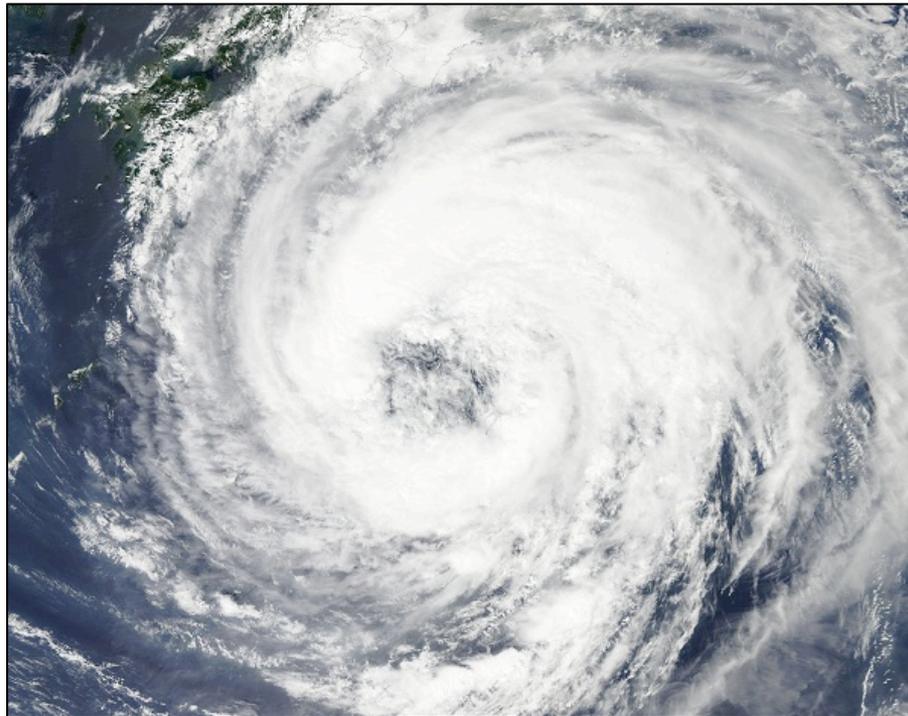


# Improvements to, and Verification of, Intraseasonal to Seasonal Prediction of Tropical Cyclogenesis

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Fort Worth, TX, 03–06 Oct 2011



# Long Lead Forecasting of Tropical Cyclone Formation in the Western North Pacific

## NPS Statistical-Dynamical Forecast System

***Build*** statistical model based on relationships between TC formations and LSEFs\*\* (based on JTWC best track and NCEP R2 reanalysis data)

***Apply*** statistical model of TC formation probability (NPS logistic regression model)

***Produce*** statistical-dynamical model output: ensemble-based long lead forecasts of TC formation probabilities (NPS TC LLFs, 0-90 day lead times)

***Force*** statistical model with dynamical, ensemble-based, long lead forecasts of LSEFs\*\* (use NCEP Climate Forecast System v1)

- \*\* LSEFs = large scale environmental factors: SST,  $\zeta_{850}$ , shear<sub>200-850</sub>, div<sub>200</sub>,  $f$
- Inputs and outputs are all on a daily, 2.5° scale.
  - Statistical model is a logistic regression model.
  - Each LSEF influences TC formation at over a 99% confidence level
  - Extensive ensembling using multiple initial conditions and lead times (e.g., 184 members for 90 day leads) ⇒ equivalent to Monte Carlo simulation.



# Statistical Model Performance Verification

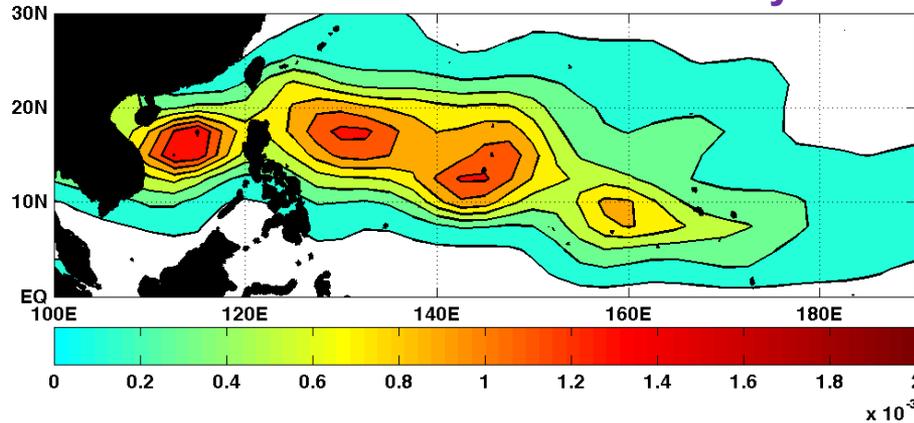
**26 years of zero lead hindcasts for western North Pacific (WNP) for 1982-2007 show statistical model has skill:**

- 1. Hindcasts evaluated at daily, 2.5° resolution**
- 2. Proportion correct: 89% (671 of 759 TCs formed within a forecasted region)**
- 3. Positive Brier skill score**
- 4. Positive ROC skill score**
- 5. Modeled probabilities match well with observed formations for:**
  - a. El Nino and La Nina**
  - b. Eight MJO phases**

