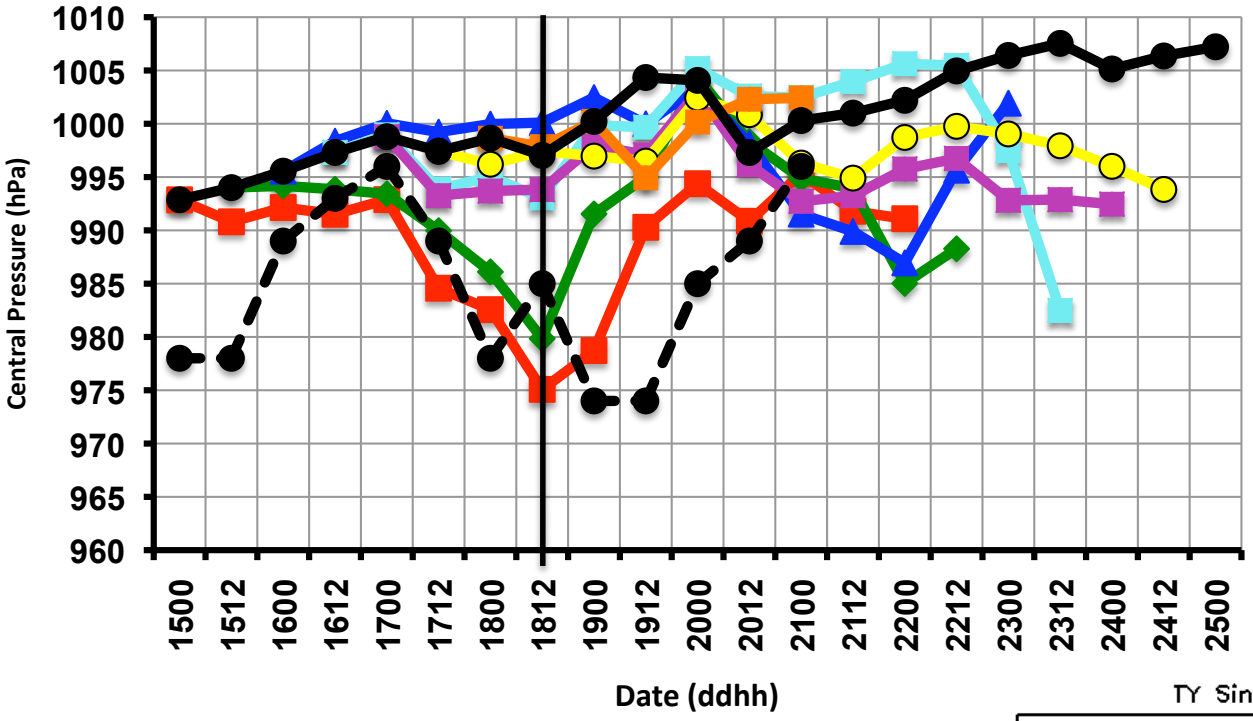
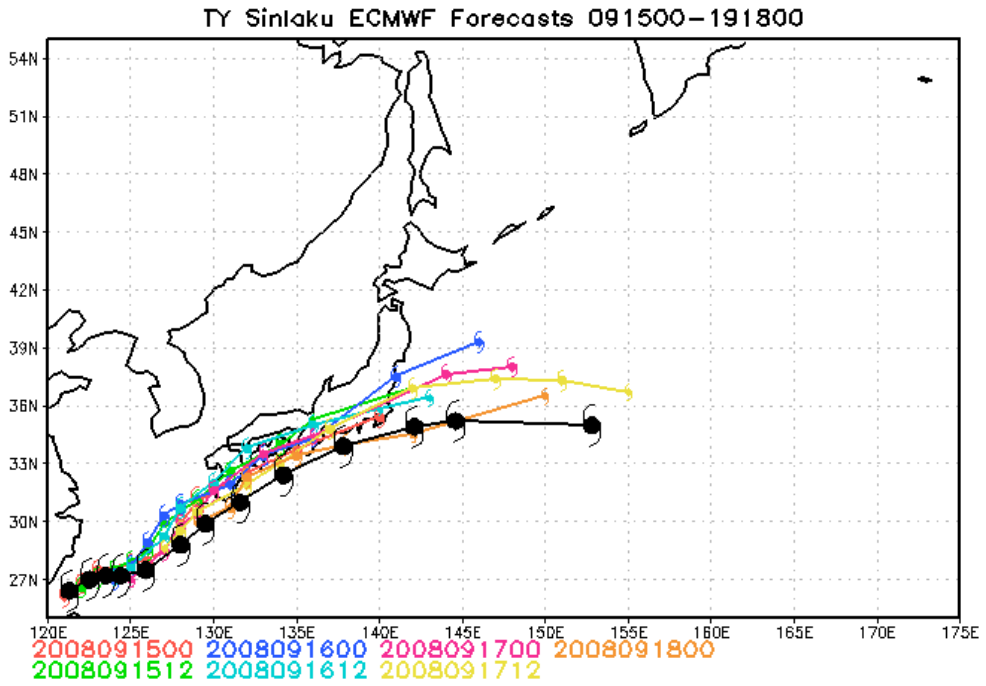
