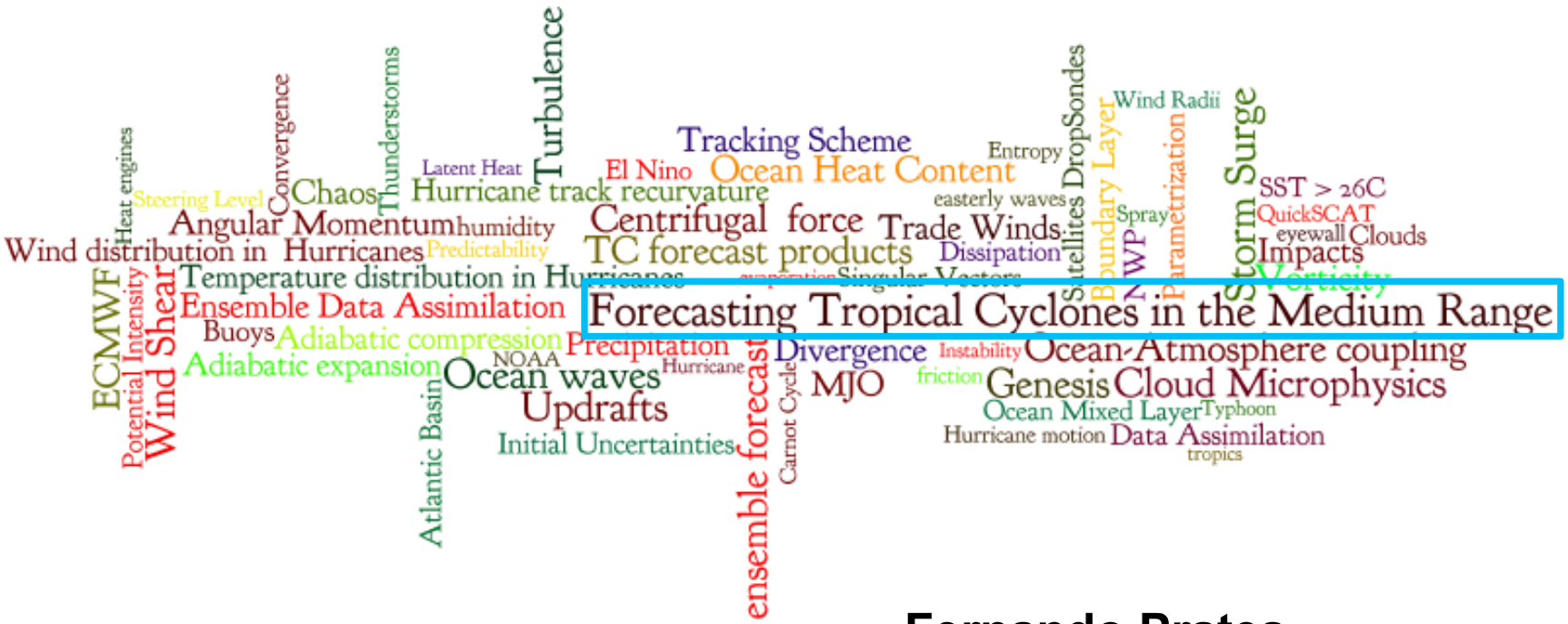


Fernando Prates

Evaluation Section

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/
- Tropical cyclone activity (including genesis)
  - 12-day

http://www.ecmwf.int/en/forecasts/charts/medium/tropical-cyclone-activity-including-genesis

  - 28-day extension

    http://www.ecmwf.int/en/forecasts/charts/mofcmulti/tropical-storm-probabilities-extended-range-forecast
- Tropical Cyclone Tracks in BUFR **(since 10 November 2015)**
  - https://software.ecmwf.int/wiki/display/FCST/Tropical+Cyclone+tracks+in+BUFR+-+including+genesis

Products for existing Tropical Cyclones

ECMWF About Forecasts Computing Research Learning

ECMWF tropical cyclones

- Charts
- Datasets
- Quality of our forecasts
- Documentation and support
- Accessing forecasts

Overview map

Latest cyclones

08U (08U) - Region 07

Filters

Year: 2016

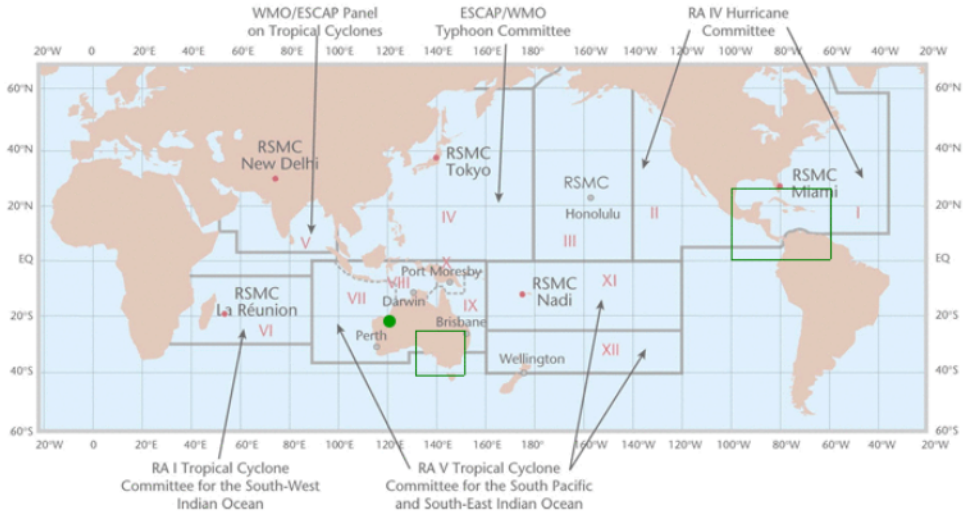
WMO region: All

Cyclone products

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

Cyclone results

08U (08U) - Region 07
STAN (08U) - Region 07



This map shows, as coloured spots, all the latest active tropical cyclones as reported by WMO Regional Specialized Meteorological Centres (RSMCs - the names of these, and their areas of responsibility, are also shown). Clicking on a spot shows what the ECMWF IFS (Integrated Forecast System) predicts the subsequent evolution of that tropical cyclone will be. Areas in the Tropics within which the ECMWF Ensemble (ENS) uses additional initial condition perturbations, specifically targetted on tropical cyclones, are shown as colour rectangles (more details can be found in the User Guide.

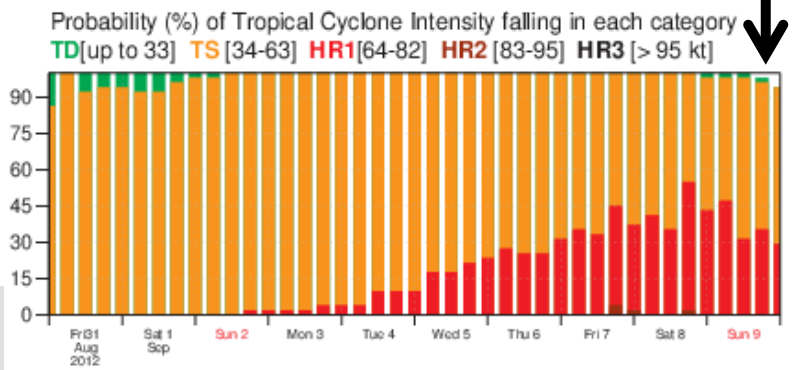
Finally it should be noted that IFS output on these pages is generated automatically, without any editing by forecast experts. It is ultimately the RMSCs that have responsibility for forecasts of tropical cyclones within their respective regions. We provide data to them.

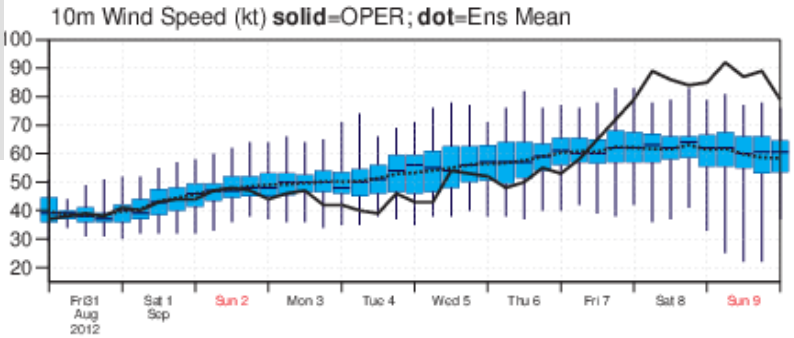
For direct access to official RSMC forecasts users can reference the WMO Severe Weather Information Centre here. And For up-to-date forecast information for their own local area the public should refer to forecasts from their own national meteorological service.