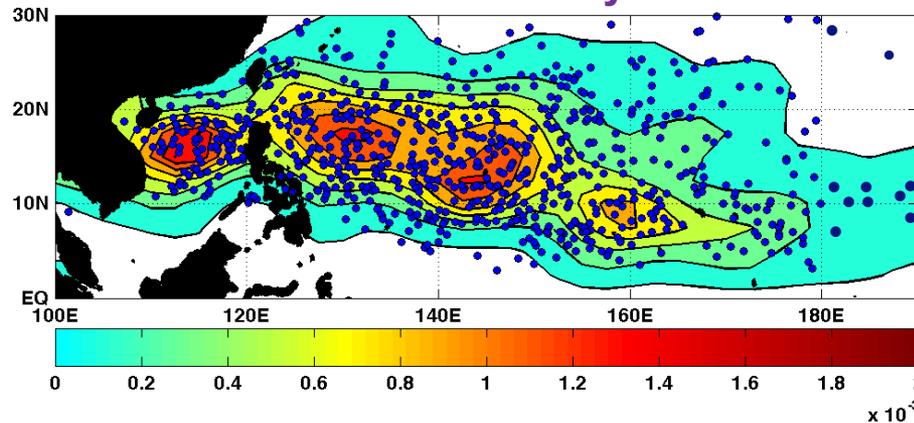


# Qualitative Statistical Model Verification: JASO LTM TC Formation Probability and Actual Formations

## LTM TC Formation Probability



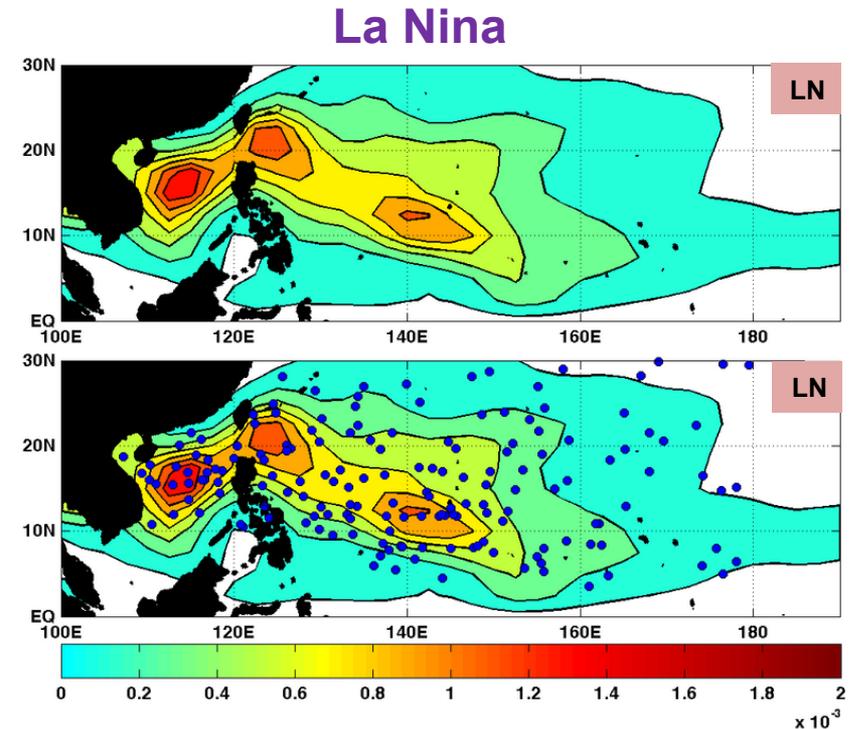
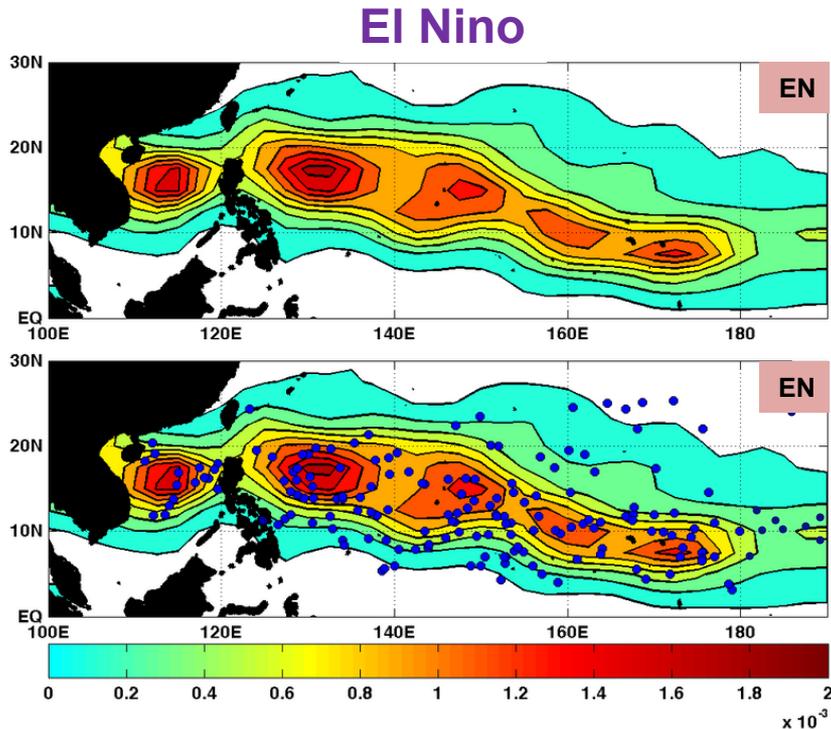
## LTM TC Formation Probability and Formations



1. Probabilities from NPS statistical model forced with R1 LTM LSEFs.
2. Probabilities *not* calculated directly from observed TC formations.
3. LTM probabilities correspond well to LTM formations.