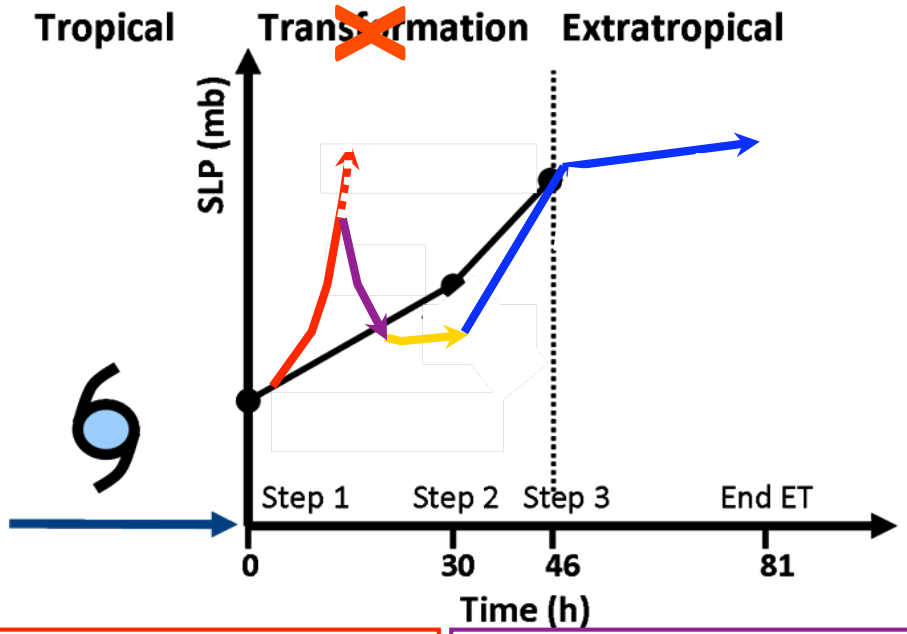
cpac 1712
cpac 1800
ANALYSIS