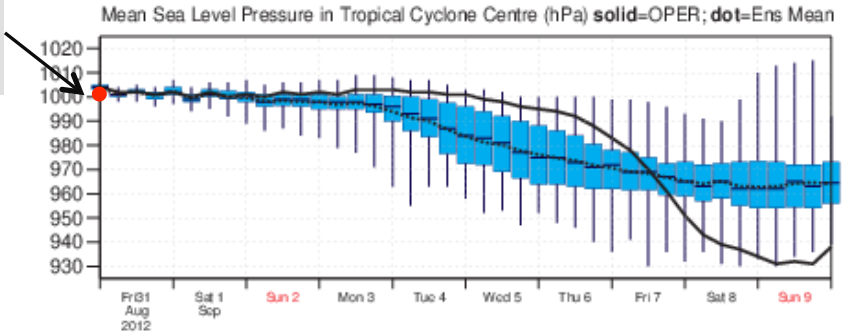
ECMWF

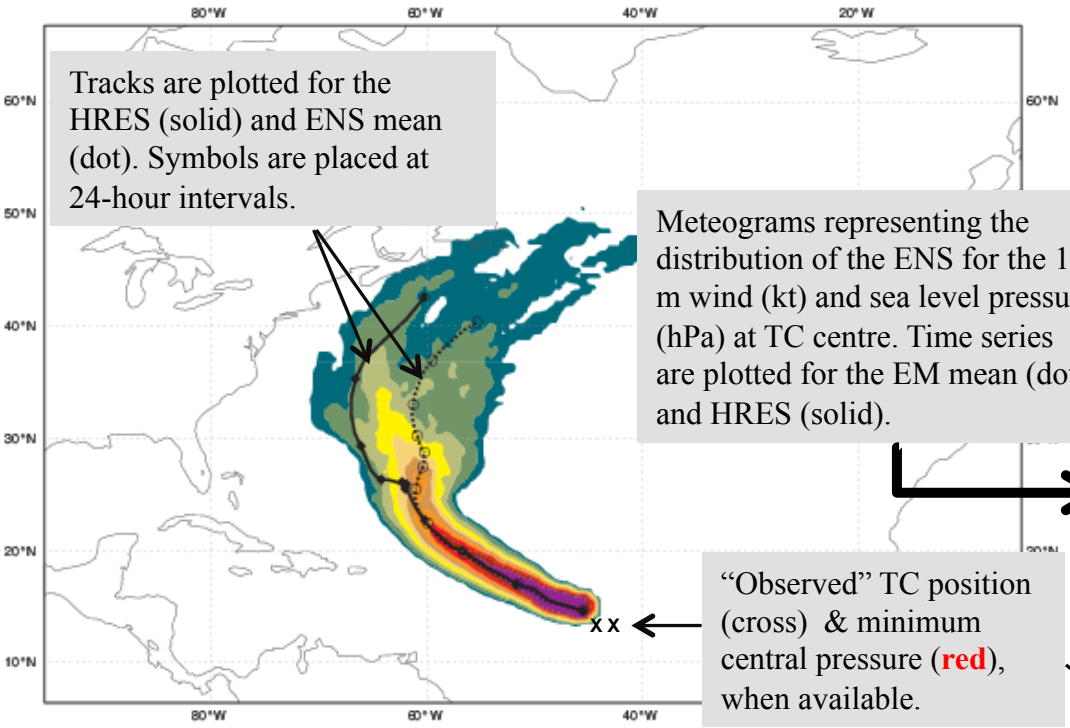
TC Products – Part I

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.





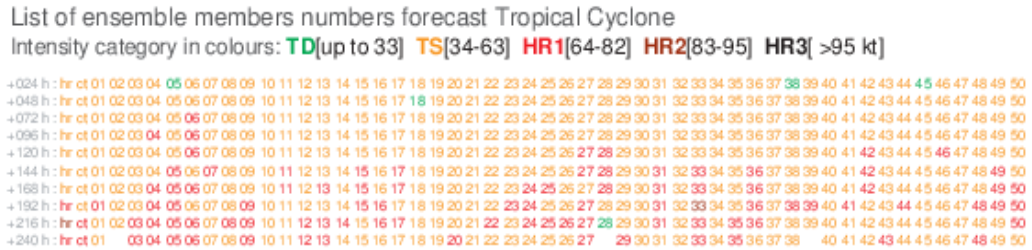




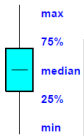
Tracks are plotted for the HRES (solid) and ENS mean (dot). Symbols are placed at 24-hour intervals.

Meteograms representing the distribution of the ENS for the 10-m wind (kt) and sea level pressure (hPa) at TC centre. Time series are plotted for the EM mean (dot) and HRES (solid).

"Observed" TC position (cross) & minimum central pressure (**red**), when available.

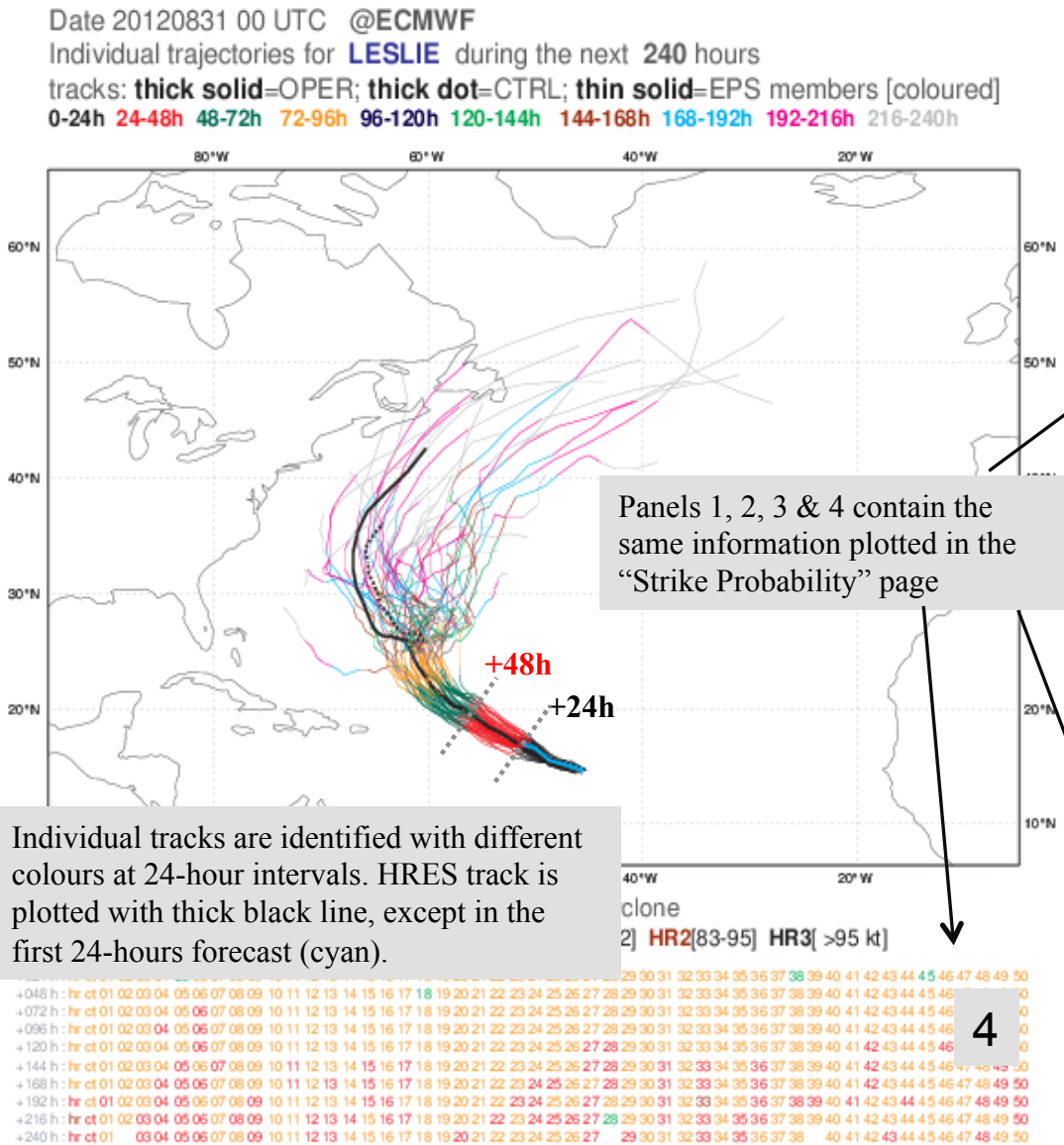


Snapshot of ENS members (numbers) tracking the storm together with intensity (colours), at 24-hours intervals. HRES and Control models are labelled 'hr' and 'ct' respectively.