# Qualitative Statistical Model Verification: JASO ENLN TC Formation Probability and Actual Formations

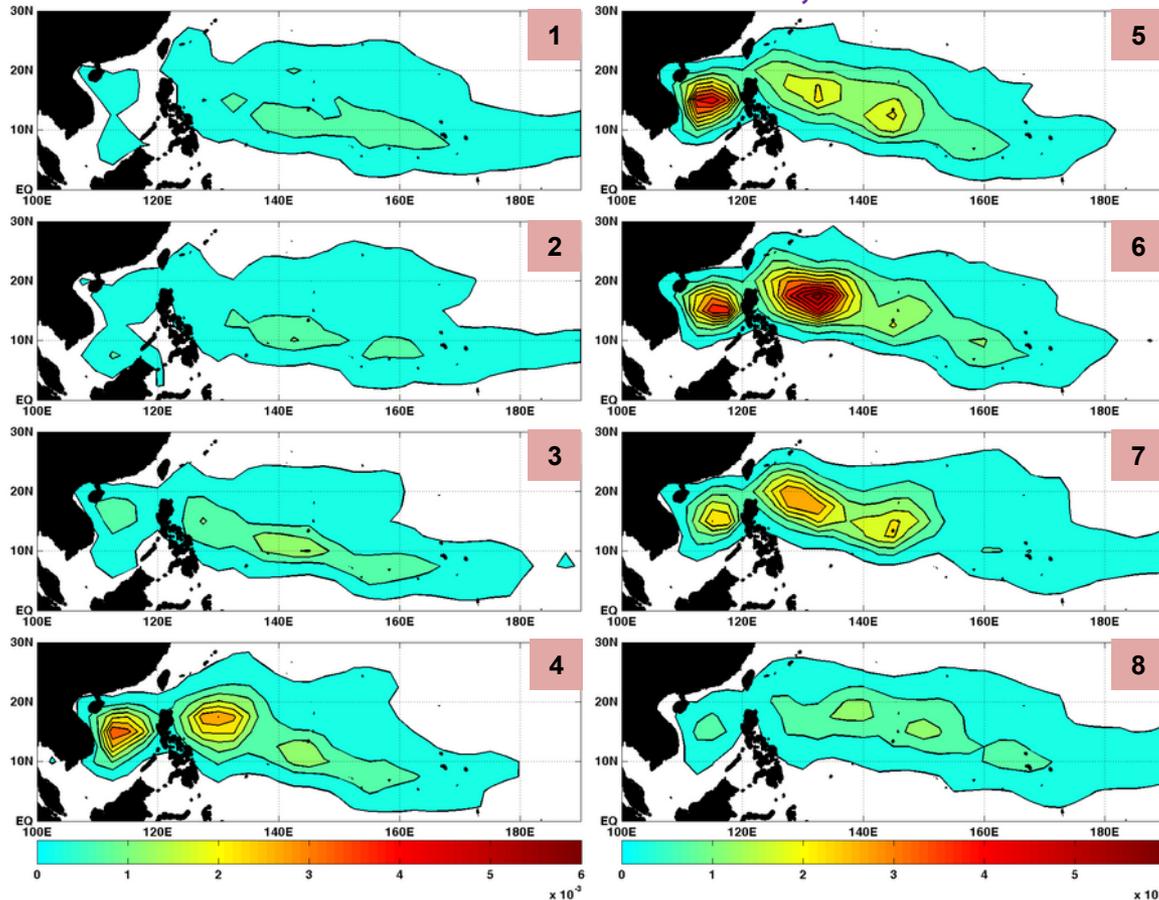


1. Statistical model based probabilities using EN and LN LSEFs.
2. EN probabilities higher in central – southeastern WNP.
3. LN probabilities higher in northwestern, northern, and southwestern WNP.
4. Probabilities correspond well to observed formations.

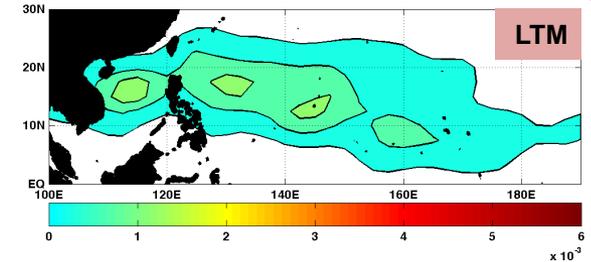


# Qualitative Statistical Model Verification: JASO MJO TC Formation Probability and Actual Formations

## MJO TC Formation Probabilities, Phases 1-8



## LTM TC Formation Probability

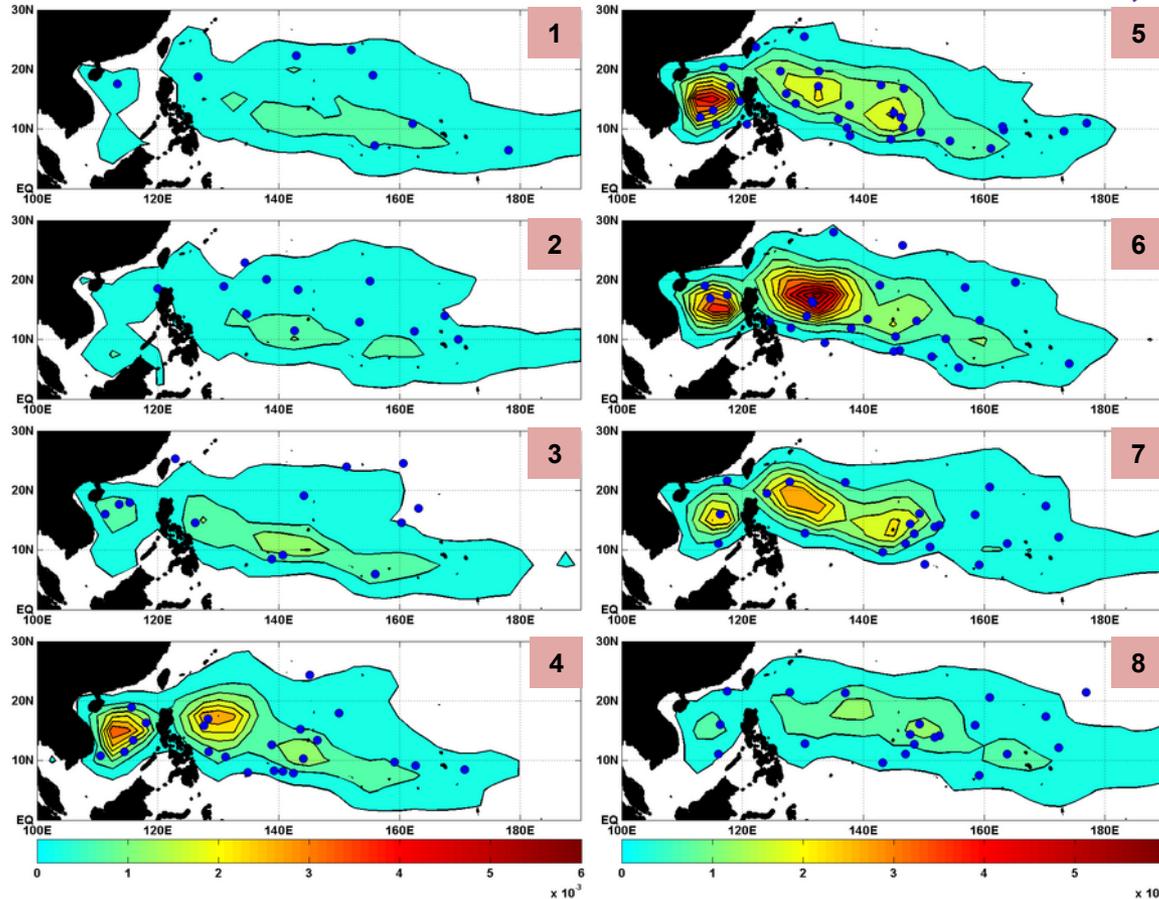


1. Statistical model based probabilities using LSEFs for phases 1-8.
2. Large variations in probability patterns and magnitudes by phase.

