

Objectives

- Have a better understanding of the Tropical Cyclone Products generated at ECMWF
- Learn the recent developments in the forecast system and its impact on the Tropical Cyclone forecast
- Learn about the skill of TC forecasts in recent years

Tropical Cyclone Products

➤ Strike probability and plumes for existing TCs

- 10-day

<http://www.ecmwf.int/en/forecasts/charts/tcyclone/> (also in ecCharts)

➤ Tropical cyclone activity (including genesis)

- 12-day

<https://www.ecmwf.int/en/forecasts/charts/catalogue/medium-tc-genesis?facets=Range,Medium%20%2815%20days%29>

(also in ecCharts)

- 28-day extension

➤ Tropical Cyclone Tracks in BUFR (since 10 November 2015)

Products for existing Tropical Cyclones

https://www.ecmwf.int/en/forecasts/charts/tcyclone/

Most Visited Advancing global NW... Getting Started Suggested Sites Web Slice Gallery

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ECMWF tropical cyclones

Overview map

Latest cyclones

CEBILE (05S) - Region 06
FEHI (08P) - Region 12

Filters

Year
2018

WMO region
All

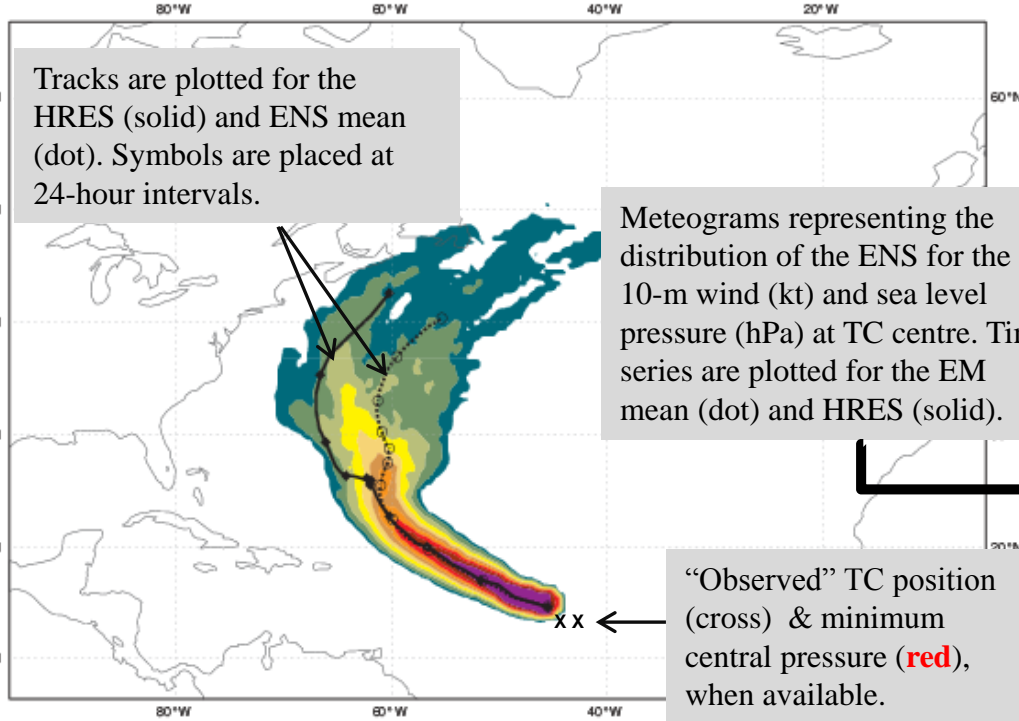
Cyclone products

- Tropical cyclone plumes
- Tropical cyclone strike probability
- Tropical cyclone track
- Tropical cyclone verification

This map shows, as coloured spots, all the latest active tropical cyclones as reported by WMO Regional Specialized

TC Products – Part I

Date 20120831 00 UTC @ECMWF
 Probability that **LESLIE** will pass within 120 km radius during the next 240 hours
 tracks: **solid**=OPER; **dot**=Ens Mean [reported minimum central pressure (hPa) 1002]



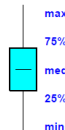
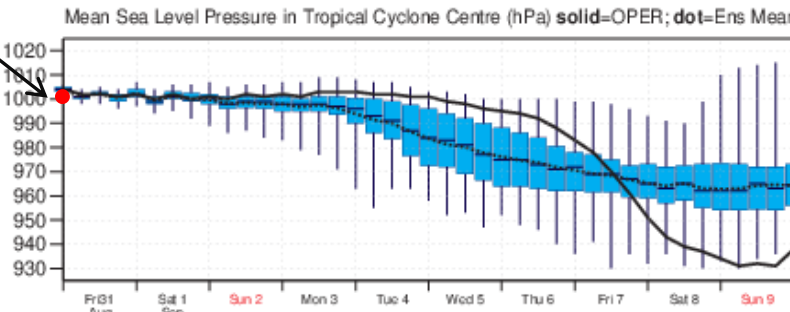
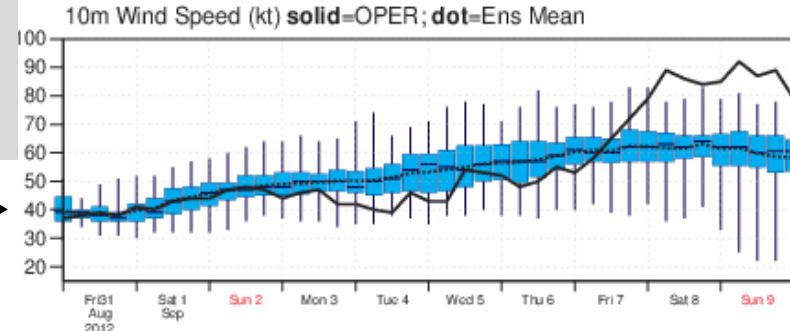
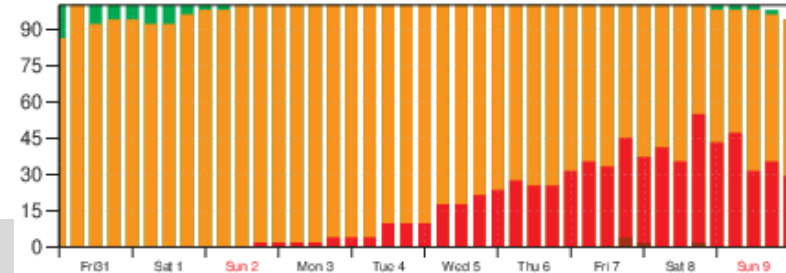
List of ensemble members numbers forecast Tropical Cyclone Intensity category in colours: **TD**[up to 33] **TS**[34-63] **HR1**[64-82] **HR2**[83-95] **HR3**[>95 kt]

+024 h:	hr ct 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50
+048 h:	hr ct 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50
+072 h:	hr ct 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50
+096 h:	hr ct 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50
+120 h:	hr ct 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50
+144 h:	hr ct 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50
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+192 h:	hr ct 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50
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+240 h:	hr ct 01 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 40 41 42 43 44 45 46 47 48 49 50

Snapshot of ENS members (numbers) tracking the storm together with intensity (colours), at 24-hours intervals. HRES and Control models are labelled ‘hr’ and ‘ct’ respectively.

Intensity probability is the fraction of the number of ENS members (relative to the total number of ENS members which held the feature) falling into each of the 5 intensity categories, at 6-hours interval up to 10 days.