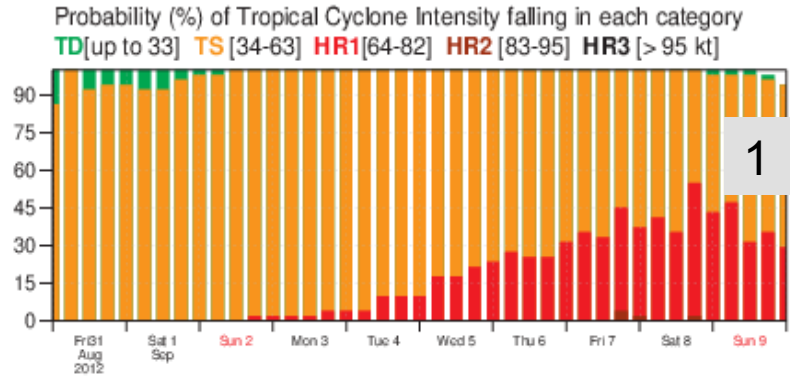
box-and-whiskers plot representing the 5 quantiles of the ENS distribution

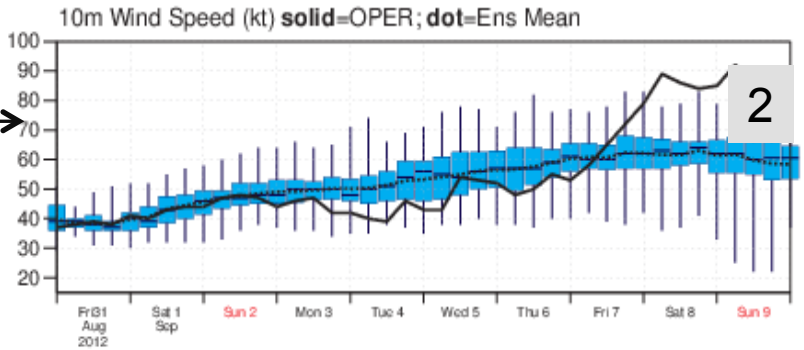
TC Products – Part II

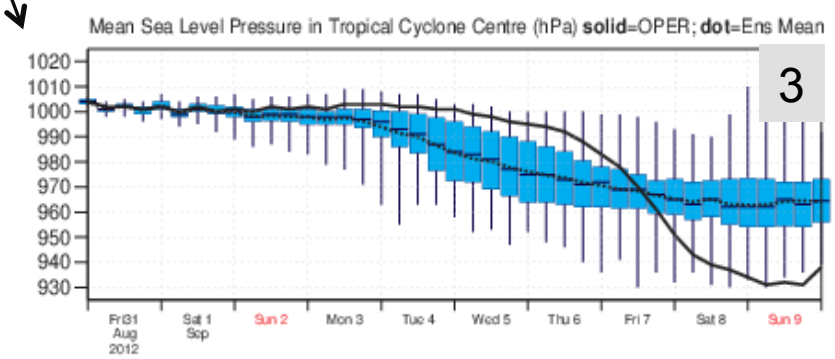


Individual tracks are identified with different colours at 24-hour intervals. HRES track is plotted with thick black line, except in the first 24-hours forecast (cyan).

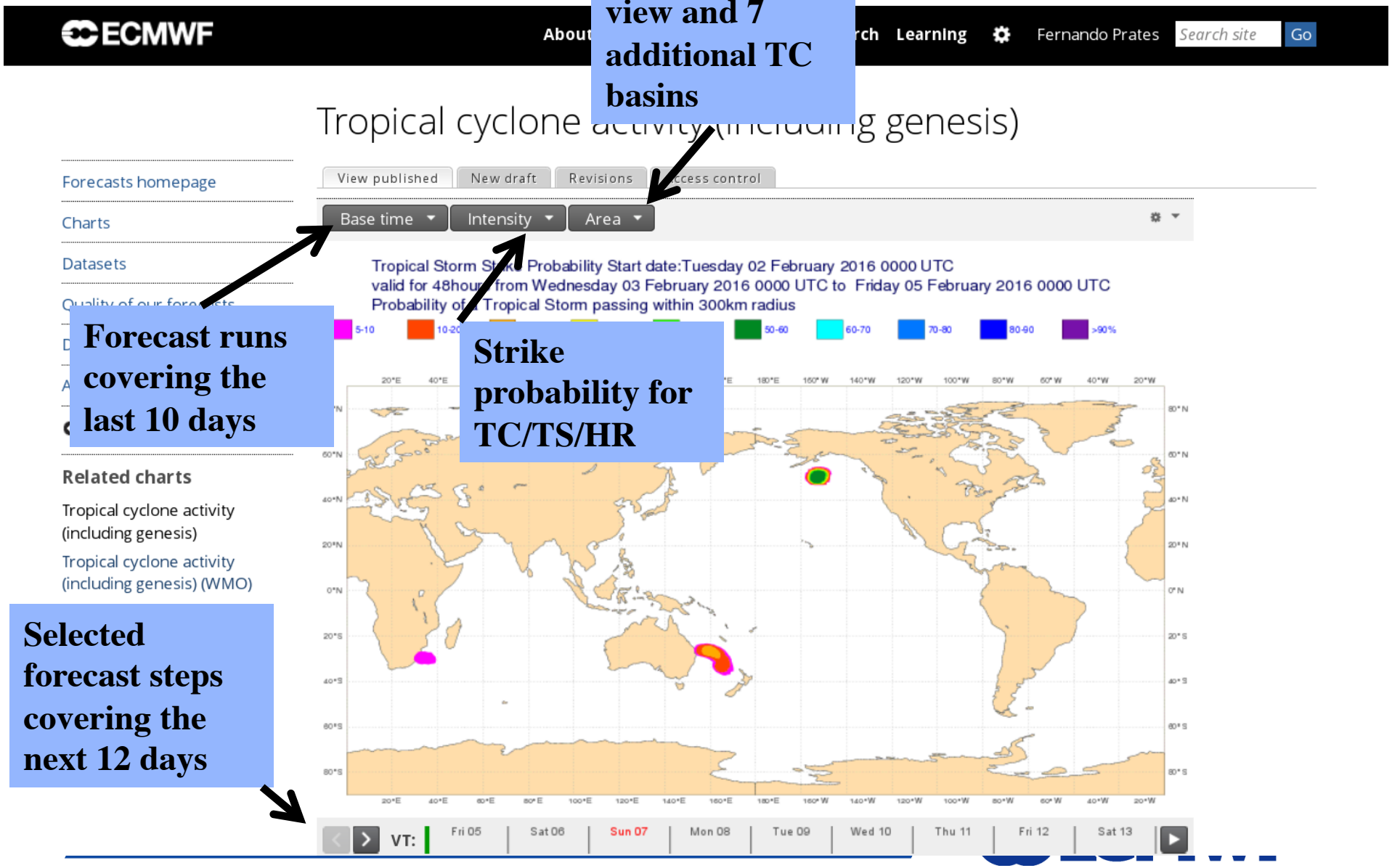
Panels 1, 2, 3 & 4 contain the same information plotted in the "Strike Probability" page







Tropical Cyclone Activity in the Medium Range ENS



Maps: global view and 7 additional TC basins

Forecast runs covering the last 10 days

Strike probability for TC/TS/HR

Selected forecast steps covering the next 12 days

Tropical Cyclone activit tended range

Maps: global view and 7 additional TC basins

ECMWF About Forecasts Fernando Prates Search site Go

Tropical storm probabilities - Extended range forecast

- Forecasts homepage
- Charts
- Datasets
- Quality of our forecasts
- Documentation and support
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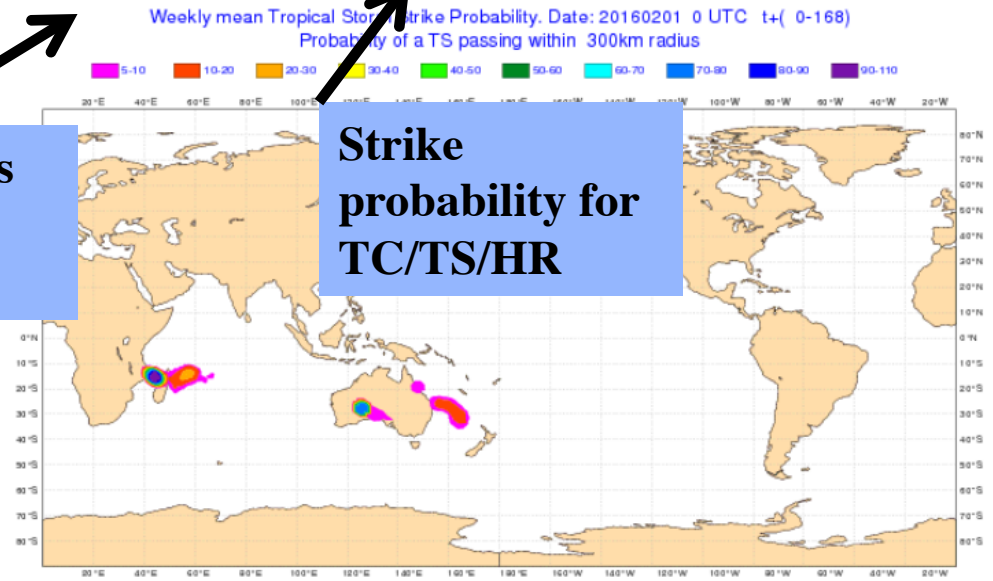
- Tropical storm frequency - Extended range forecast
- Tropical storm probabilities - Extended range forecast