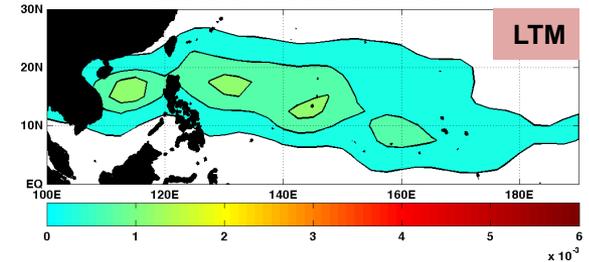


# Qualitative Statistical Model Verification: JASO ENLN TC Formation Probability and Actual Formations

## MJO TC Formation Probabilities and Actual Formations , Phases 1-8



## LTM TC Formation Probability and Formations

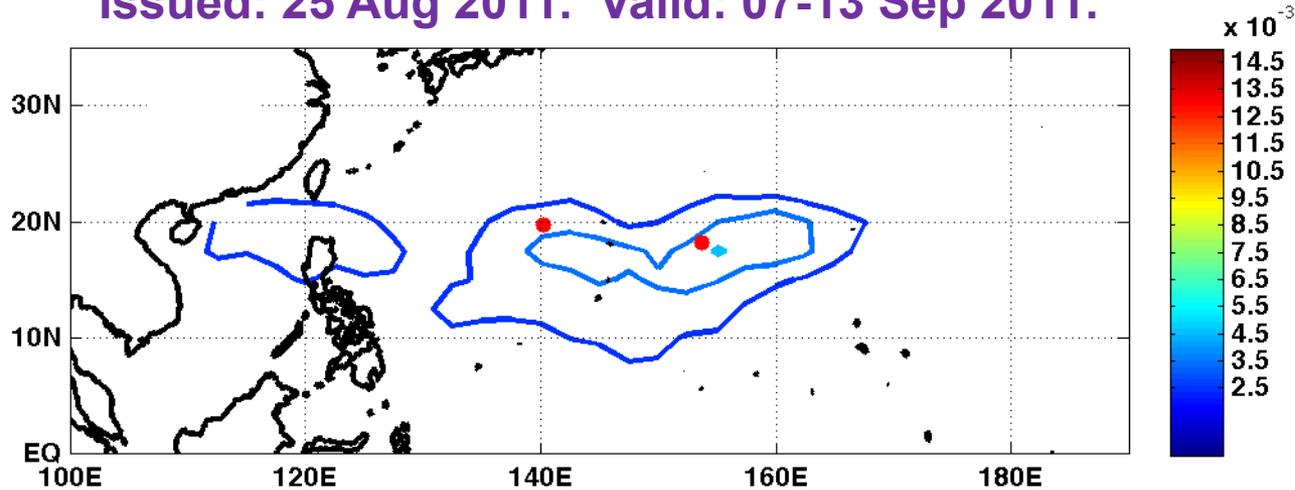


• Good agreement between statistically modeled probabilities and actual formations for phases 1-8.



# Sample NPS TC Formation Forecast System Output: Probability of TC Formation at Intraseasonal Leads

TC Formation Daily Probability Forecast  
Issued: 25 Aug 2011. Valid: 07-13 Sep 2011.

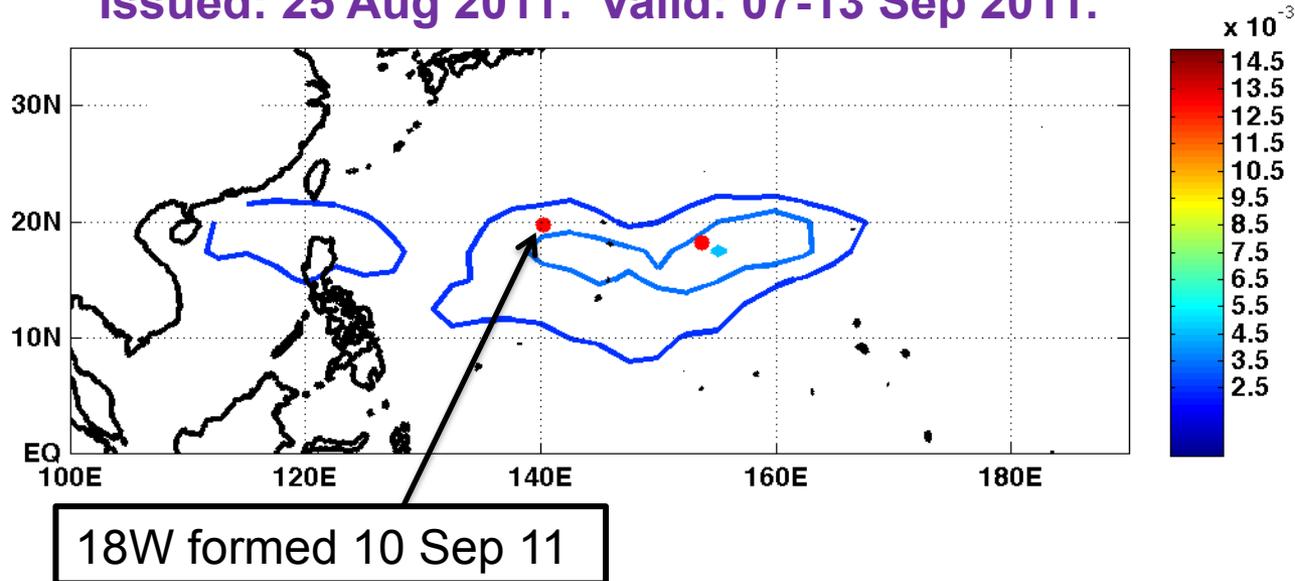


1. Weekly forecasts: average of 7 consecutive daily 21 day lead forecasts.
2. Forecast shown is an example of NPS inputs to CPC GTHB technical teleconference (but with subsequent addition of verifying formations in red).
3. Preliminary verification: from first position in JTWC TCFAs.
4. Updated verification: from JTWC best track data (released in following Mar-Apr).



# Sample NPS TC Formation Forecast System Output: Probability of TC Formation at Intraseasonal Leads

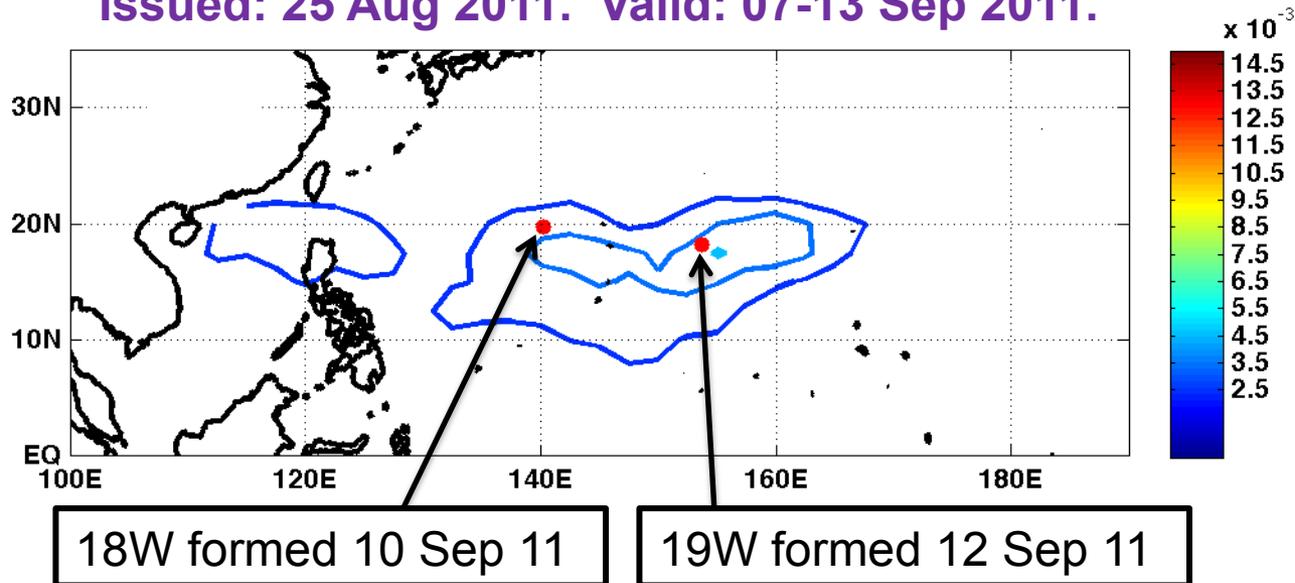
TC Formation Daily Probability Forecast  
Issued: 25 Aug 2011. Valid: 07-13 Sep 2011.