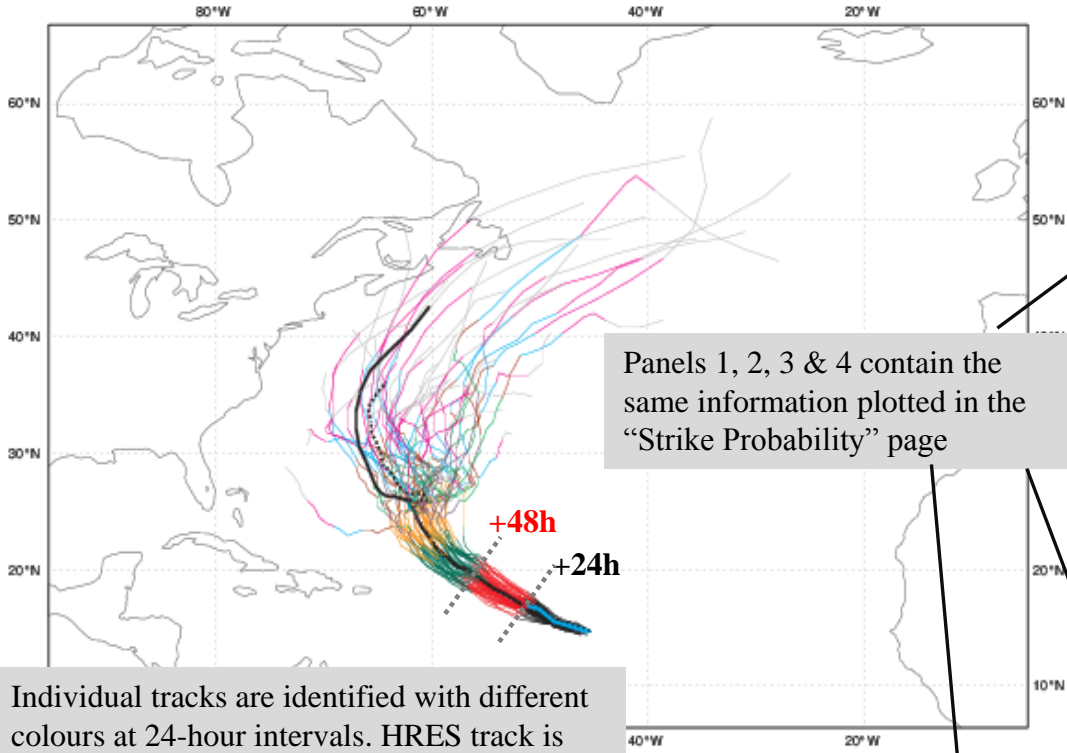
Probability (%) of Tropical Cyclone Intensity falling in each category
TD[up to 33] **TS**[34-63] **HR1**[64-82] **HR2**[83-95] **HR3**[> 95 kt]



box-and-whiskers plot representing the 5 quantiles of the ENS distribution

TC Products – Part II

Date 20120831 00 UTC @ECMWF
 Individual trajectories for **LESLIE** during the next 240 hours
 tracks: **thick solid**=OPER; **thick dot**=CTRL; **thin solid**=EPS members [coloured]
0-24h 24-48h 48-72h 72-96h 96-120h 120-144h 144-168h 168-192h 192-216h 216-240h



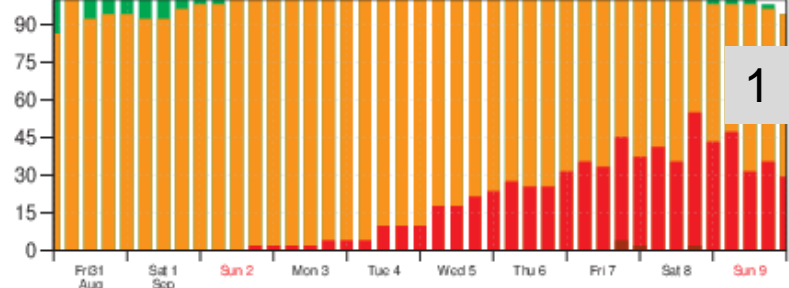
Panels 1, 2, 3 & 4 contain the same information plotted in the "Strike Probability" page

Individual tracks are identified with different colours at 24-hour intervals. HRES track is plotted with thick black line, except in the first 24-hours forecast (cyan).

Time	ct	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	
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+072 h	hr	ct	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
+096 h	hr	ct	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
+120 h	hr	ct	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
+144 h	hr	ct	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
+168 h	hr	ct	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
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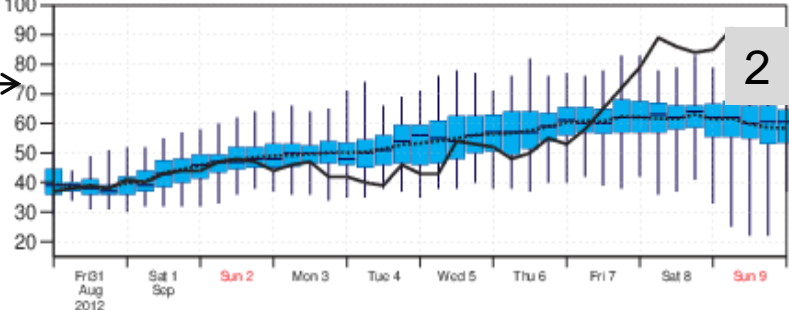
4

Probability (%) of Tropical Cyclone Intensity falling in each category
TD[up to 33] **TS** [34-63] **HR1**[64-82] **HR2** [83-95] **HR3** [> 95 kt]



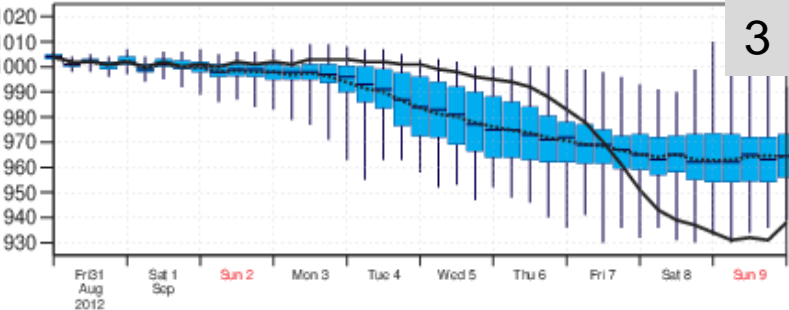
1

10m Wind Speed (kt) **solid**=OPER; **dot**=Ens Mean



2

Mean Sea Level Pressure in Tropical Cyclone Centre (hPa) **solid**=OPER; **dot**=Ens Mean



3

Tropical Cyclone Activity in the Medium Range ENS

Tropical cyclone activity (including genesis)

Maps: global view and 7 additional TC basins

Forecasts homepage

View published | New draft | Revisions | Access control

Charts

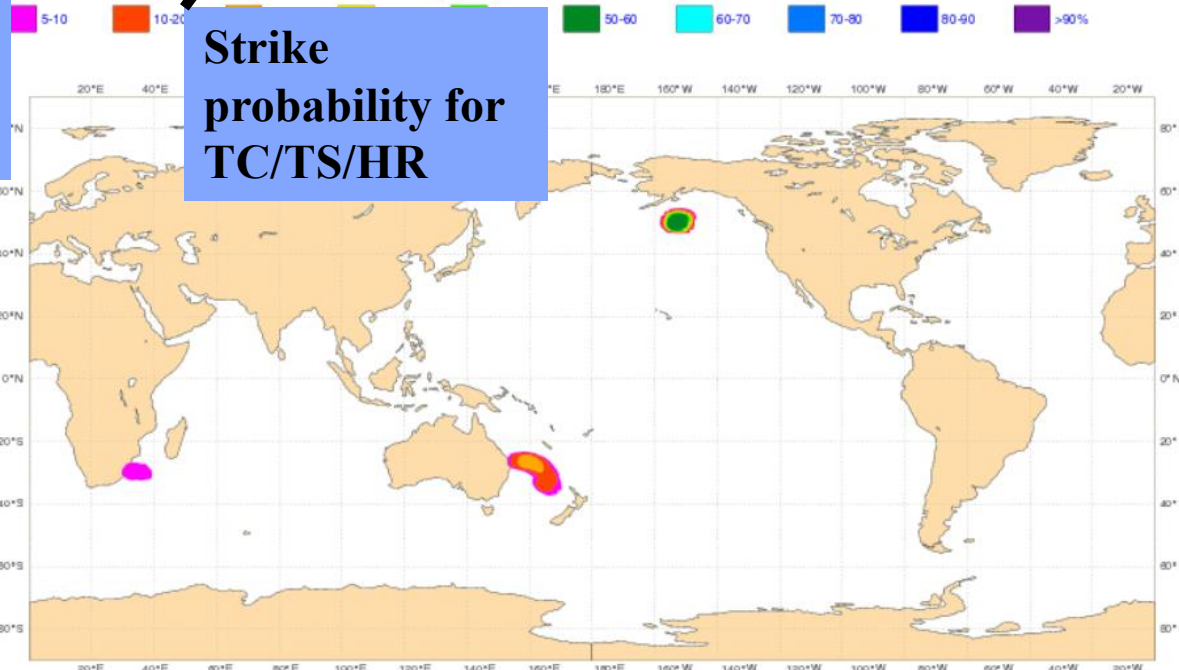
Base time | Intensity | Area

Datasets

Quality of our forecasts

Forecast runs covering the last 10 days

Tropical Storm Strike Probability Start date: Tuesday 02 February 2016 0000 UTC
valid for 48 hours from Wednesday 03 February 2016 0000 UTC to Friday 05 February 2016 0000 UTC
Probability of a Tropical Storm passing within 300km radius



Strike probability for TC/TS/HR

Related charts

Tropical cyclone activity (including genesis)

Tropical cyclone activity (including genesis) (WMO)

Selected forecast steps covering the next 12 days

VT: | Fri 05 | Sat 06 | Sun 07 | Mon 08 | Tue 09 | Wed 10 | Thu 11 | Fri 12 | Sat 13