View published | New draft | Revisions | Access contr

Base time | Parameter | Intensity | Area

Forecast runs covering the last 10 days

Strike probability for TC/TS/HR



Selected forecast steps covering the next 4 weeks

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 8m*s(-1), while "tropical storms" includes all TCs with a wind speed higher than 17 m*s(-1) and hurricanes are just those TCs with a wind speed higher than 32 m*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

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:

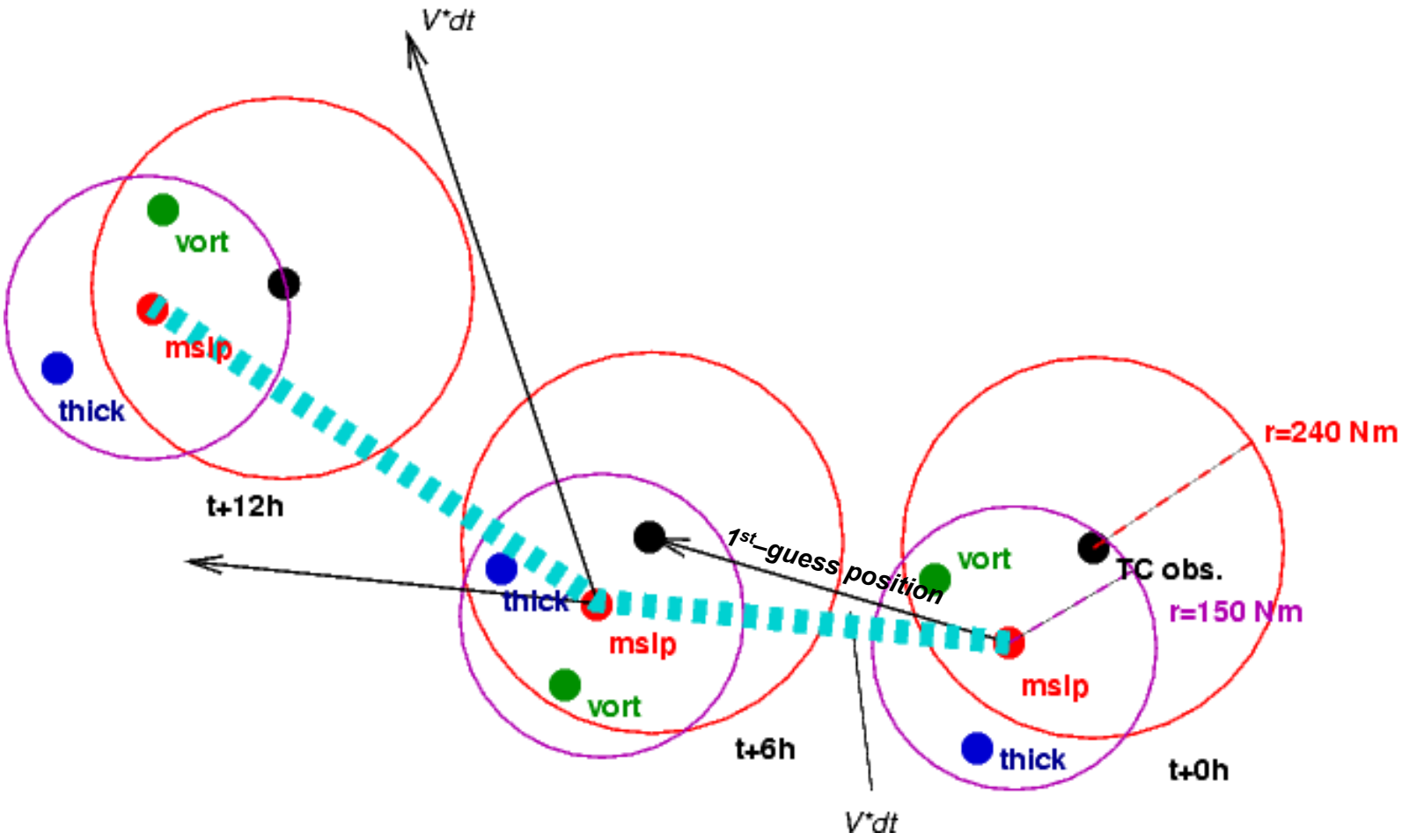
http://www.ecmwf.int/publications/newsletters/

ECMWF TC Tracker – How it works

vort 850hPa

warm core 500-200 hPa

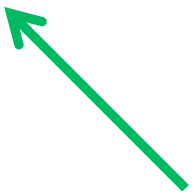
V 850,700,500,200 hPa



ECMWF

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,

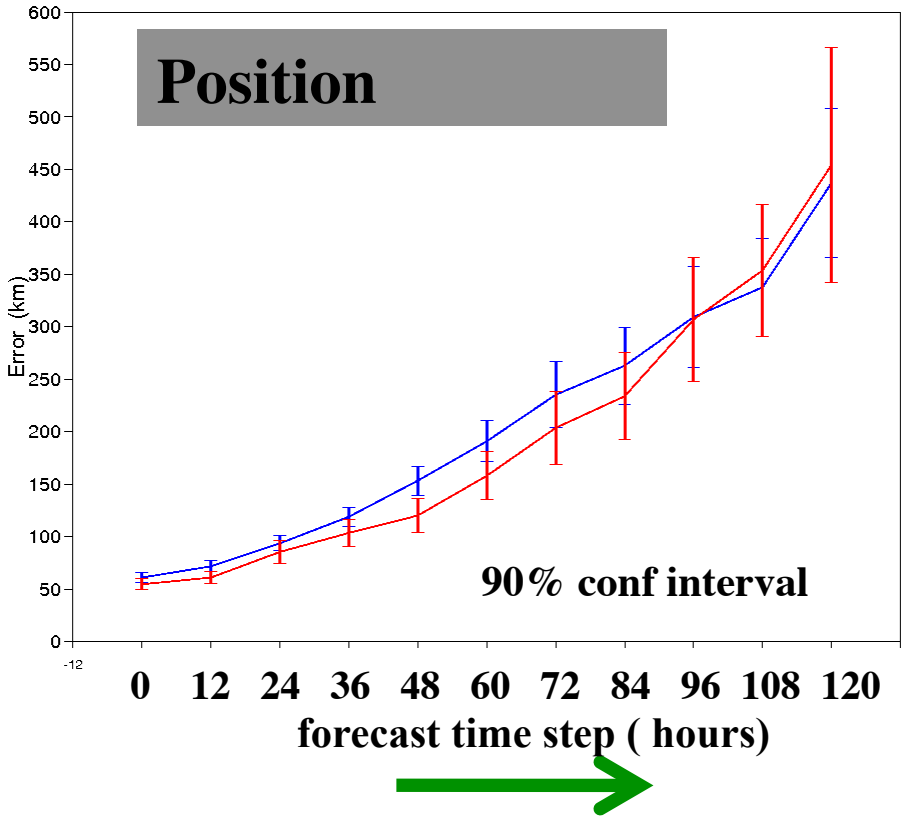
- Increase of model horizontal and vertical resolution
- Massive use of Satellite data in Data Assimilation (DA)
- Improvements of the physical processes (parametrization of convection, new cloud microphysics,…)
- Methods for Global Ensemble Prediction : ENS evolved SVs , stochastic physics and perturbations 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)*