# Sample NPS TC Formation Forecast System Output: Probability of TC Formation at Intraseasonal Leads

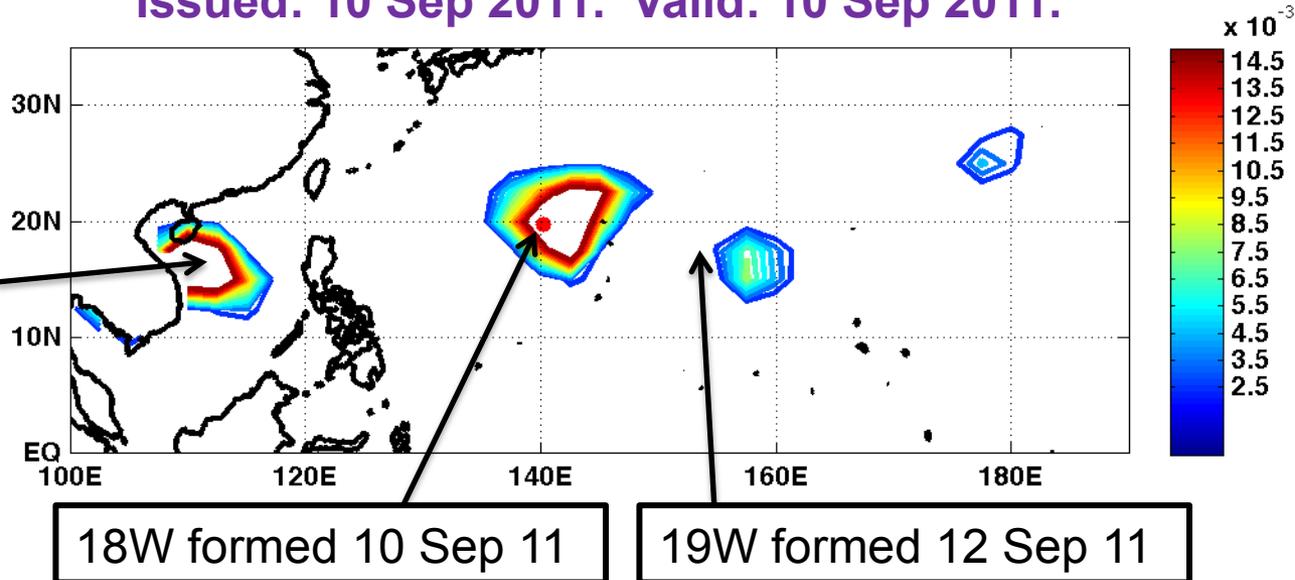
TC Formation Daily Probability Forecast  
Issued: 25 Aug 2011. Valid: 07-13 Sep 2011.





# Sample NPS TC Formation Forecast System Output: Probability of TC Formation at Zero Lead

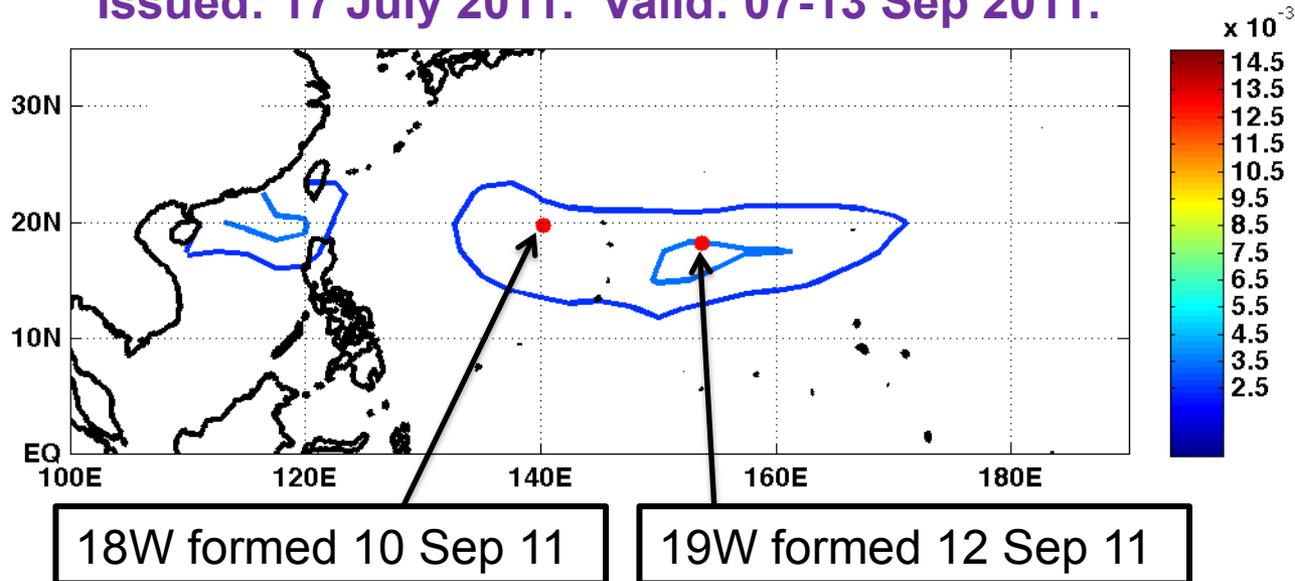
TC Formation Daily Probability Forecast  
Issued: 10 Sep 2011. Valid: 10 Sep 2011.