Tropical Cyclone activity

Extended range



About Forecasts



Fernando Prates

Search site



Maps: global view and 7 additional TC basins

Tropical storm probabilities - Extended range forecast

Forecasts homepage

Charts

Datasets

Quality of our forecasts

Documentation and support

Access

Basins

Related

Tropical storm frequency - Extended range forecast

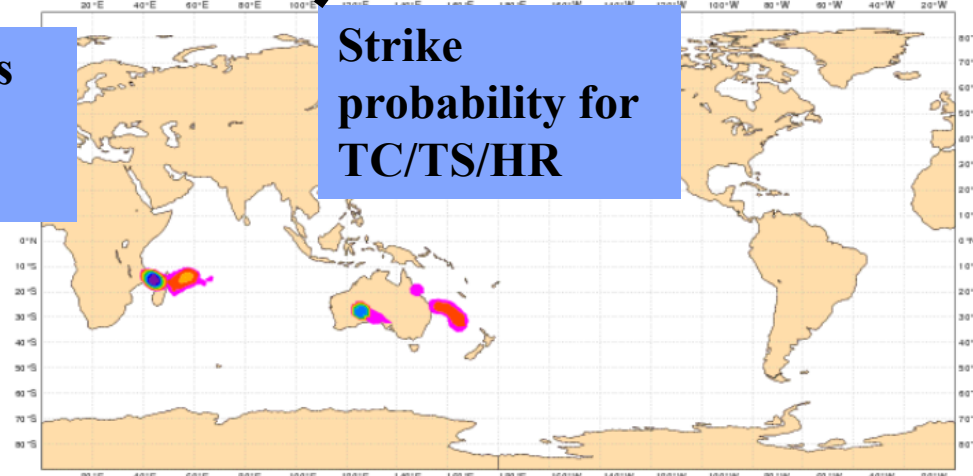
Tropical storm probabilities - Extended range forecast

View published New draft Revisions Access control

Base time Parameter Intensity Area

Weekly mean Tropical Storm Strike Probability. Date: 20160201 0 UTC t+(0-168)
Probability of a TS passing within 300km radius

5-10 10-20 20-30 30-40 40-50 50-60 60-70 70-80 80-90 90-110



Forecast runs covering the last 10 days

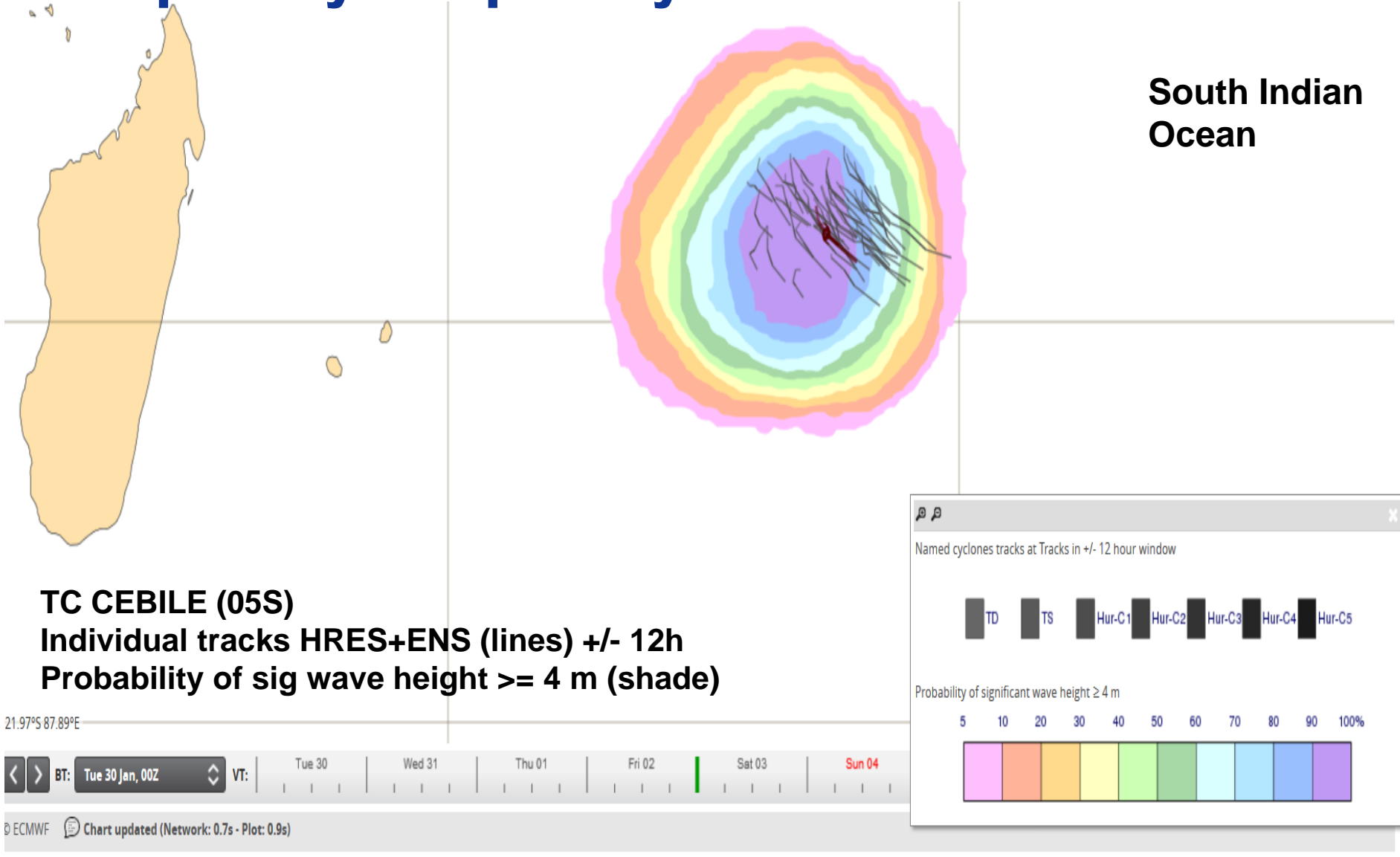
Strike probability for TC/TS/HR

Selected forecast steps covering the next 4 weeks

< > VT: | Sun 14 Feb 2016 Sun 21 Feb 2016 ▶

Probability in % that a tropical storm, a tropical depression or an hurricane will strike within 300 km for weekly periods. "Tropical depressions" includes all tropical cyclones with wind speed higher than $8\text{ m}\cdot\text{s}^{-1}$, while "tropical storms" includes all TCs with a wind speed higher than $17\text{ m}\cdot\text{s}^{-1}$ and hurricanes are just those TCs with a wind speed higher than $32\text{ m}\cdot\text{s}^{-1}$. Probabilities are computed from the 51 members of the real-time monthly forecasts. In order to determine if those probabilities are higher than the climatological probabilities, probability anomalies are also available. They are computed by subtracting the model climatological probabilities from the real-time forecast probabilities. Blue colours indicate less

Tadpole-style tropical cyclone tracks in ecCharts



Why is important to have an operational tracking scheme running at the Centre?

- In operational environments, when the forecaster has to look at different NWP model outputs, the analysis of TC forecast is possible only when the information (position/intensity) is delivered (displayed) in a compact format (post-processing)
- It makes possible to verify objectively the TC forecasts. Can be used for comparing different model versions (model upgrades)
- At ECMWF:
 - Operational tracking scheme since 2003. The switch from the current to the new tracker was successfully implemented on **2nd December 2013**.
 - The algorithm runs twice a day (00 & 12 UTC) for high HRES model and ENS (51 perturbed members & control)
 - generates a track which is nothing more, nothing less than a sequence of locations of minimum (maximum) in MSLP (10m speed) every 6 hours.
 - **NEW**: TC tracks are produced up to 240h (previously 120h) & extra web products.

What model fields are used in the tracking scheme?

➤ Surface fields

- Mean sea level pressure
- Wind at 10 m

➤ Upper level fields

- Vorticity (850 hPa)
- Wind (multi-levels) for steering wind
- Temperature (multi-levels) for warm core detection

The tracker is applied to NWP output every 6 hours and allows a tropical cyclone to 'disappear' for 24 hours (a tropical cyclone may weaken for a short period of time when crossing an island for instance).