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

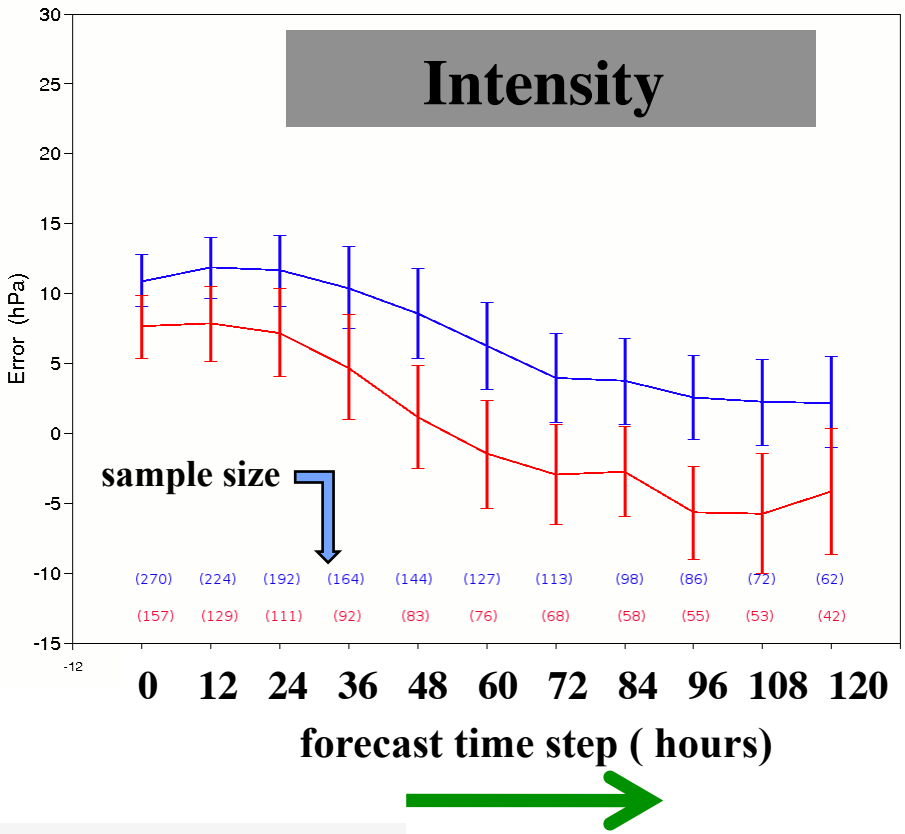
Click me to jump to the next slide

TC forecast performance T799 (~25 km) v T1279 (~16 km)

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



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

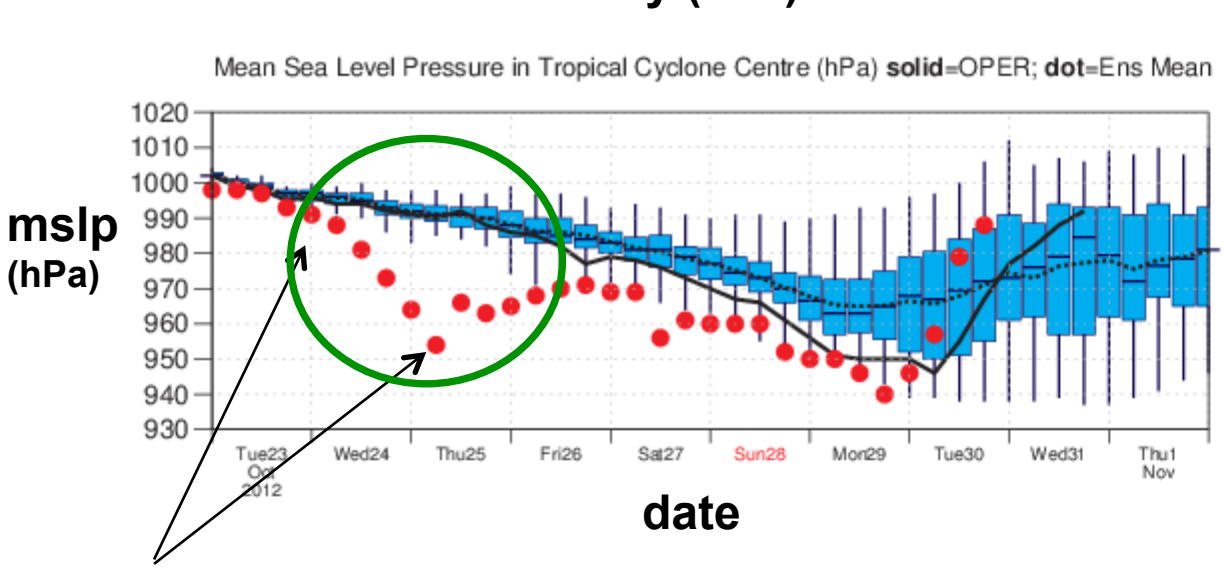


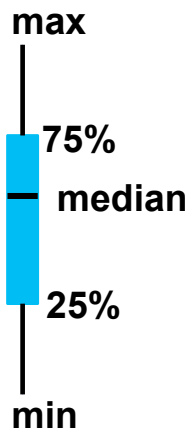
Error = Forecast – Obs
Obs from the best track reports

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)



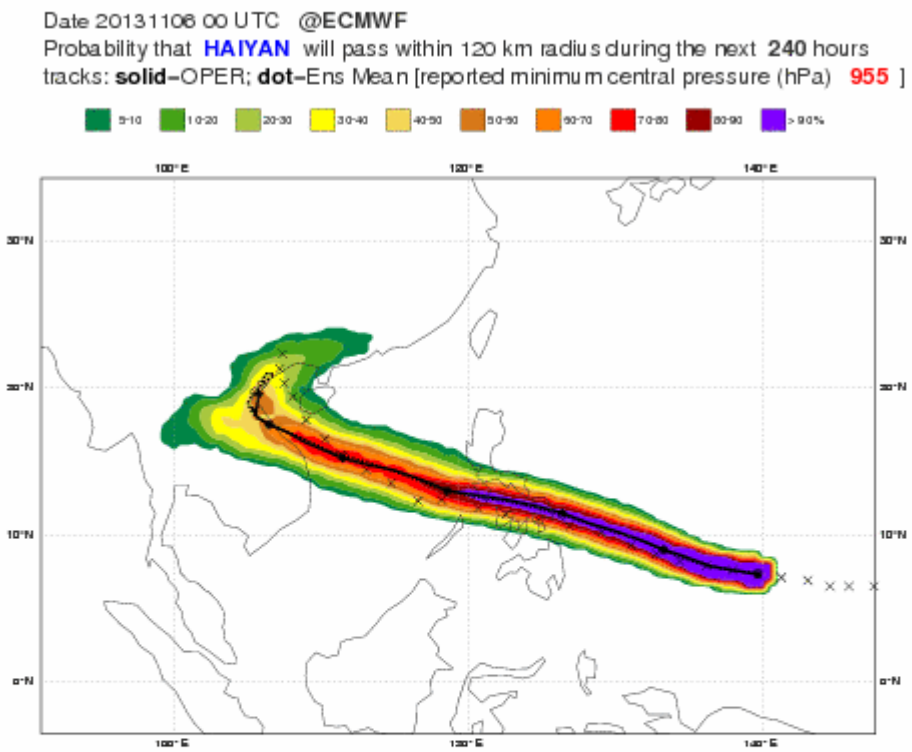


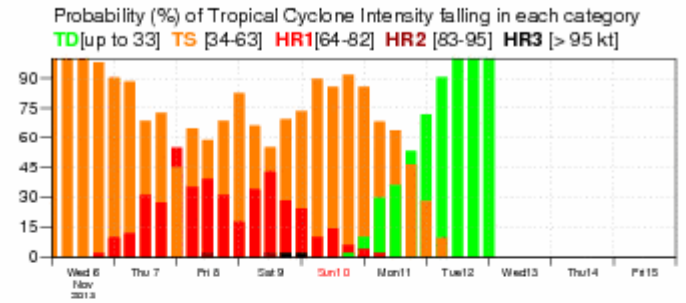
Obs report

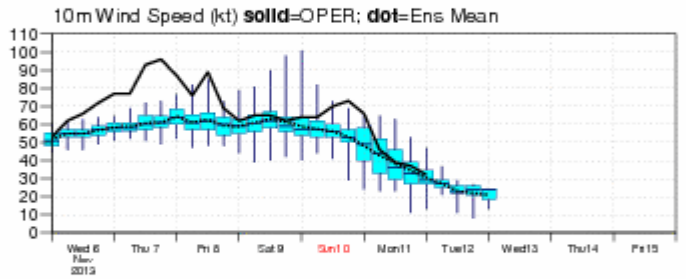
Rapid intensification
~40 hPa in 30 hrs

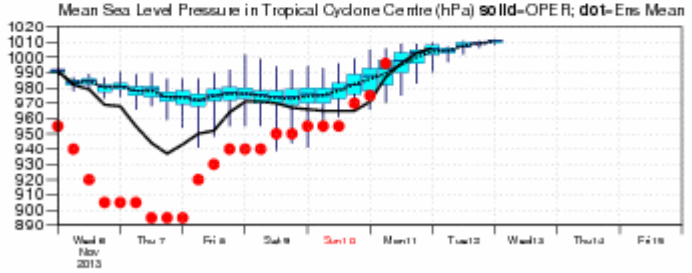
In general , rapid intensification of TCs is still poorly handled by the current global models