ECMWF Forecast Central Pressure

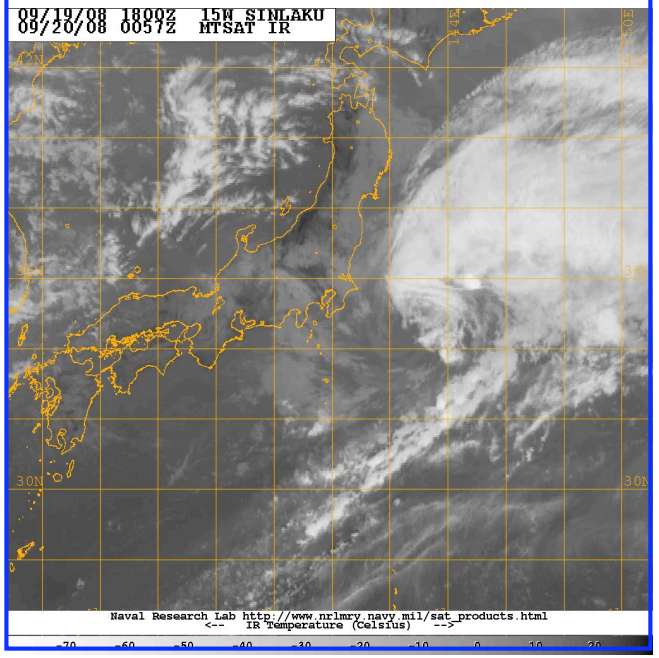




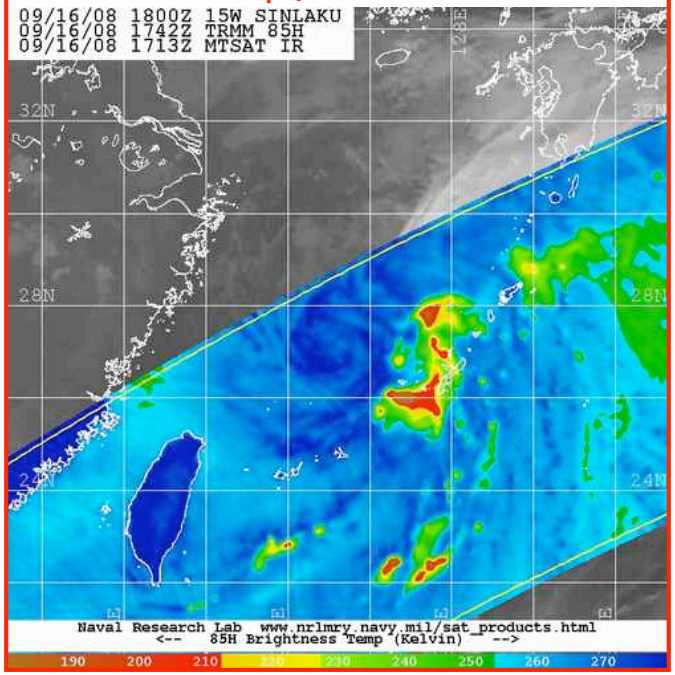
Post-recurvature Sinlaku



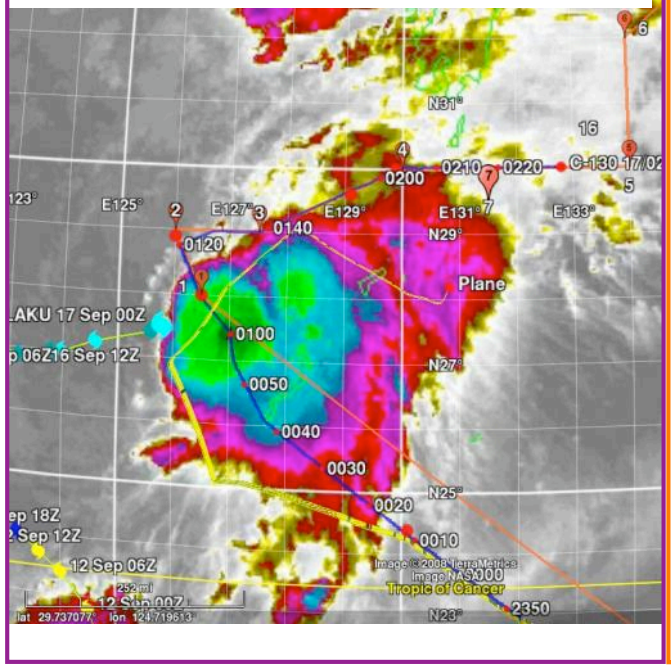