For more details see ECMWF Newsletter No 130:

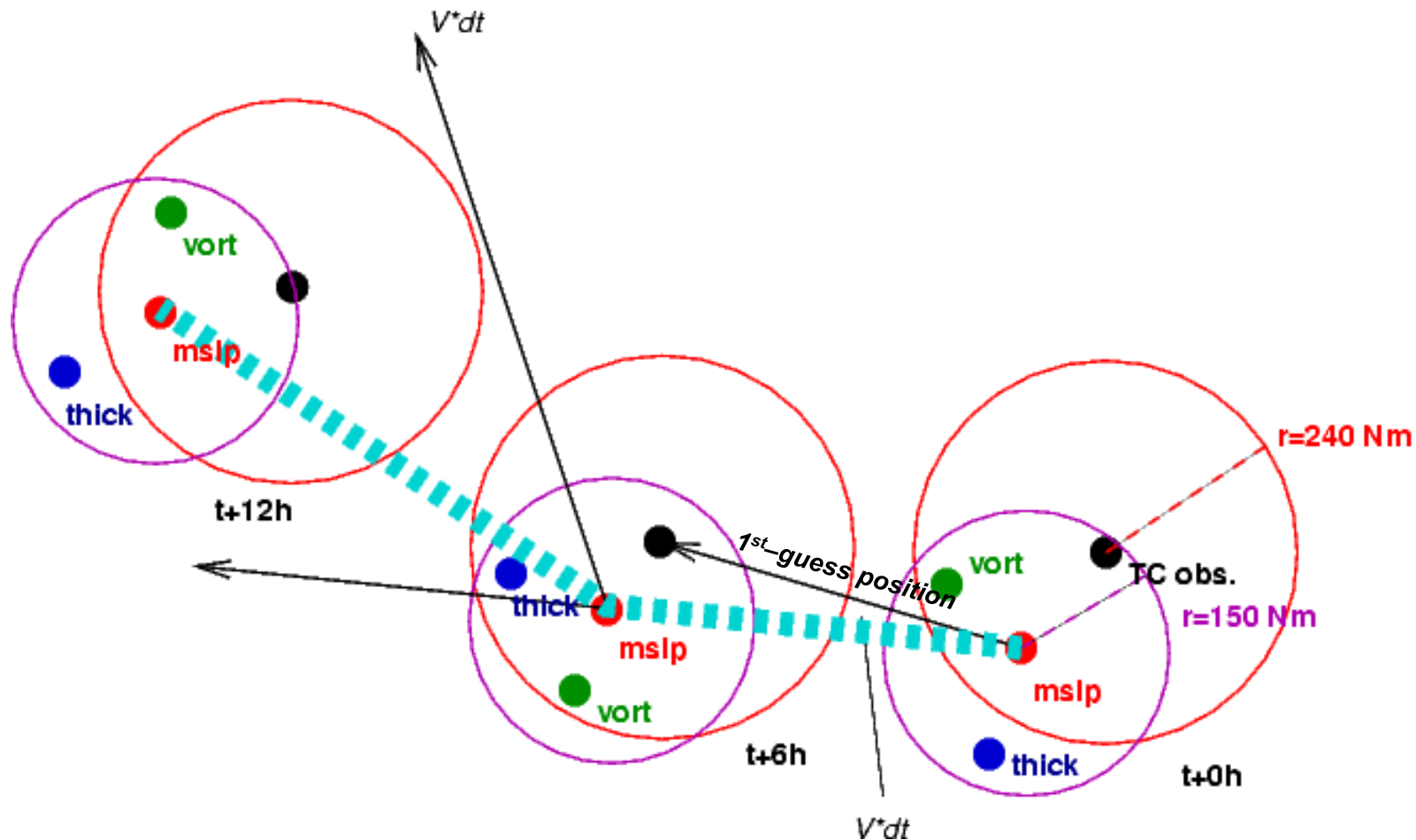
<http://www.ecmwf.int/publications/newsletters/>

ECMWF TC Tracker – How it works

vort 850hPa

V 850,700,500,200 hPa

warm core 500-200 hPa



Tracker output (ALSO available in BUFR format)


Lat	Lon	ENS member (1, ...,51)	fc date	hour	mslp
36.94	-38.96	1	20121001	0	988
36.13	-39.4	1	20121001	600	997.6
35.4	-38.89	1	20121002	1200	999.7
35.09	-38.54	1	20121002	1800	999.6
34.52	-37.83	1	20121003	0	1005.6
33.99	-36.13	1	20121003	0600	1006.1
34.75	-33.02	1	20121004	1200	1003.6
37.2	-29.58	1	20121004	1800	995
36.8	-38.7	2	20121001	0	989

36.93	-38.96	52	20121001	0	987.9
36.52	-39.09	52	20121001	600	986.9
36.02	-39.12	52	20121001	1200	992.6
35.61	-38.91	52	20121001	1800	993.6
35.37	-38.45	52	20121002	0	994.6

HRES model

Why TC forecasts have improved in recent years?

Due to the continuous upgrades of the forecast system at ECMWF,

- Increase of model horizontal and vertical resolution 
- Massive use of Satellite data in Data Assimilation (DA)
- Improvements of the physical processes (parametrization of convection, new cloud microphysics,...)
- Methods for Global Ensemble Prediction : ENS evolved SVs , stochastic physics and perturbations target at observed TCs and **more recently** the implementation of Ensemble Data Assimilation
- Since November 2013:
 - *The atmosphere-ocean coupling of the ENS is active from initial time of the forecast using a new version of the NEMO ocean model (cy40r1). **Model upgrade 43r1: 75levels (before was 42) and 0.25° (instead of 1 °).***

..... At ECMWF there is no artificial bogus vortex scheme for TCs. We allow the observations to do their job

Click me to jump to the next slide

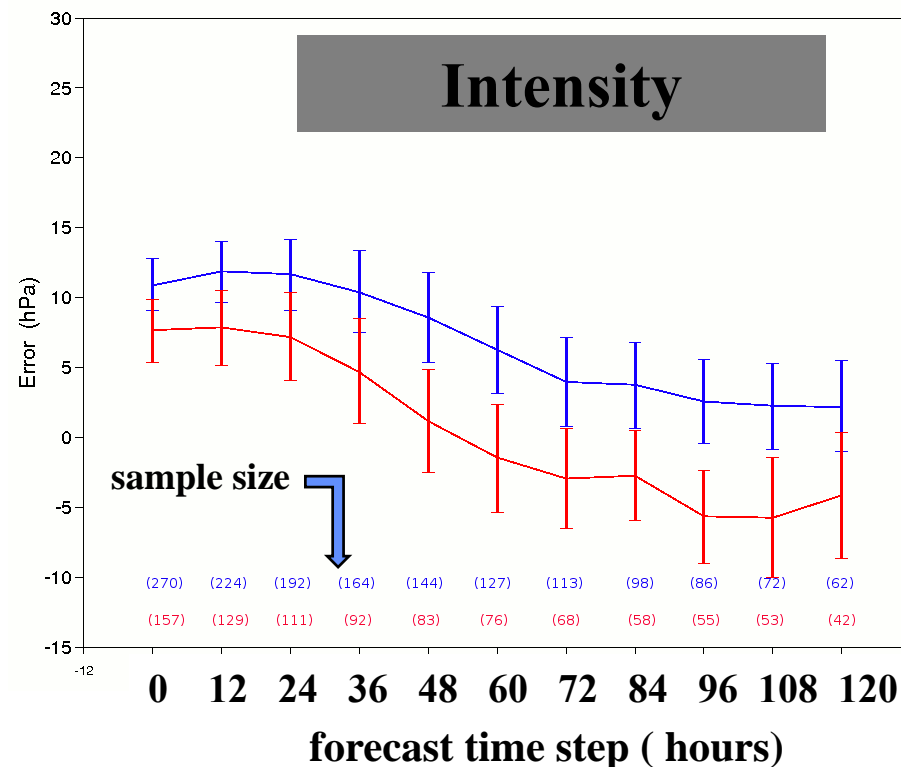
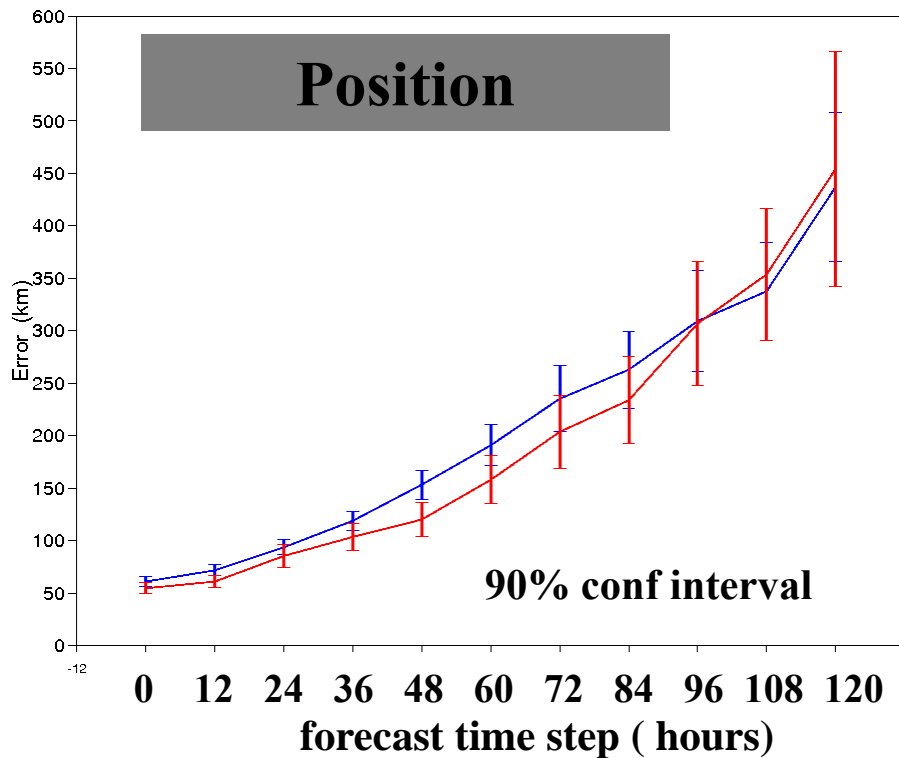