Haiyan 2 days before landfall









Effect of atmosphere-ocean coupling on intensity forecast of TCs

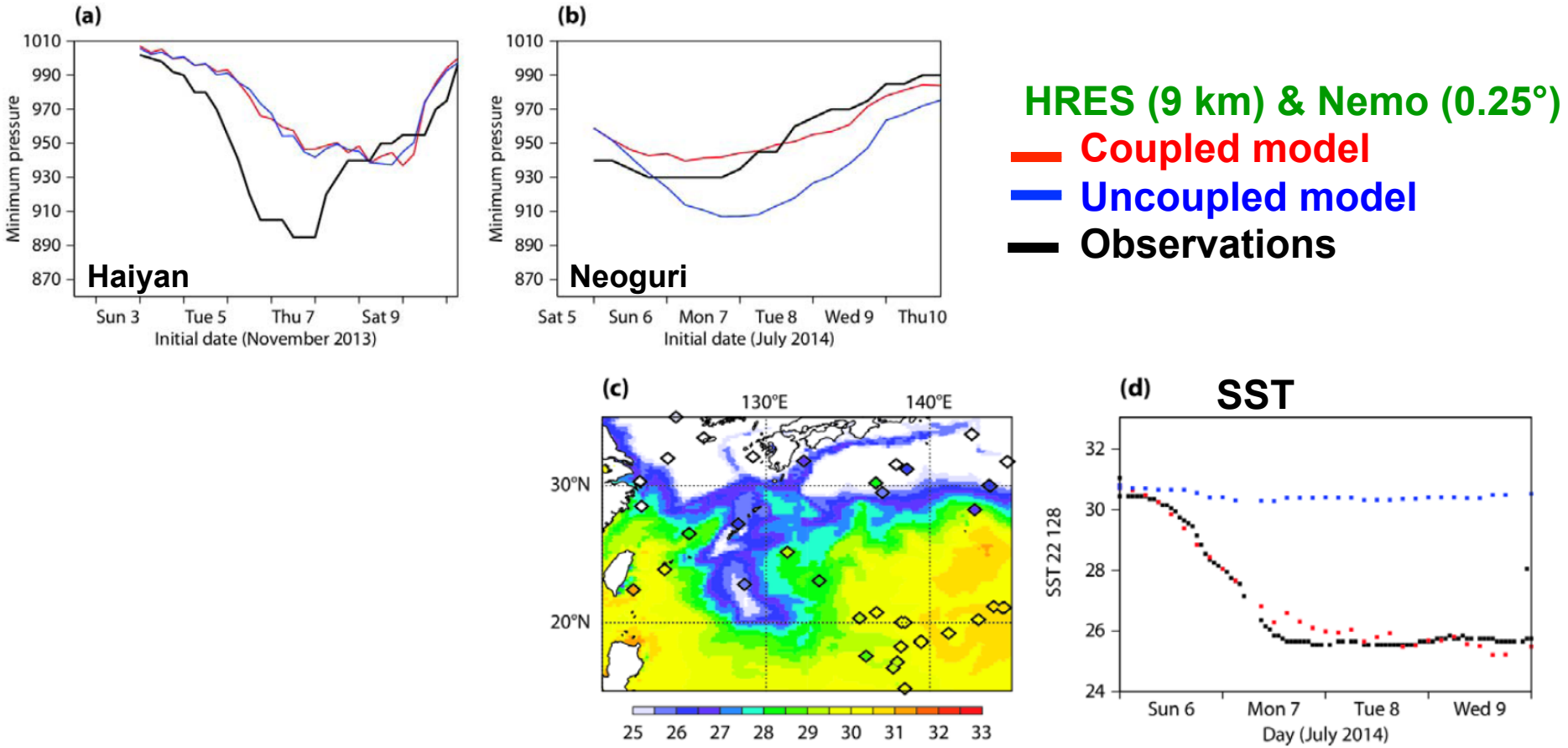


Figure 4: Central pressure forecasts for (a) TC Haiyan and (b) TC Neoguri, with TCo1279 resolution in the atmosphere: (blue) uncoupled model and (red) coupled model. (c) Shading shows D+4 SSTs from the coupled forecast initialised at 0UTC on 6 July 2014. Diamonds show the contemporaneous observations. (d) SST time-series from the (black) observations, (blue) uncoupled forecast and (red) coupled forecast at the location of a buoy with approximate position 22°N, 128°E.

Credit: Linus Magnusson

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.

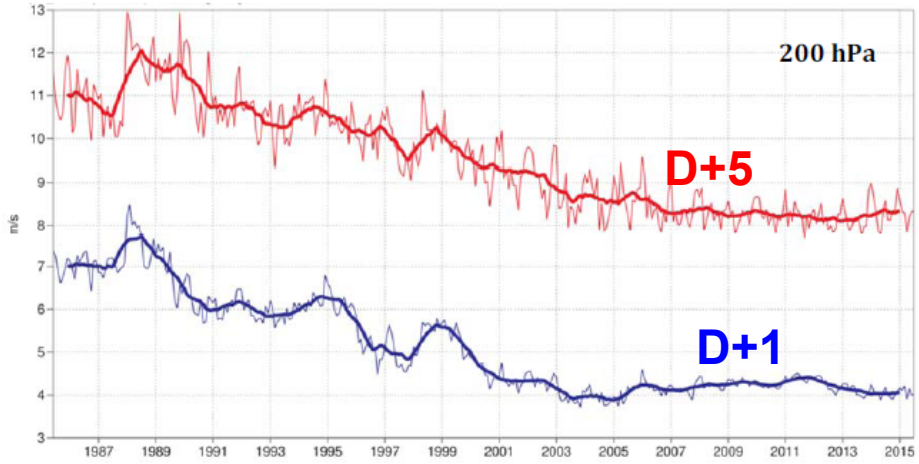
- Mean position error for HRES, Control models and ENS mean
- Mean intensity error (ME)
- Mean speed error (ME) for HRES
- Reliability and ROC for the Strike Probability Products
- ENS Spread & EM Error

★also available in technical memoranda document

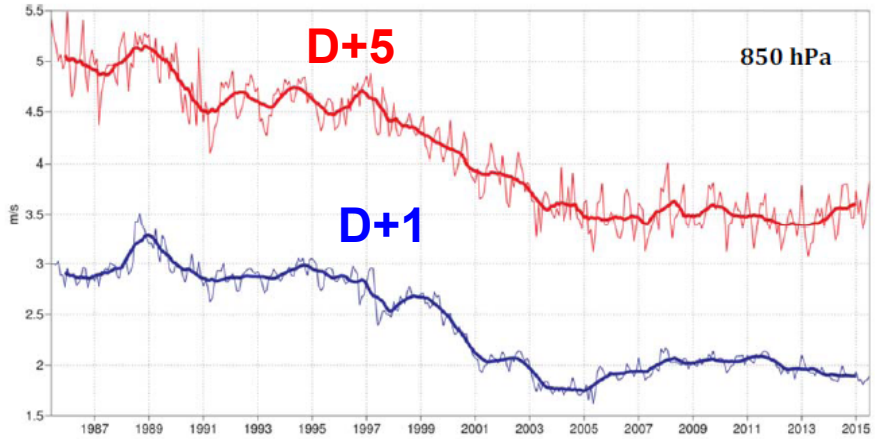
http://www.ecmwf.int/search/elibrary/?solrsort=ts_biblio_year%20desc&secondary_title=Technical%20Memorandum