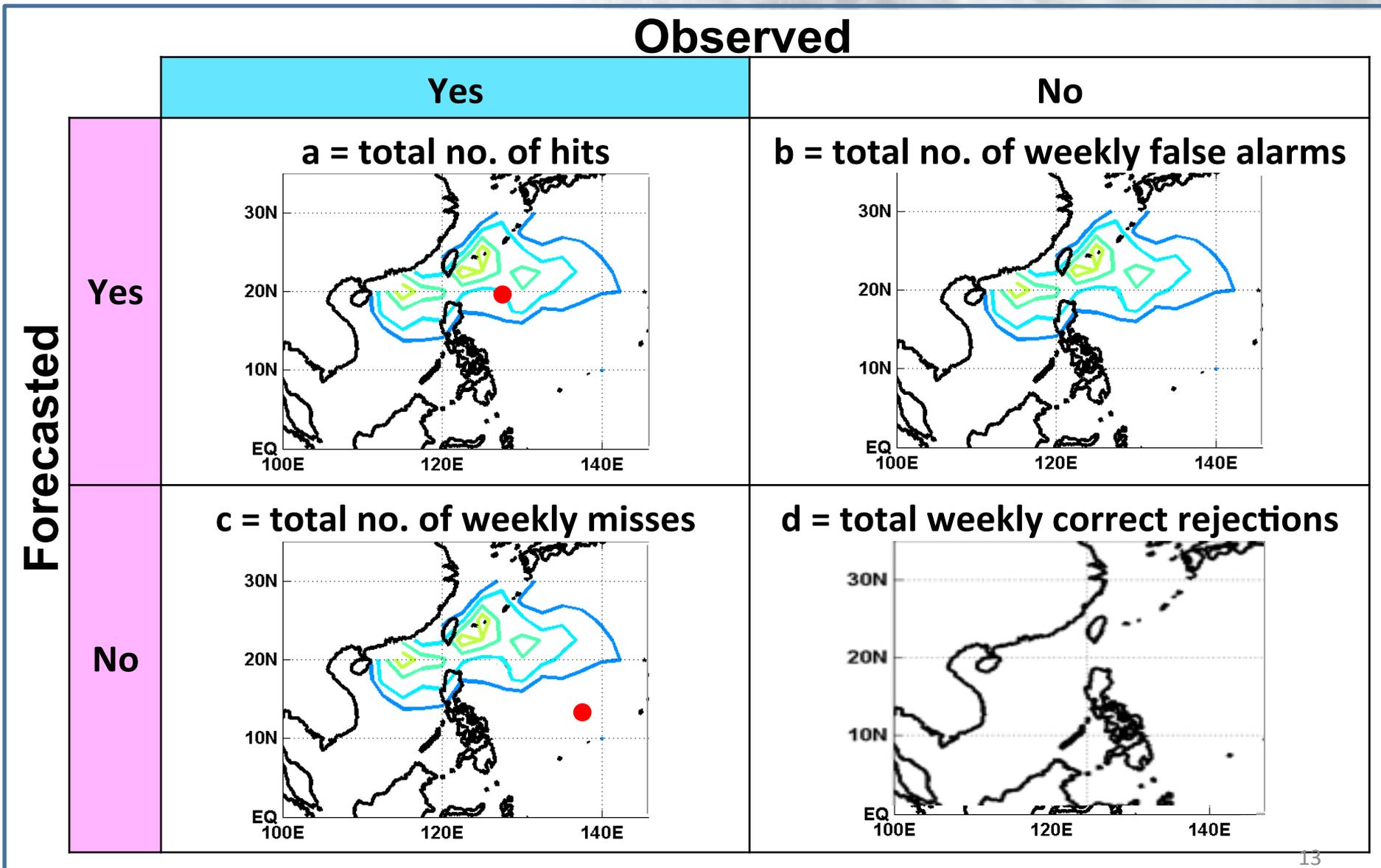
# Sample NPS TC Formation Forecast System Output: Probability of TC Formation at Two Month Leads

TC Formation Daily Probability Forecast  
Issued: 17 July 2011. Valid: 07-13 Sep 2011.



