ICCARUS 2020
Deutscher Wetterdienst
Frankfurter Straße 135, 63067 Offenbach

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Ensemble based tracking of cyclones

by Michael Denhard, Tel.:+49 69 8062 2683, michael.denhard@dwd.de

An automatic cyclone tracking algorithm has been developed in PYTHON to generate tracking products and track based verification. It also monitors the related wind and precipitation fields. Tracks are computed for hourly to 3-hourly forecasts up to +180h lead time on the global native ICON grid at 13km horizontal resolution for the deterministic system and 40km for the ensemble (ICON-EPS). The MSLP minima of a track are identified using masks of MSLP and 10m wind speeds generated from the global ICON-EPS.

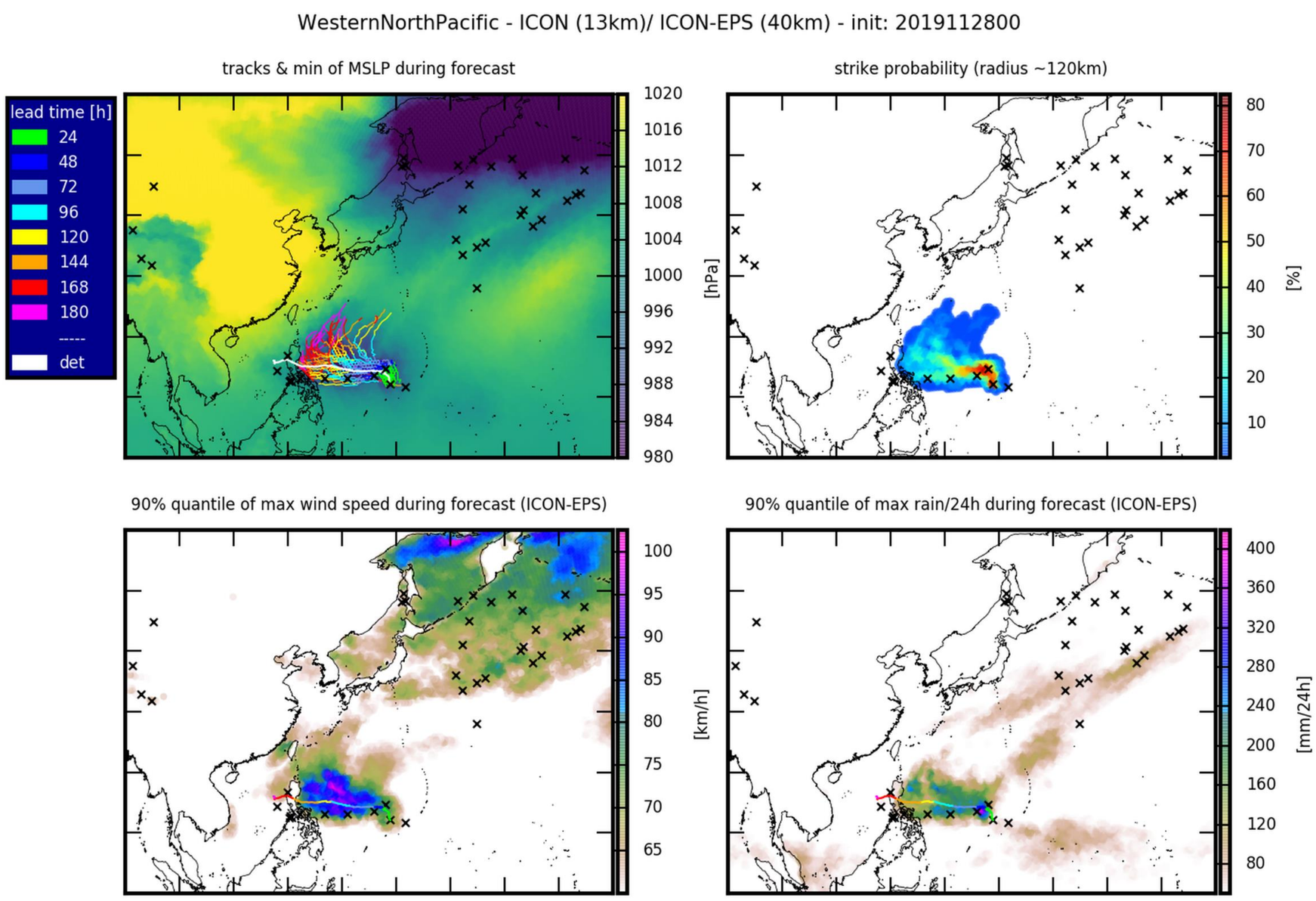

Figure 1: Cyclone Tracks of Taifun Kammuri. The forecast was initialized on 28 November 2019 at 00UTC. The upper left panel shows the cyclone tracks of ICON-EPS, where the colors indicate the lead time, and the deterministic run (white color). The background field in the upper left panel gives the minima of the 10% MSLP quantiles, which occur during the forecast at each grid point. In the same way the lower panels show the wind speed (left) and precipitation (right) masks. The upper right panel shows the strike probability, using an influence radius for each track of about 100km on the ICON native grid. The black crosses determine the MSLP minima of the analysis fields which are filtered by setting thresholds on the MSLP and wind speed masks. The precipitation mask is used for sorting out the relevant tracks of tropical cyclones.