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

RMS VECTOR WIND at 200 hPa



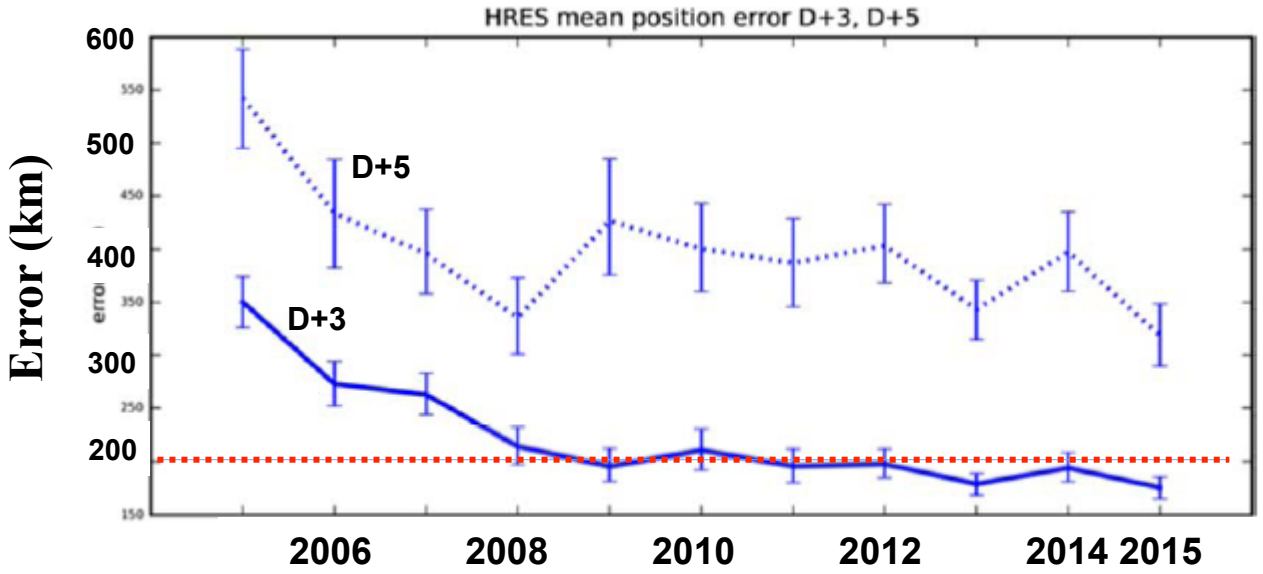
RMS VECTOR WIND at 850 hPa



ECMWF

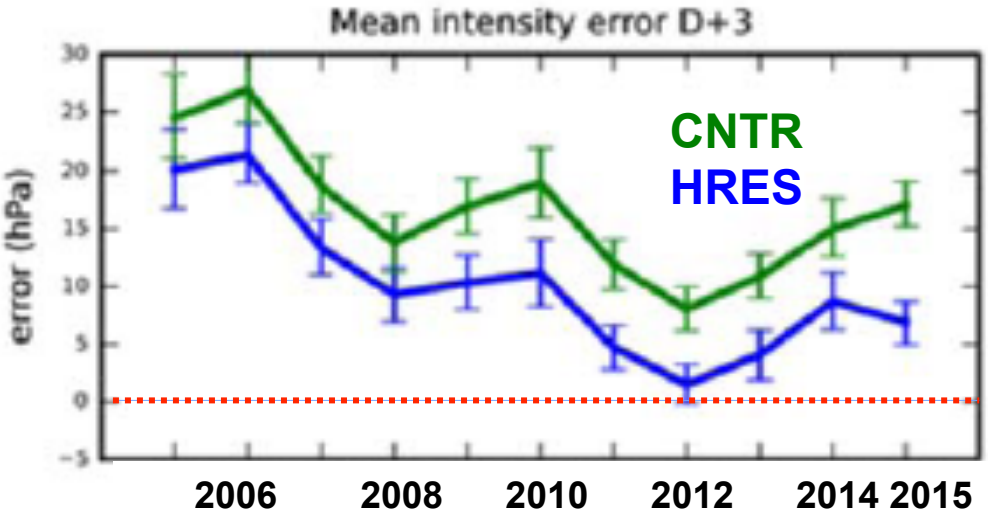
How accurate are the TC Fcs from ECMWF (Part II) ?

HRES verification (12 month means ending on 30 June)



position

intensity



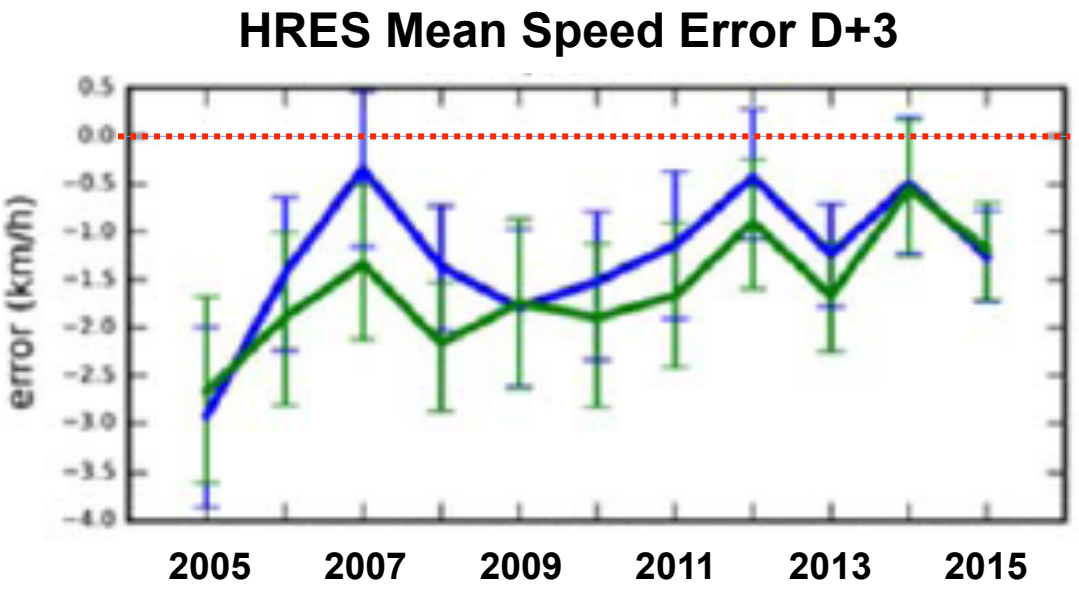
Error = Forecast – Obs
Obs from the best track reports

ECMWF

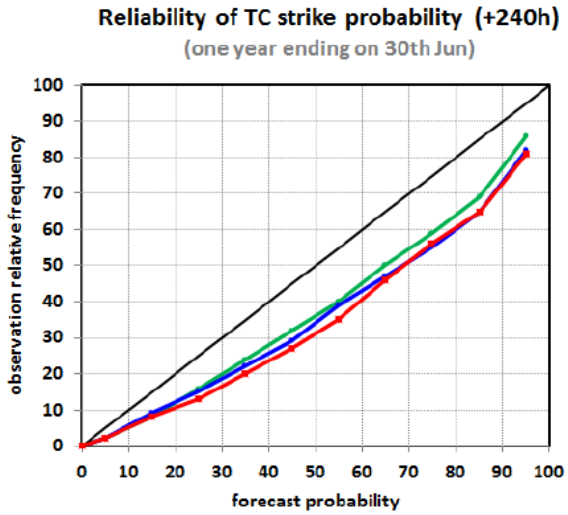
On average TCs move slower in the model (Part III)

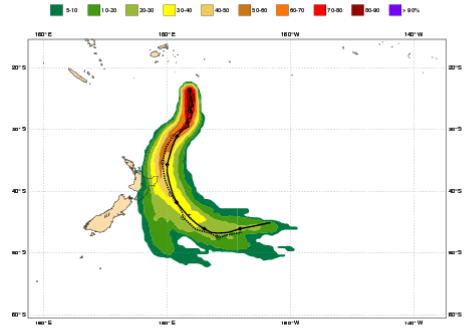
CNTR
HRES

2006

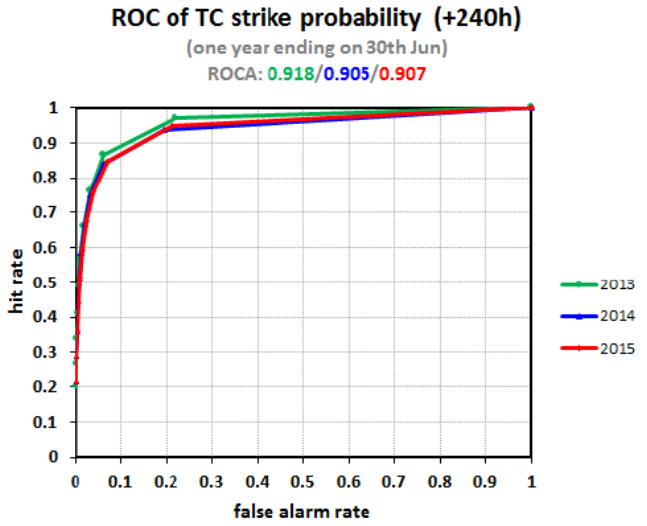


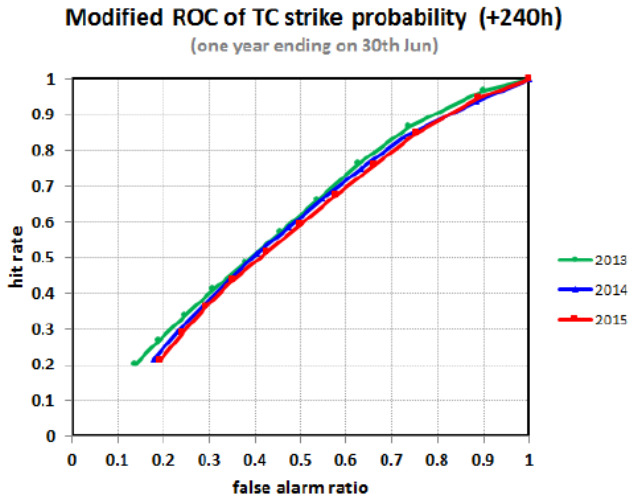
Verification of the ENS Strike Probability product (Part V)