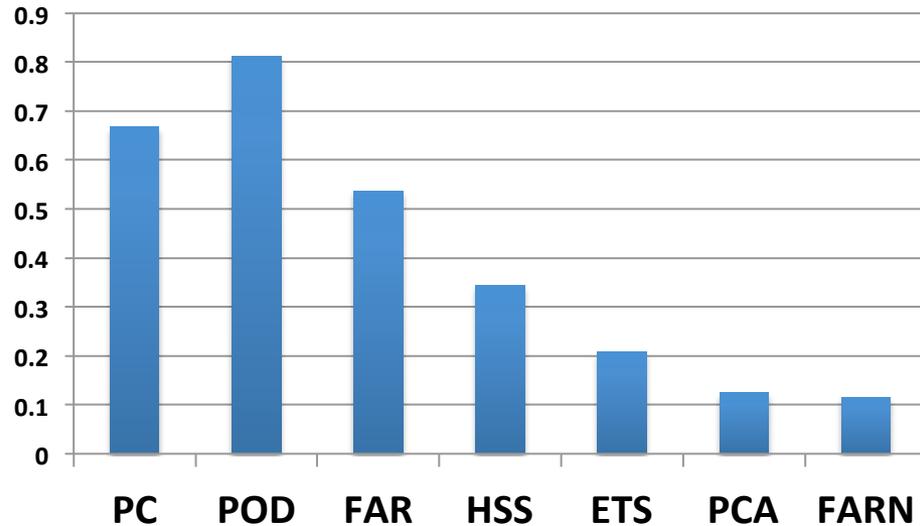


# Forecast Verification Methods: Graphic Contingency Table





# Quantitative Forecasting System Skill Assessment, Week One and Week Two Outlooks, Jun-Nov 2010



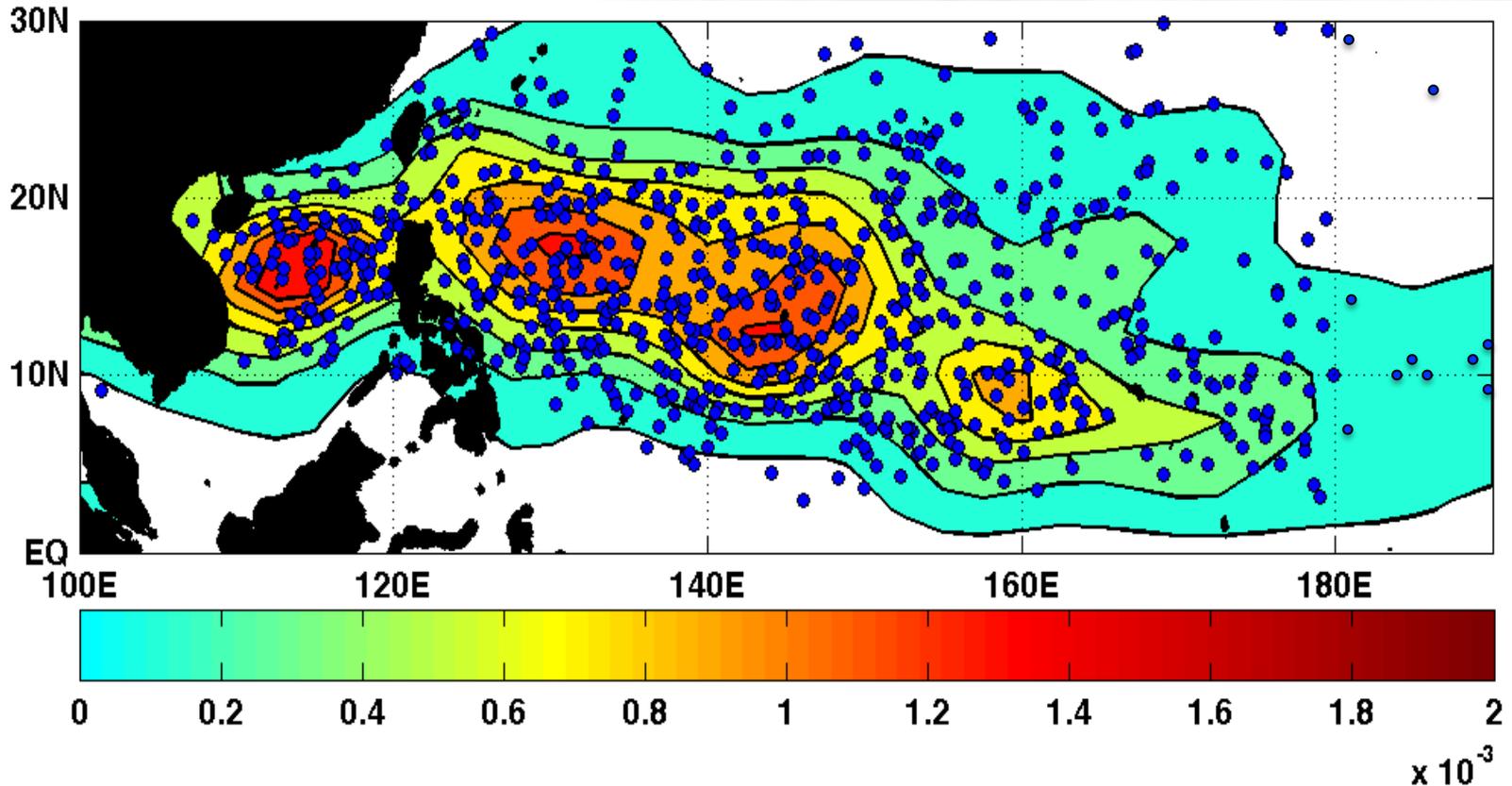
1. One and two week outlooks: same as weekly forecasts we now provide to CPC.
2. Verification done on weekly basis.
3. Neighborhood radius of  $2.5^\circ$  used on observations.

PC: Proportion Correct. POD: Probability of Detection.  
FAR: False Alarm Ratio. HSS: Heidke skill score.  
ETS: Equitable Threat Score. PCA: proportion of WNP  
within forecast contours. FARN: False Alarm Ratio for  
forecasted non-formation

1. Good overall performance but FAR is higher than we would like.
2. Additional indicator of good skill: positive Brier skill scores for all leads.
3. Stable performance: similar performance in 2009 and 2011 (preliminary).
4. Similar skill at longer leads (21-90 days), but at a cost of reduced resolution and sharpness.



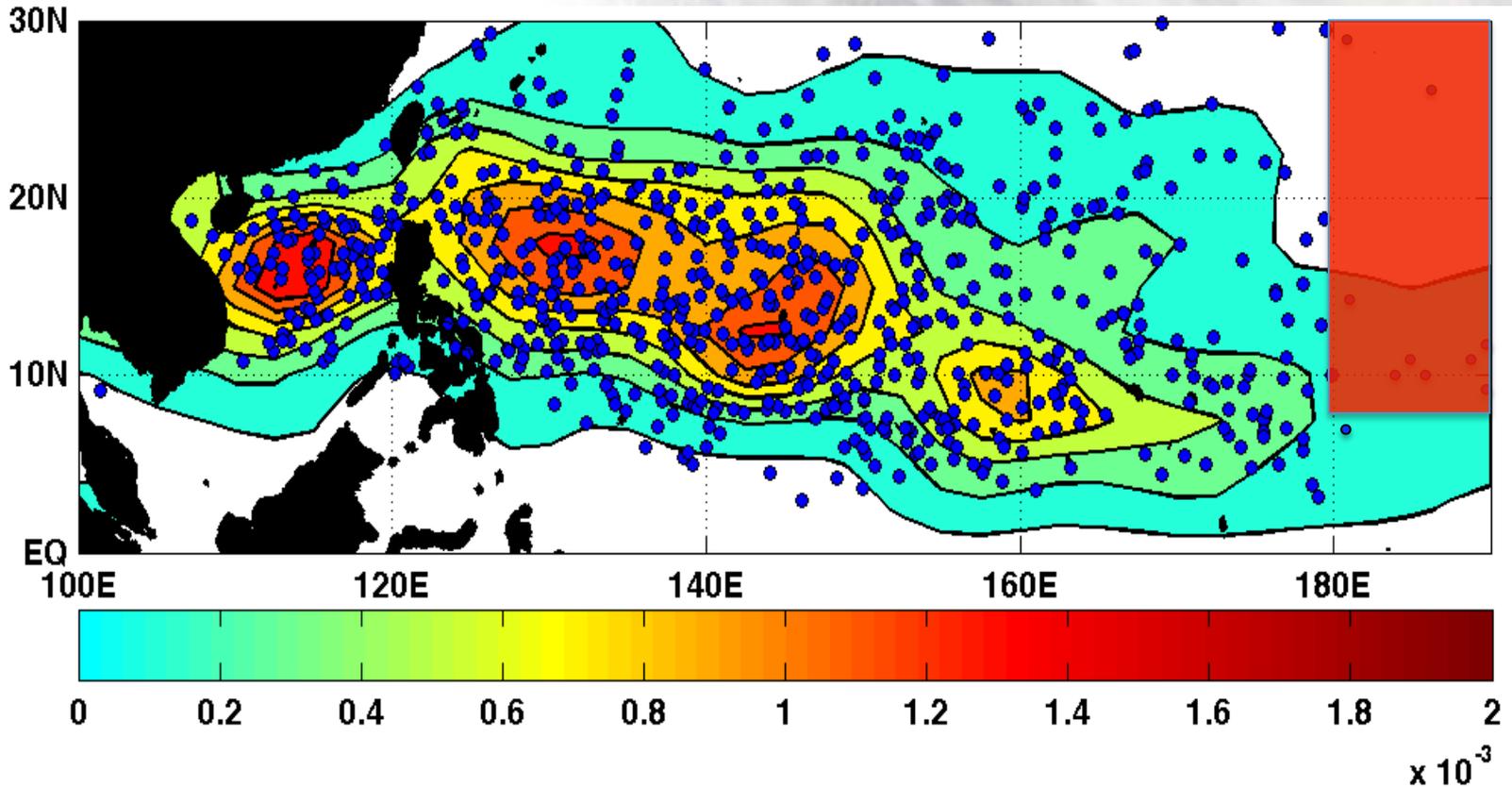
# Quantitative Forecasting System Skill Assessment: Total Forecasted Area



1. Total marine area of the WNP is ~25 million square kilometers.
2. Almost all of this marine area is capable of TC formation during JASO.