TC forecast performance **T799** v **T1279**

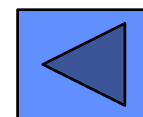
(~25 km) v (~16 km)

Tropical cyclone mean position error
fc period [20091004 to 20100121]

Tropical cyclone mean intensity error
fc period [20091004 to 20100121]



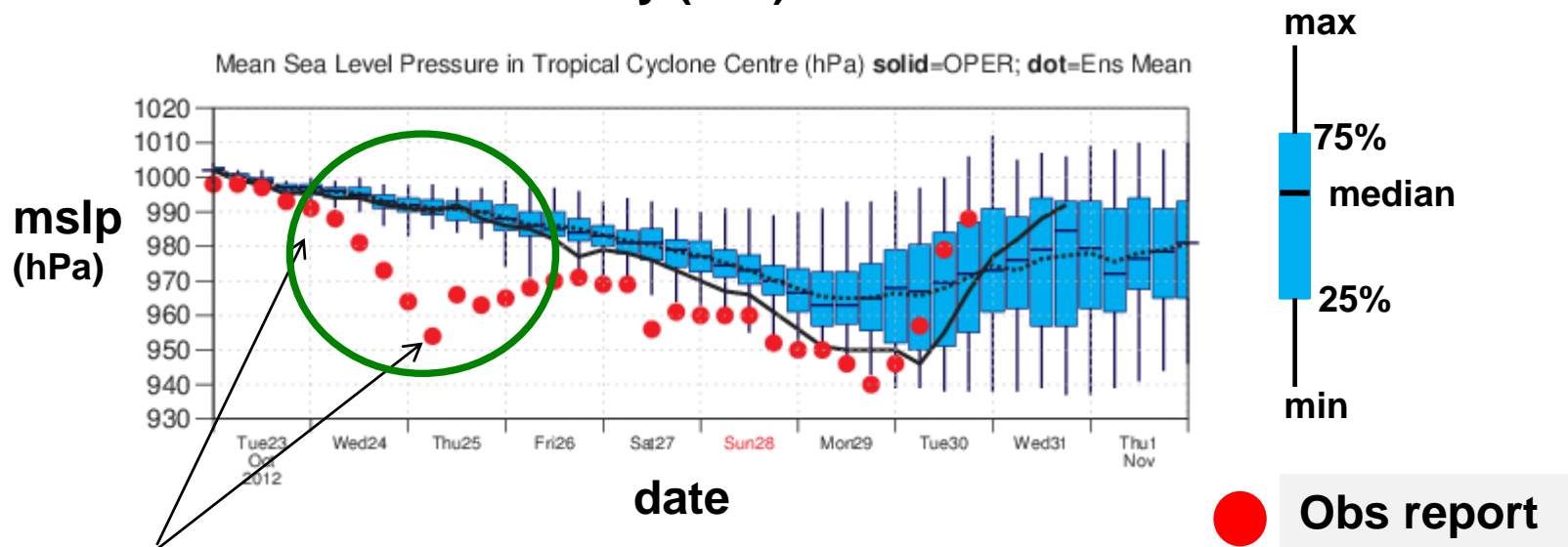
$Error = Forecast - Obs$
Obs from the best track reports



TC intensity forecast – on going problem

For a comprehensive list of known IFS forecast issues go to the link <https://software.ecmwf.int/wiki/display/FCST/Forecast+User+Home>

HR Sandy (18L)



Rapid intensification
~40 hPa in 30 hrs

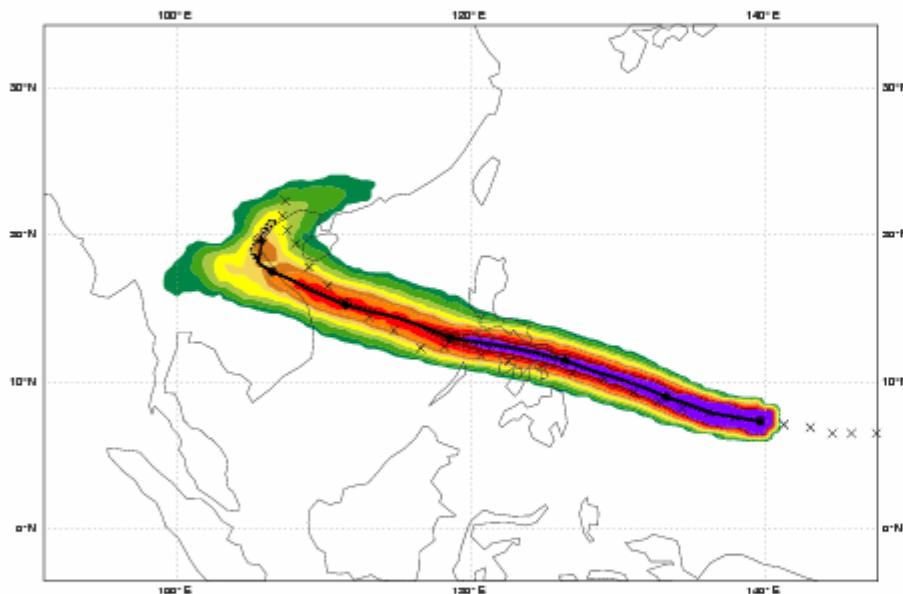
In general , rapid intensification of TCs is still poorly handled by the current global models

Haiyan 2 days before landfall

Date 20131106 00 UTC @ECMWF

Probability that **HAIYAN** will pass within 120 km radius during the next 240 hours
tracks: **solid**-OPER; **dot**-Ens Mean [reported minimum central pressure (hPa) **955**]

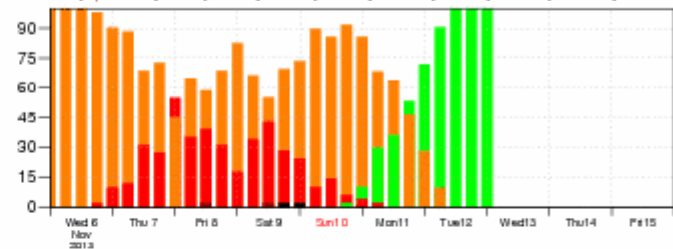
■ 0-10 ■ 10-20 ■ 20-30 ■ 30-40 ■ 40-50 ■ 50-60 ■ 60-70 ■ 70-80 ■ 80-90 ■ >90%



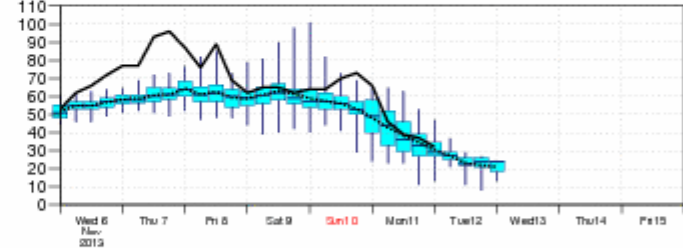
List of ensemble members numbers forecast Tropical Cyclone
Intensity category in colours: **TD**[up to 33] **TS**[34-63] **HR1**[64-82] **HR2**[83-95] **HR3**[>95 kt]

+024 h	hr	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
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+216 h	hr					05	09						13	14	15	16	17	18	20	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50			
+240 h	hr																																																		