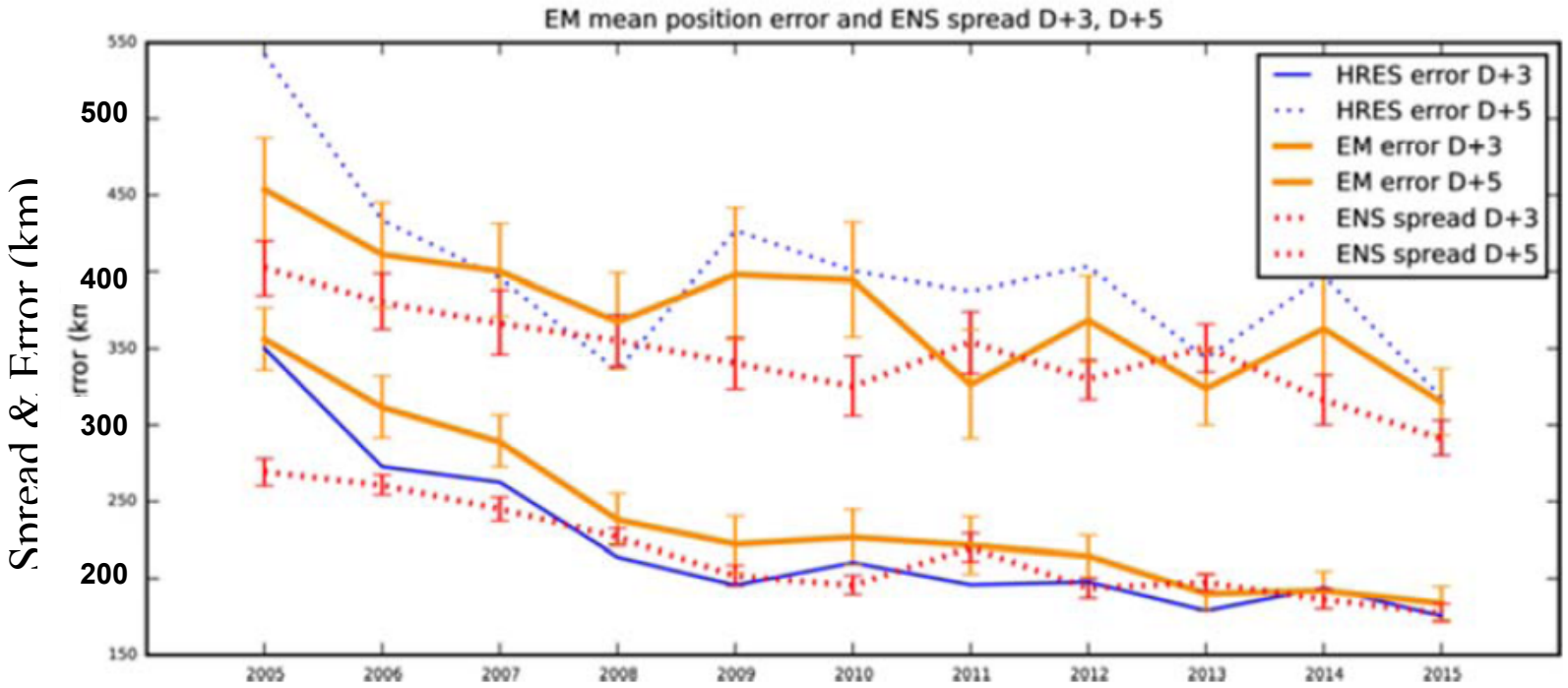


Strike probability of TC within 120 km in the next 10 days





ENS SPREAD & EM ERROR (Part VI)



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

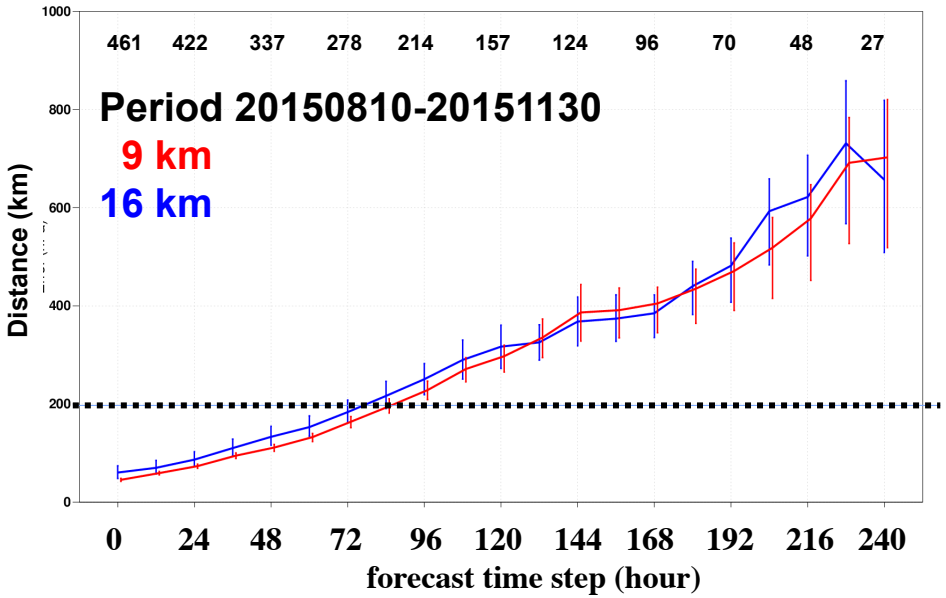
ECMWF

TC forecast performance T1279 v TCo1279

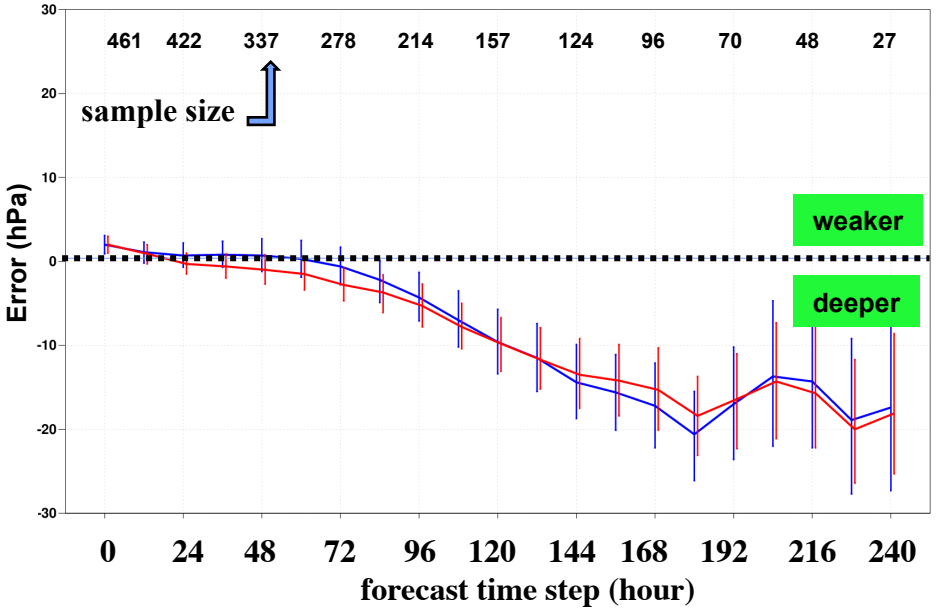
Next model upgrade (March 2016)

~16 km ~9 km

Position



Intensity



Error = Forecast – Obs
Obs from the best track reports

ECMWF

QUESTIONS?