Ensemble based tracking

We use forecasts from the global ICON-EPS to identify the MSLP Minima which belong to a cyclone track. In a first step the 10%/90% quantiles of MSLP, wind and precipitation are computed for every lead time at each grid point. In the second step we determine min/max values of these quantiles at each grid point sampling the lead times. The result is a single field mask (see Figure 1 on the left) which flags the areas of possible cyclone tracks by setting thresholds for MSLP and wind. The advantage of such an ensemble based filter is that cyclones which fall below the detection threshold in a single forecast might still be tracked, because some other members keep the filter mask above the detection threshold.

Outlook

Up to now only tropical cyclones are tracked. The next steps will be:

- Setting up a verification system at DWD
- Contribution to the TIGGE cyclone database at NCAR
- Extension of the algorithm to extratropical cyclone features.

The latter will be done within the framework of the BMVI „Network of Experts“.

Verification strategy

Two different approaches:

a) Track errors by comparing track position, forecasted winds an precipitation to the corresponding values from the analysed tracks.

b) Select time dependent areas of increased cyclone activity in standard analysis verification (3d). These areas will be determined using thresholds for
MSLP (<1000hPa)
Wind (>17m/s)
(tropics and extra tropics)

Comparison of different tracking algorithms *based on IMILAST, BAMS 2013, SUPPLEMENT A*

	Intensity	Identification	Tracking	Elimination	Remarks
Pinto/Ulbrich/ Leckebusch (2005)	Core P, P gradients, local Laplacian of P, radius, depth	Min SLP, Laplacian of SLP (related to relative vorticity); determines SLP min (closed lows) as well as inflection points (open systems)	Estimate new position based on change of last 6h. Search radius is 12. 5°	- Laplacian of pressure <0.1 hPa (°lat)$^{-2}$; - terrain height >1500 m - threshold 98th perc of ERAINTERIM 10m wind	Tracks which consists entirely of open systems are removed.
Hewson and Titley (2010)	SLP at feature point; vorticity at feature point at 1-km altitude; max wind at 1-km altitude within ~300-km radius of feature point	barotropic lows (A), frontal waves (B), diminutive waves (C). For A uses SLP equivalent and Laplacian mask. Feature identification is based, using contour intersections.	- Half-time tracking: forward movement based on previous movement and steering wind, backward movement based on steering wind. - 1000–500hPa thickness change	Identification incorporates various thresholds.	12-h time step
Vitard et al. (1997), Grijn et al. (2005)	MSLP, relative vorticity, warm core	- Min SLP - Max in 850hPa relative vorticity, - 850-200hPa thickness, - Max of average temperature between 500 and 200 mb - Maximum in thickness, only if TC is extratropical - Warm core must be detected only once,	Weighted average of past movement and mid-troposphere steering wind (= weighted average of 850, 700, 500 and 200 hPa wind)	- MSLP>1015hPa - Max wind<17m/s - 10 m wind speed<8 ms^{-1} (only required over land) - Vorticity<|5x10^{-5}s^{-1}| - Terrain height>1000 m	- dissapear for 24h - TC must not be present in the initial conditions, - Min lifetime 12h
Wernli and Schwierz (2006)	Core P; difference between core P and P of outermost closed contour; min core P along cyclone track	Min SLP; min is only considered, if it is surrounded by at least one closed SLP contour whose value is 0.5 hPa higher than the SLP min	- Prev displacement * 0.75 (typical slow down of cyclone propagation) - candidate closest to first guess within rectangle stretched along propagation direction	No closed contour around P Min	dissapear for 12h
DWD under construction	- MSLP - Wind speed - Precipitation	Ensemble Mask Fields: max wind speeds max rain min MSLP during forecast	successive nearest neighbour search – 200, 400, 600 km – 980, 990, 1000 hPa	- MSLP > 1015hPa - Max wind < 17m/s - Track must exist at least 24h	1h / 3h time steps Max along track: Wind > 20 m/s Rain > 200 mm/24h

Tracking algorithm

hourly up to + 72h
every 3 hours up to +180h

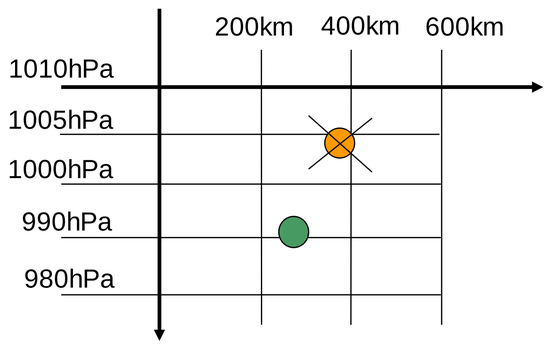

Figure 2: Ilustration of the tracking algorithm. If more than one MSLP minimum is located in the search radius the minimum with the lowest MSLP is selected

Supported by

BMVI Expertennetzwerk
Wissen Können Handeln