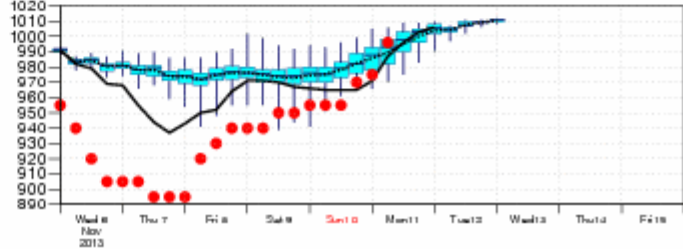
Probability (%) of Tropical Cyclone Intensity falling in each category
TD[up to 33] **TS** [34-63] **HR1**[64-82] **HR2** [83-95] **HR3** [>95 kt]



10m Wind Speed (kt) **solid**=OPER; **dot**=Ens Mean



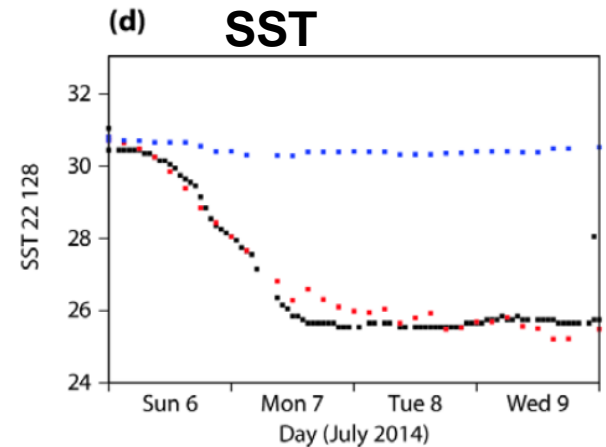
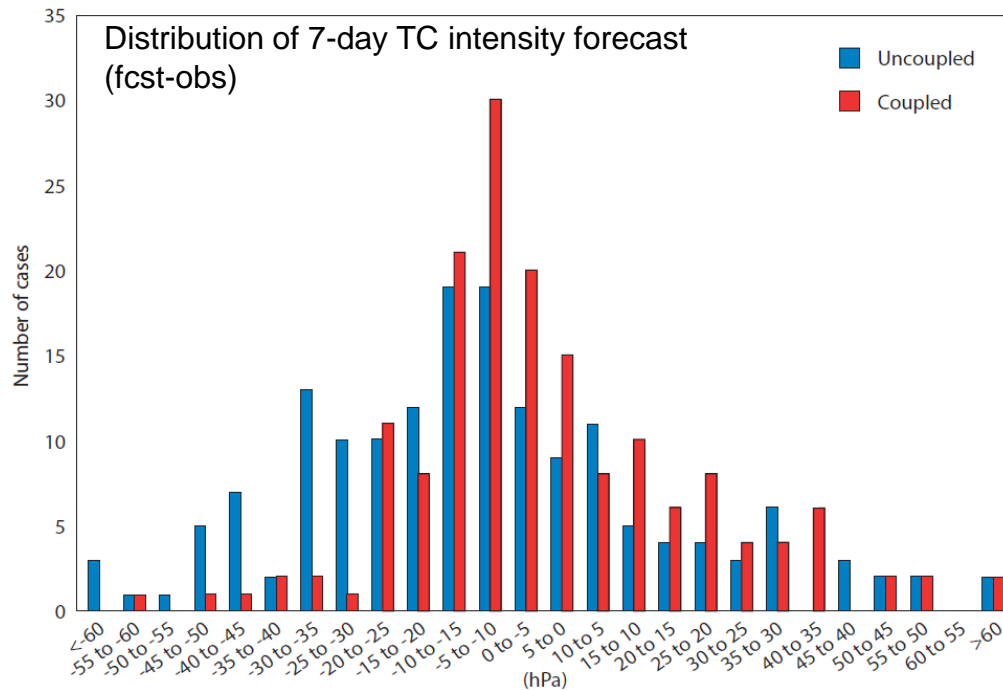
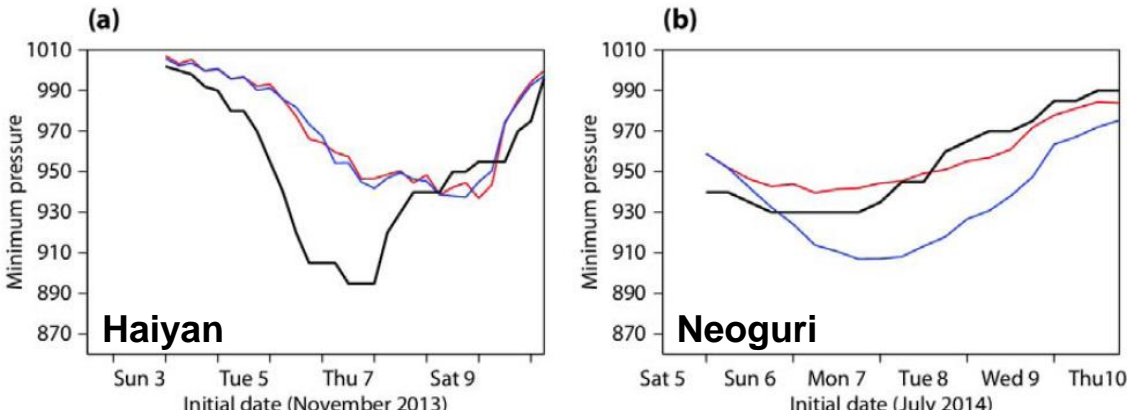
Mean Sea Level Pressure in Tropical Cyclone Centre (hPa) **solid**=OPER; **dot**=Ens Mean



Effect of atmosphere-ocean coupling on intensity forecast of TCs

Newsletter 154
winter 2017/18

HRES (9 km) & Nemo (0.25°)
— Coupled model
— Uncoupled model
— Observations



(a) TC Haiyan and (b) TC Neoguri, with TCo1279 uncoupled model and (red) coupled model. (c) Shading of SST initialised at 0UTC on 6 July 2014. Diamonds represent observations. (d) SST time-series from the (black) observations, and (red) coupled forecast at the location of a buoy with

Forecast performance

The forecast performance for TCs is checked regularly and compared with the previous years for the Global HRES model and ENS. The results are reported to the Technical Advisory Committee[★] every year.

- Mean position error for HRES, Control models and ENS mean
- Mean intensity error (ME)
- Mean speed error (ME) for HRES
- Reliability and ROC for the Strike Probability Products
- ENS Spread & EM Error

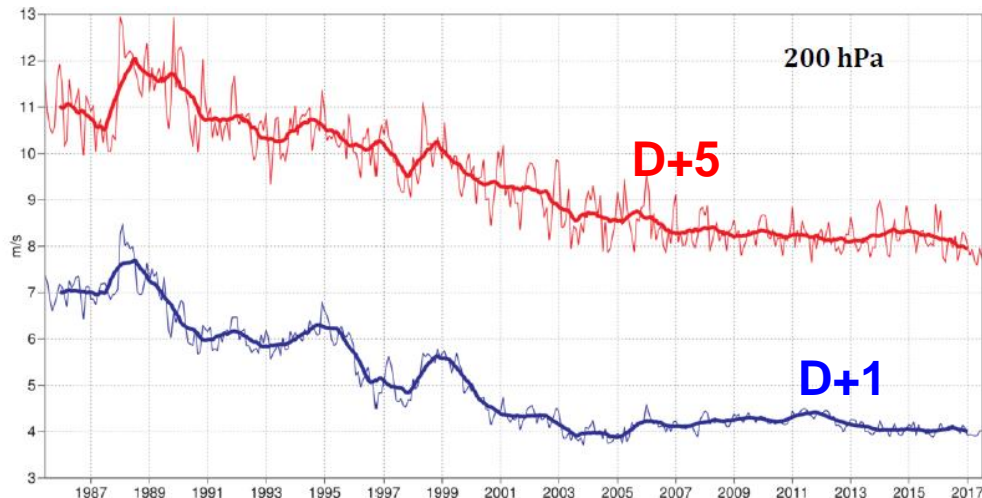
★ also available in technical memoranda document

[http://www.ecmwf.int/search/elibrary/?solrsort=ts_biblio_year%20desc&secondary_title=Technical%20](http://www.ecmwf.int/search/elibrary/?solrsort=ts_biblio_year%20desc&secondary_title=Technical%20Memorandum)

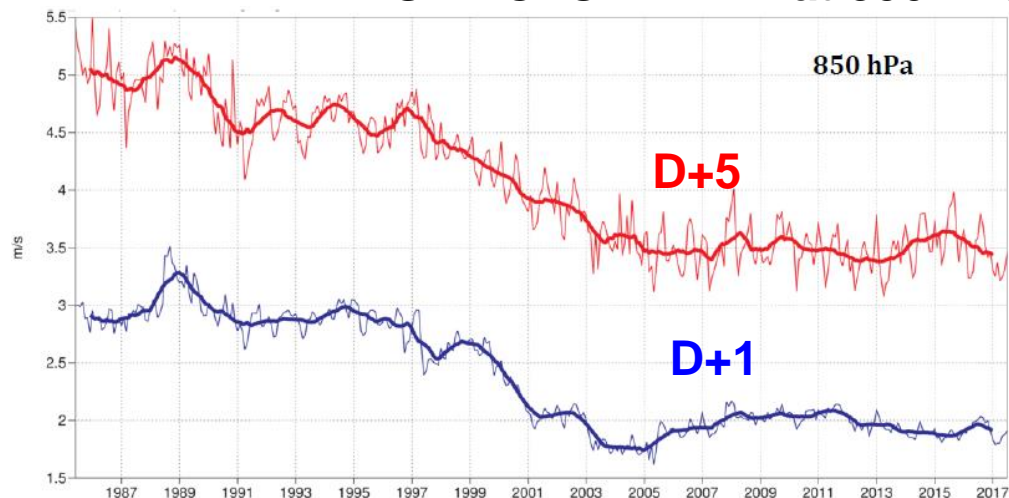
[Memorandum](#)

How accurate are the TC forecasts from ECMWF (Part I)?