20 Sep / 0100 UTC



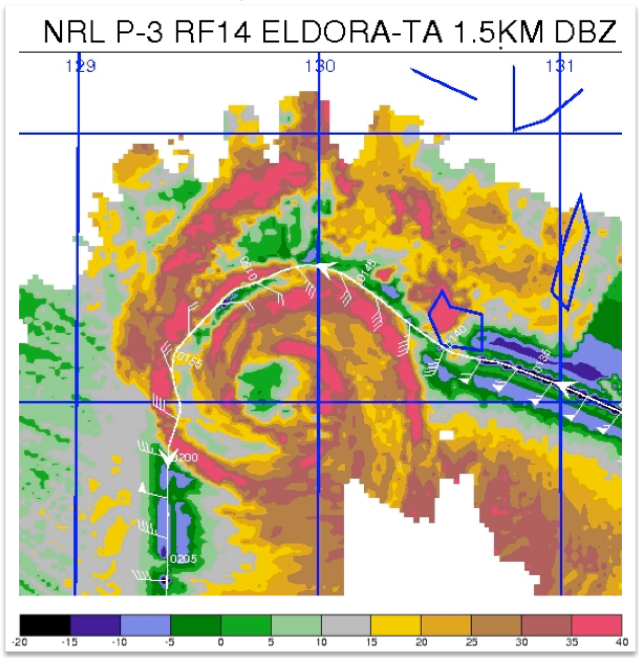
16 Sep / 1800 UTC



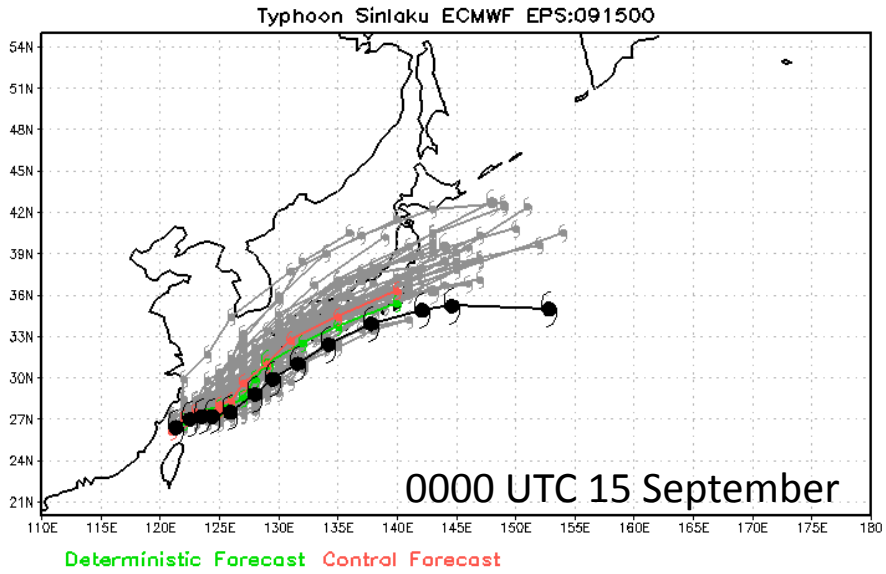
17 Sep / 0200 UTC

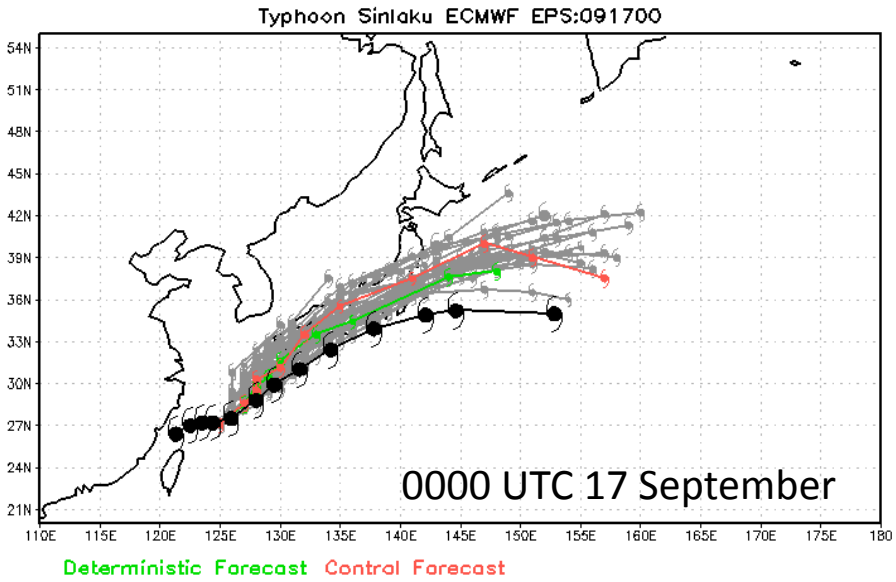