# Quantitative Forecasting System Skill Assessment: Total Forecasted Area



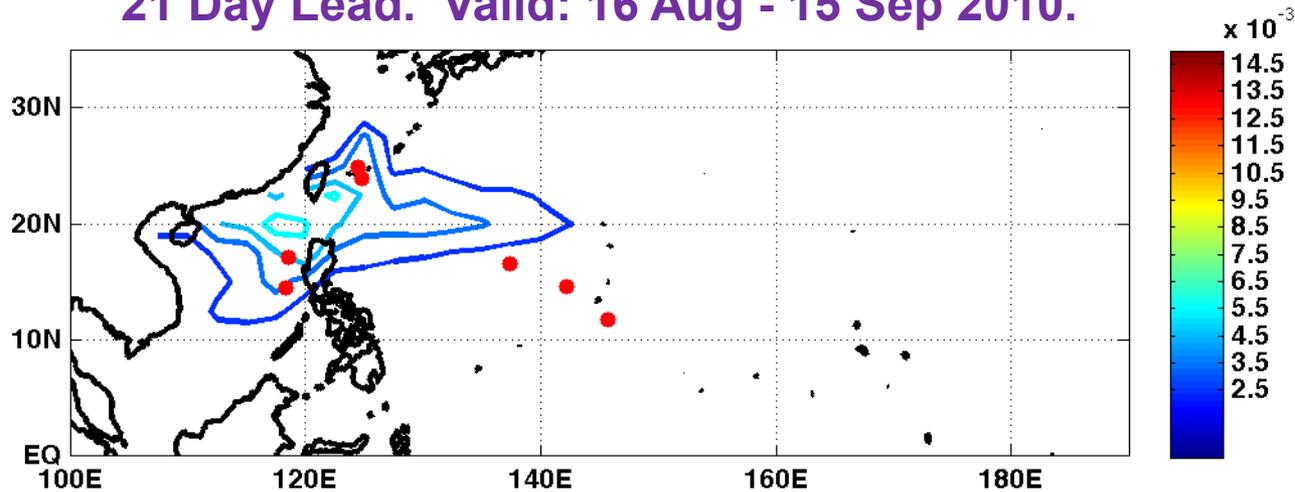
**Red box represents:**

- Total forecasted area in an average daily probability forecast
- 10% of the WNP marine area



# Qualitative Forecasting System Skill Assessment: Intraseasonal Forecasts - Peak Season 2010 vs. 2011

Monthly Average of Daily Probability Forecasts  
21 Day Lead. Valid: 16 Aug - 15 Sep 2010.

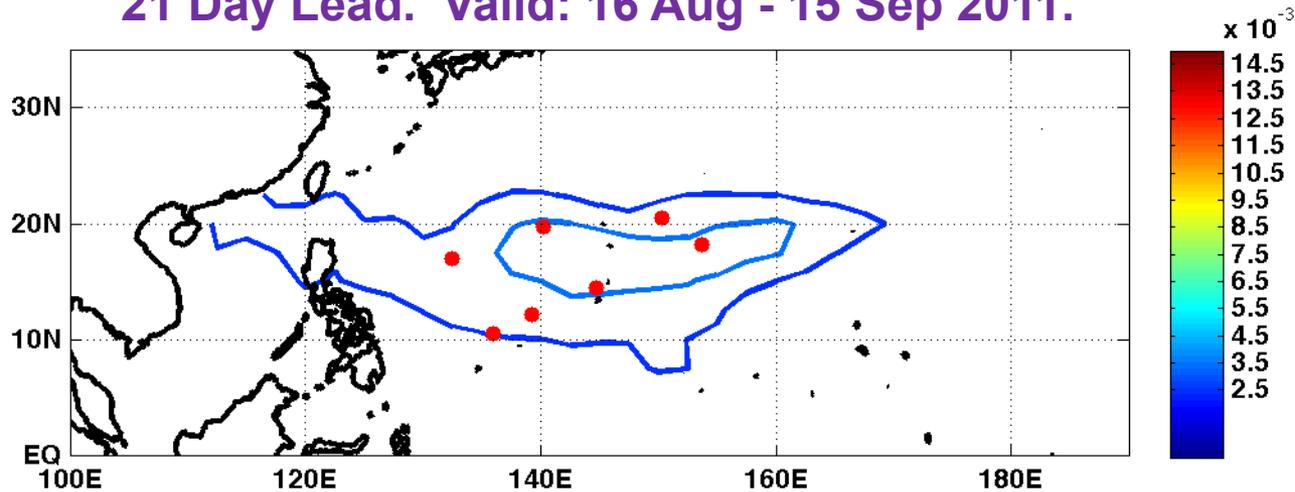


1. Highest formation probabilities and most TCs occurred west of 125E.
2. This probability pattern typical for much of 2010.
3. Formations typical for La Niña periods.
4. 5 of 7 TCs successfully forecasted (2.5° neighborhood).
5. Monthly average probability locations and magnitudes similar to those in corresponding weekly forecasts.



# Qualitative Forecasting System Skill Assessment: Intraseasonal Forecasts - Peak Season 2010 vs. 2011

Monthly Average of Daily Probability Forecasts  
21 Day Lead. Valid: 16 Aug - 15 Sep 2011.



1. Highest formation probabilities and all TCs occurred east of 130E.
2. This probability pattern typical for much of 2011.
3. Northern formations may be indication of La Nina impacts.
4. 7 of 7 TCs successfully forecasted ( $2.5^\circ$  neighborhood).
5. Monthly average probability locations and magnitudes similar to those in corresponding weekly forecasts.



# NPS TC Forecasting System: Summary and Plans

- 1. Skill assessment:**
  - a. Skill evaluated over three years of forecasts, 2009-2011, with:**
    - 1. EN, LN, neutral, and MJO conditions**
    - 2. A total of 69 TCs**
  - b. Quantitative: System has skill over chance and/or climatology at all leads (out to 90 days) and at daily and weekly resolution**
  - c. Qualitative: System represents EN, LN, and MJO formation probability patterns**
- 2. Statistical model being rebuilt based on CFSR and additional years**
- 3. Reforecast 2011 and forecast 2012 with rebuilt statistical model and CFSv2 as dynamical component.**
- 4. Expand forecast regions to N Atlantic and other basins (promising results from preliminary work).**



# **NPS TC Forecasting System: Summary and Plans**

- 5. Begin issuing experimental forecasts from corresponding TC intensity forecasting system. Preliminary WNP results are very promising.**
- 6. Begin work on corresponding TC track forecasting system.**
- 7. Generate new statistical model for off season forecasting**
- 8. Continue coordination / collaboration with: CPC, FNMOC, JTWC, NHC**
- 9. Continuing and expanding discussions with potential forecast customers.**



# Long Lead Forecasting of Tropical Cyclones: Contact Information

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