RMS VECTOR WIND at 200 hPa

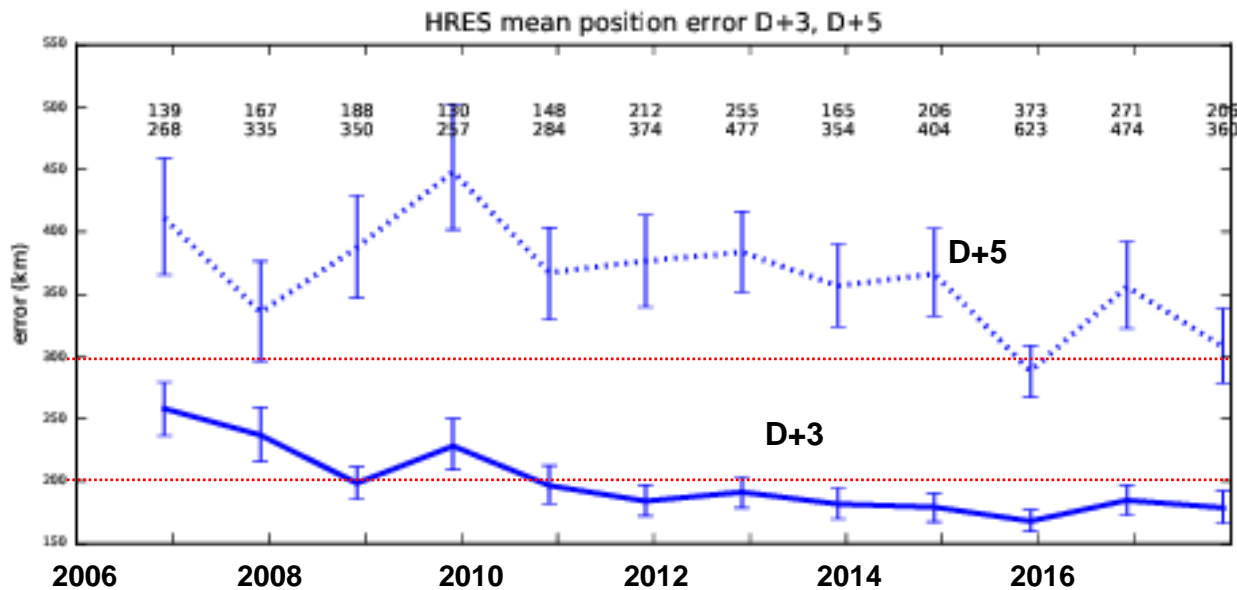


RMS VECTOR WIND at 850 hPa

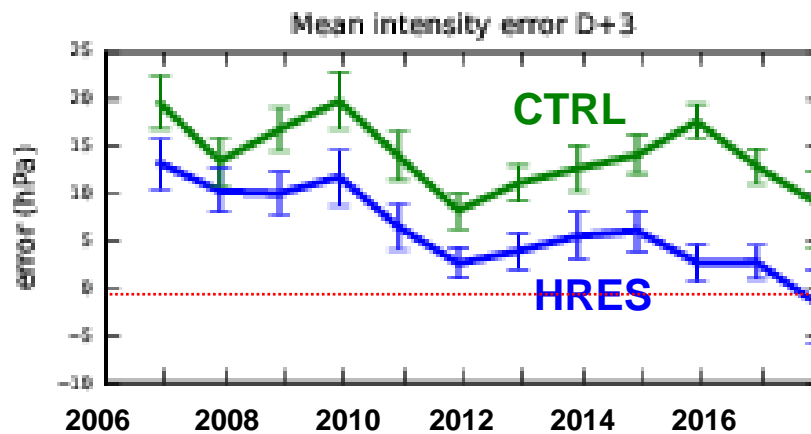


How accurate are the TC Fcs from ECMWF (Part II) ?

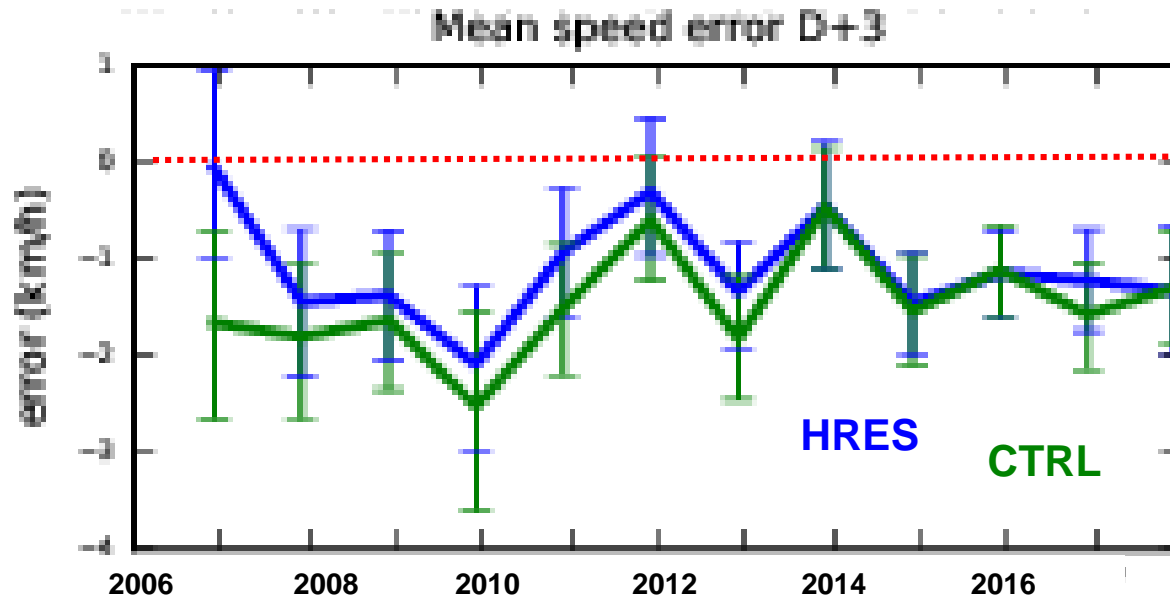
HRES verification (12 month means ending on 30 June)



Annual mean position errors

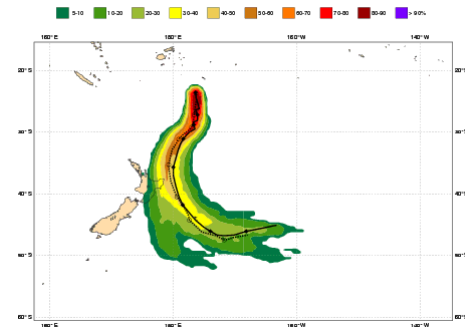
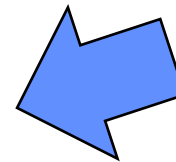
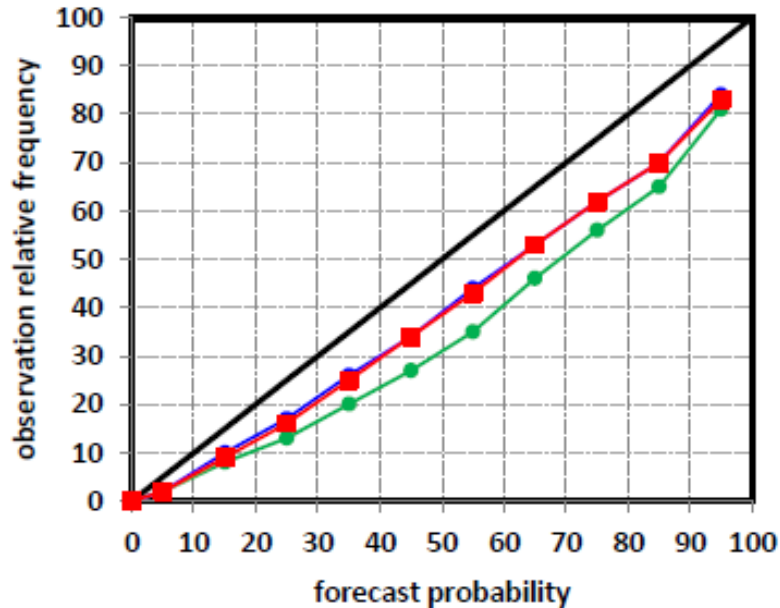