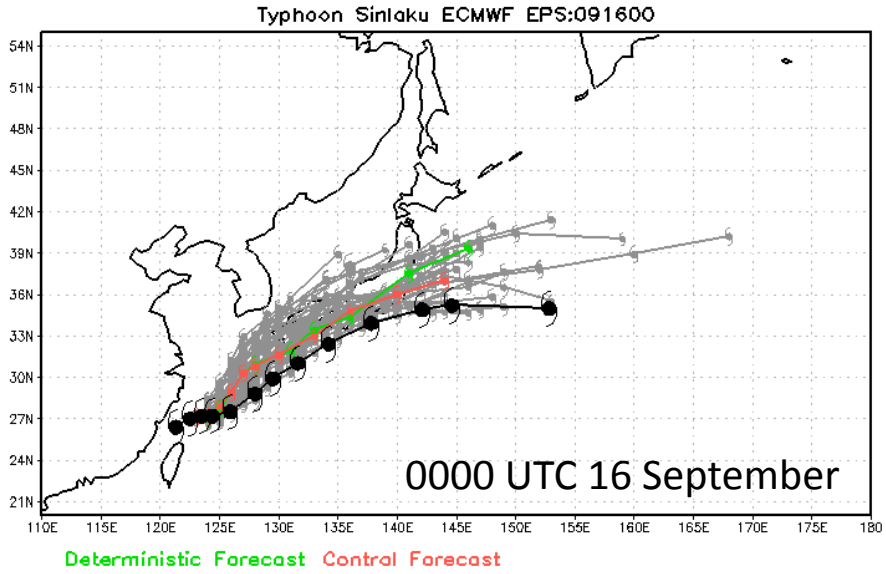
18 Sep / 0200 UTC

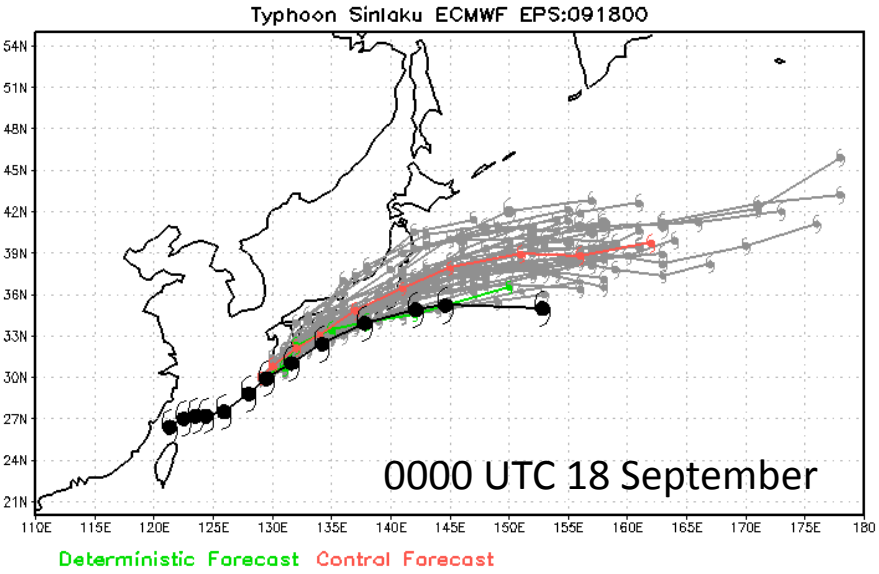


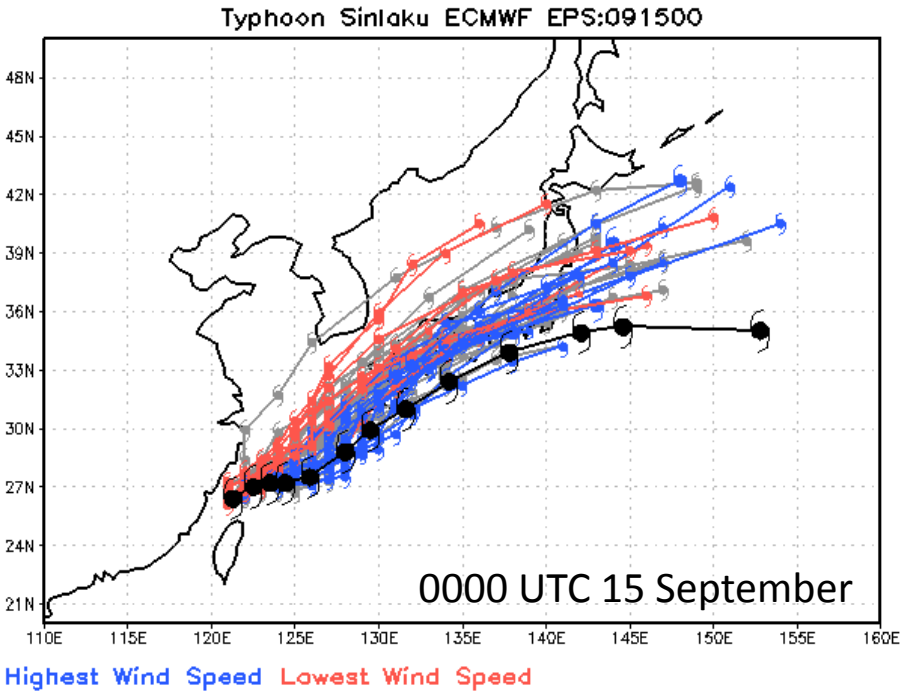
ECMWF Ensemble Members (TIGGE CXML)

