Statistical-Dynamical Long Lead Prediction of Tropical Cyclogenesis in the Western North Pacific

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Prediction of Tropical Cyclogenesis in the Western North Pacific

Build statistical model based on relationships between TC formations and LSEFs

Use dynamical, ensemble-based, long range forecasts of LSEFs to force statistical model

Statistical model of TC formation probability

Statistical-dynamical model output: long range forecasts of TC formation probabilities

Inputs, outputs, are all on a daily, 2.5° scale
Prediction of Tropical Cyclogenesis in the Western North Pacific: Statistical Model

Modeling Process

1. We statistically related the LSEFs to the probability of TC formation (logistic regression)
   a. Model built using daily, 2.5° horizontal resolution data
   b. Data: NCEP reanalysis data, NOAA OISST, JTWC Best Tracks
   c. Model validated with 25 years of independent zero-lead hindcasting based on LSEFs from NCEP Reanalysis 2 and verified against JTWC best track data. Results:
      1. Positive Brier skill score
      2. Reliable; good resolution
      3. 89% hit rate (formations occurred in predicted region)
      4. Physically plausible

2. Modeling results indicate that if skillful forecasts of LSEFs are available, skillful forecasting of TC formation is possible.
Long Range Forecasts (LRFs) of LSEFs

Dynamical Inputs to Model

NCEP Climate Forecast System (CFS) chosen as source of long lead forecasts of the LSEF:

1. CFS has desired resolution.

2. CFS output relatively accessible.

3. CFS has data for the needed LSEFs, or variables from which we could derive the needed LSEFs:
   a. SST
   b. Vertical wind shear (u and v, 200 hPa minus 850 hPa)
   c. Relative vorticity (850 hPa, derived from u and v)
   d. Divergence (200 hPa, proxy for $\omega$, derived from u and v)

4. Use CFS forecasts of the LSEFs to forecast TC formation for the 2009 WNP TC season to evaluate statistical-dynamical forecasting system performance.
Experimental Long Range Forecasting of Tropical Cyclogenesis: Sample Results

8 day lead forecast, valid: 27Sep09, issued: 19Sep09

19W located here at 1200Z, 27Sep09. (Actually formed on 26 Sep)

20W formed here at 1800Z, 27Sep09.

- Contours indicate where TC formation is likely.
- Warmer colors: higher formation probability regions associated with warm SST, low shear, positive upper level divergence, positive low level vorticity.
- Minimum contour is set at 0.003, which exceeds the long term mean probability of formation.
Experimental Long Range Forecasting of Tropical Cyclogenesis: Summary of Results

Early Results Show Promise

1. Probability contours are subjectively correct.
2. Some TCs are predicted at leads of ~ two weeks, possibly longer.
3. Positive resolution and promising reliability.
4. Very good and expected agreement between formation probability contours and low OLR.
5. Useful input for decision makers
   a. High enough resolution (storm avoidance)
   b. Identifies where TC formation is unlikely
   c. Low OLR regions are typically places to avoid if given the choice
14-Day Lead: Valid 02Aug09, Issued 19Jul09

7-Day Lead: Valid 02Aug09, Issued 26Jul09

Approximate formation location for 9W (Morakot) on 02 Aug 09
Note the reasonable skill in forecasting TC formation, and the indications of day to day variability in CFS forecasts.
13 day lead forecast, valid: 08/07/2009, issued: 07/25/2009

10W formed here around 0600Z 7Aug (21N, 142E)
12 day lead forecast, valid: 08/07/2009, issued: 07/26/2009

10W formed here around 0600Z 7Aug (21N, 142 E)
11 day lead forecast, valid: 08/07/2009, issued: 07/27/2009

10W formed here around 0600Z 7Aug (21N, 142E)
10W formed here around 0600Z 7Aug (21N, 142 E)
10W formed here around 0600Z 7Aug (21N, 142 E)
10W formed here around 0600Z 7Aug (21N, 142 E)
10W formed here around 0600Z 7Aug (21N, 142 E)
6 day lead forecast, valid: 08/07/2009, issued: 08/01/2009

10W formed here around 0600Z 7Aug (21N, 142E)
10W formed here around 0600Z 7Aug (21N, 142E)
Experimental Long Range Forecasting of Tropical Cyclogenesis: Sample Results

4 day lead forecast, valid: 08/07/2009, issued: 08/03/2009

10W formed here around 0600Z 7Aug (21N, 142 E)

Favorable LSEF conditions associated with pre-existing 9W
10W formed here around 0600Z 7Aug (21N, 142 E)

Favorable LSEF conditions associated with pre-existing 9W
2 day lead forecast, valid: 08/07/2009, issued: 08/05/2009

10W formed here around 0600Z 7Aug (21N, 142 E)

Favorable LSEF conditions associated with pre-existing 9W
Experimental Long Range Forecasting of Tropical Cyclogenesis: Sample Results

TC Formation Probability for 07 Aug 2009. Contours circled for comparison to observed OLR.

2 day lead forecast, valid: 08/07/2009, issued: 08/05/2009

10W formed here approximately 0600Z, 07Aug09 (21N, 142 E).
10W formed here approximately 0600Z 07Aug09 (21N, 142 E).

Observed OLR for 07 Aug 2009. Good correspondence between high formation probabilities and low OLR.
1. The statistical model performs well, but post-season comparisons of LSEFs from CFS and NCEP reanalysis may help identify potential model improvements.

2. CFS has consistency issues, as well as spatial and temporal skill issues, even at short (2 day) leads.
   a. This is the largest source of error, even at short (2 day) leads.
   b. Investigate use of high resolution CFS or ECMWF inputs.
   c. Combine LSEF forecasts at multiple leads.

3. Forecasts show subjective skill at lead times of 2+ weeks.
   a. Probability contours frequently correspond well to NRL invests.
   b. Probability contours have strong correspondence with low OLR.
Experimental Long Range Forecasting of Tropical Cyclogenesis: Preliminary Assessment

4. System reliability needs to be improved (currently over-forecasts)
   a. Use LSEF thresholds
   b. Revisit formations and individual LSEF values at formation
   c. Determine optimal minimum contour to maximize hits / minimize false alarms
   d. Numerous false alarms (though some are established storms or storms that are slow in the making)
   e. Favorable LSEFs are necessary but not sufficient for formation

5. Potential to “take the human out of the loop” for TC formation forecasts based on dynamical model output.

6. Unplanned apparent track prediction capability.

7. CFS shows promise at multi-week leads, but experimentation is required to tap into this potential.
Experimental Long Range Forecasting of Tropical Cyclogenesis: Contact Information

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Questions?