On average TCs move slower in the model (Part III)



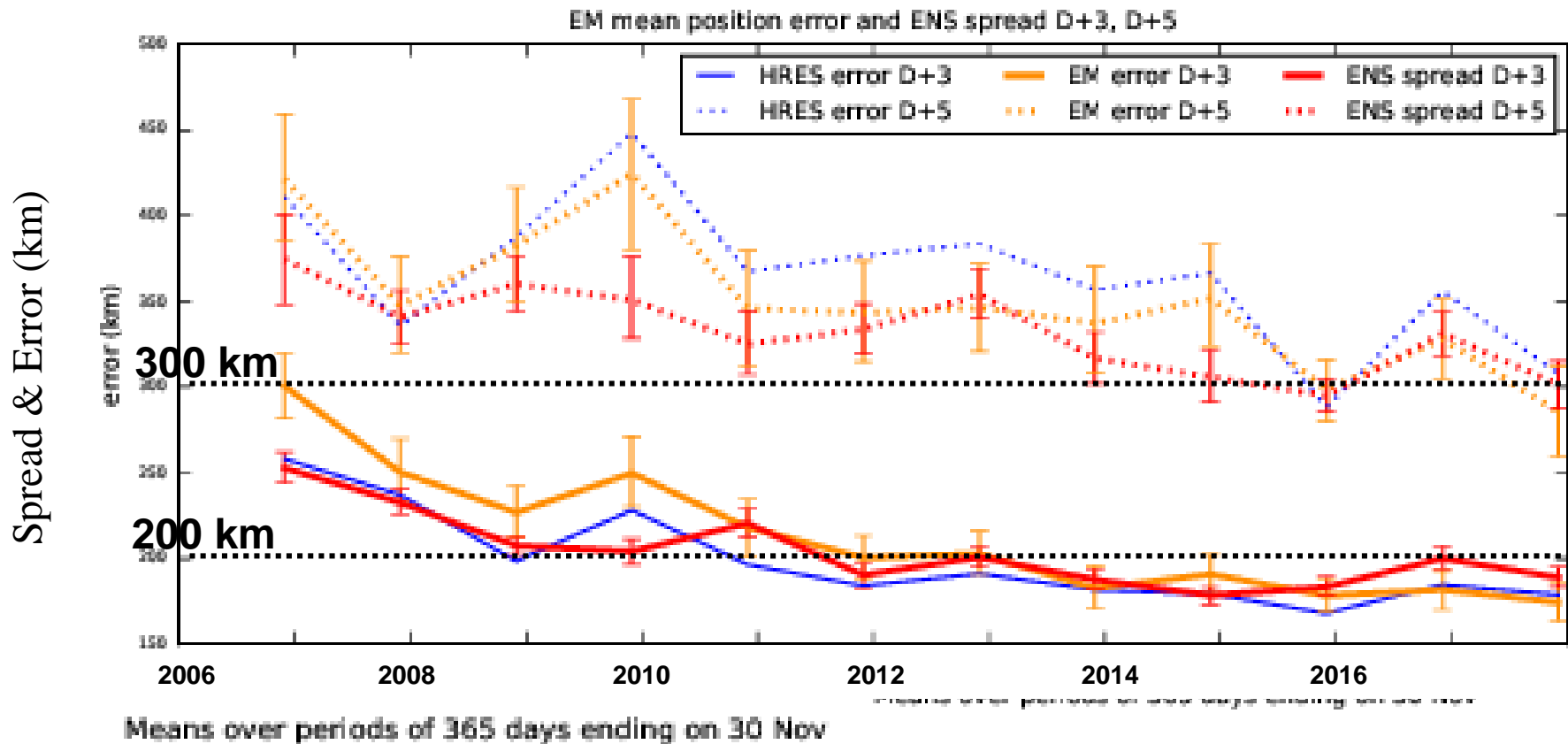
Verification of the ENS Strike Probability product (Part V)

Reliability of TC strike probability (+240h)
(one year ending on 30th Jun)



Strike probability of TC within 120 km in the next 10 days

ENS SPREAD & EM ERROR (Part VI)



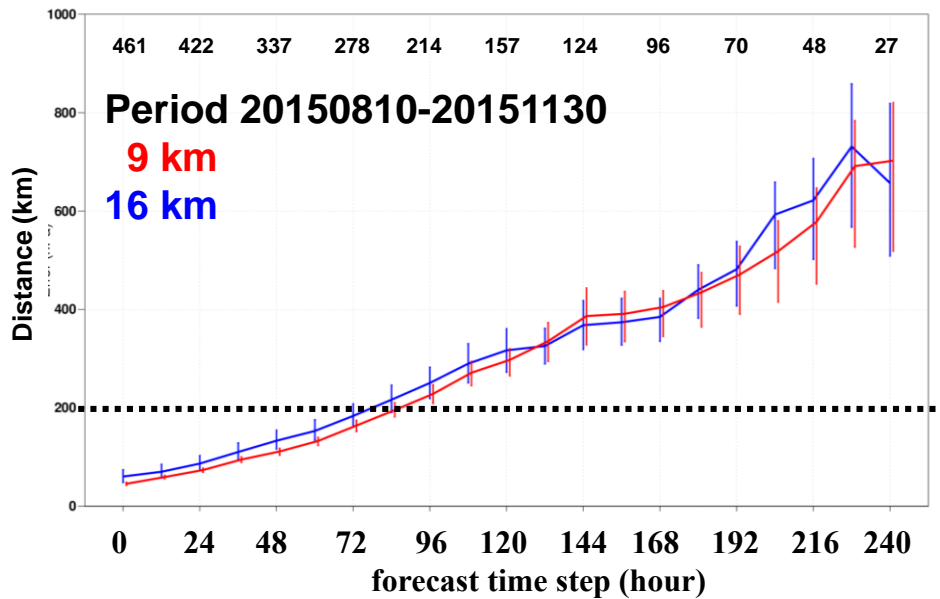
A calibrated ENS should provide consistency between the EM error and spread.

TC forecast performance **T1279** v **TCo1279**

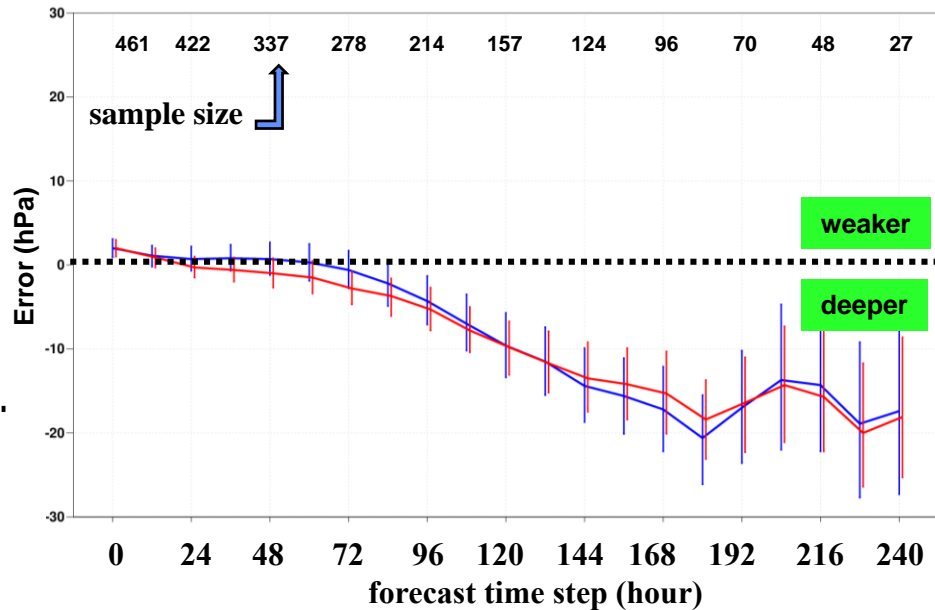
Model upgrade (March 2016)

T1279 ~16 km **TCo1279** ~9 km

Position



Intensity



Error = Forecast – Obs
Obs from the best track reports

QUESTIONS?