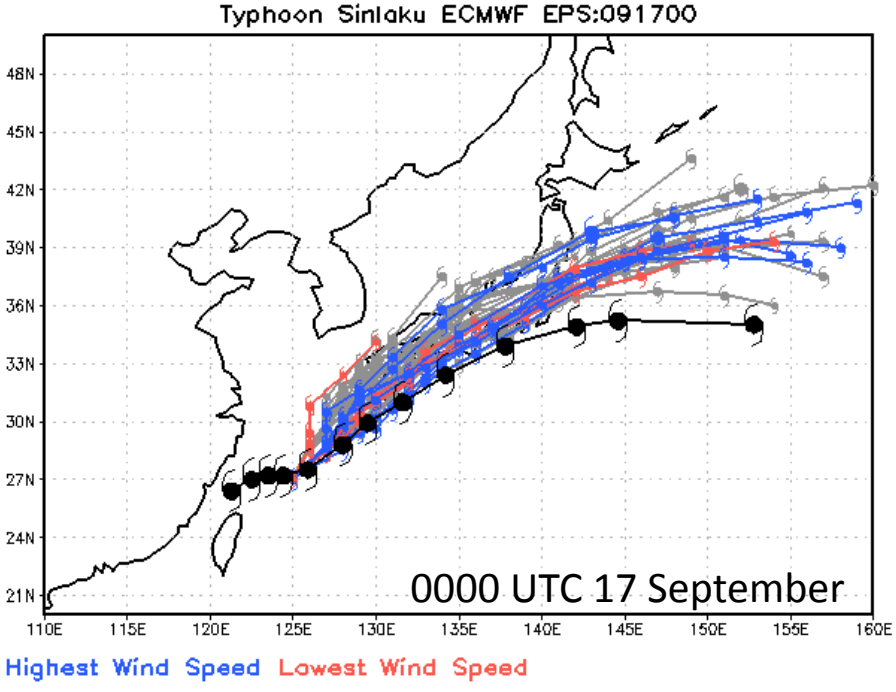


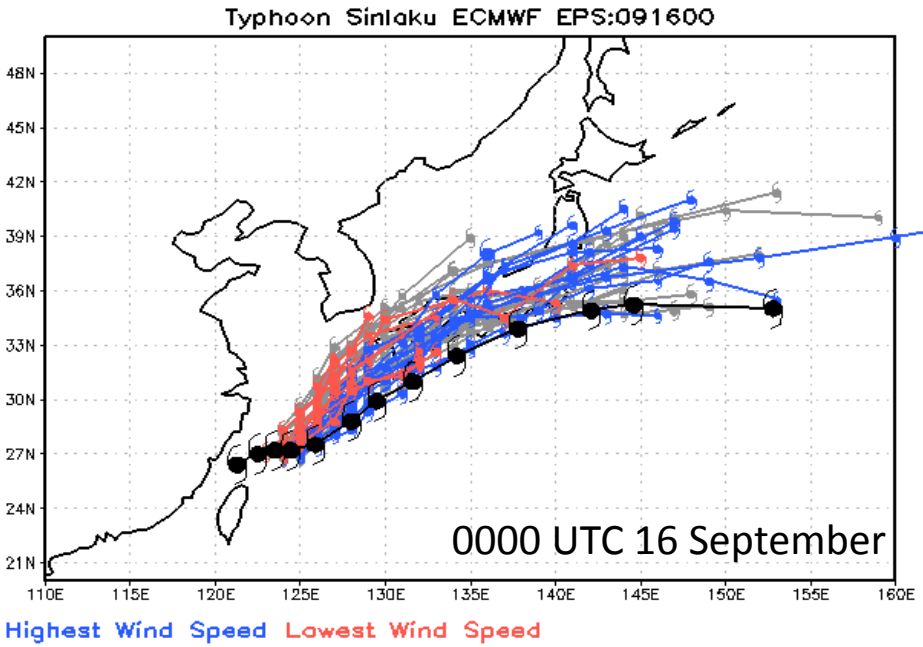










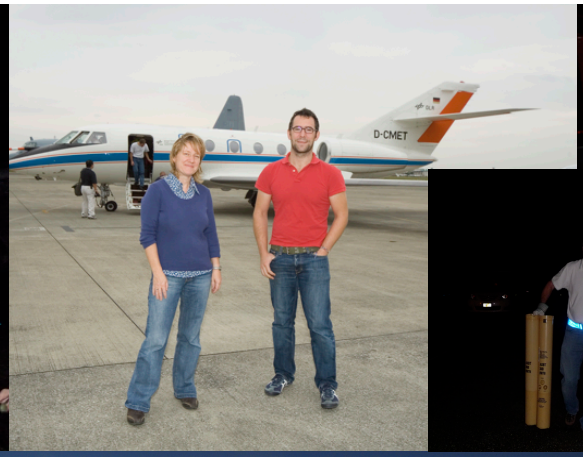


Highest wind speed = 67% of the individual forecasts were in the top 25% of the wind speed value

Lowest wind speed = 67% of the individual forecasts were in the lowest 25% of the wind speed value

Summary

- RESULTS:
  - REDUCED PREDICTABILITY FOLLOWING THE RECURVATURE OF TYPHOON SINLAKU
    - *TRANSFORMATION STAGE:* Weakening of the tropical cyclone; rapid re-intensification in the subtropics.
    - *EXTRATROPICAL STAGE:* False alarms in multiple forecasts from 3 global models
  - REDEVELOPMENT OF TY SINLAKU WAS CRITICAL TO ET: Redevelopment of TY Sinlaku SW of Japan as a warm core tropical system enabled the dissipating system to reach the midlatitudes and begin extratropical transition east of Japan.
  - GREATEST VARIABILITY/ERRORS IN FORECAST DD IN THE CENTRAL NORTH PACIFIC
    - Over-forecast TC during the extratropical stage over the western North Pacific
    - Excess EKE propagation from the western North Pacific
- CURRENT WORK:
  - Sensitivity of DD to Track using the ensemble members
  - Mechanisms by which Sinlaku re-intensified
  - INVESTIGATE SENSITIVITIES OF THE DD TO THE RE-INTENSIFICATION OF THE TC
    - Identify mechanisms that were poorly forecast resulting in false reintensification and DD:
      - Vertical wind shear, upper-level outflow, diabatic influences, upstream trough, etc.
    - Detailed analysis of aircraft and ELDORA radar data
  - WRF SIMULATIONS WITH AND WITHOUT SINLAKU



Acknowledgments:

Funding agencies in Germany, U.K., France, South Korea, Canada, Japan, Taiwan, and the U.S.

WMO/WWRP/THORPEX

WMO/WWRP/TMRP

Many Operators, PIs, Students.