ECMWF progress in tropical cyclone forecasts

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ECMWF

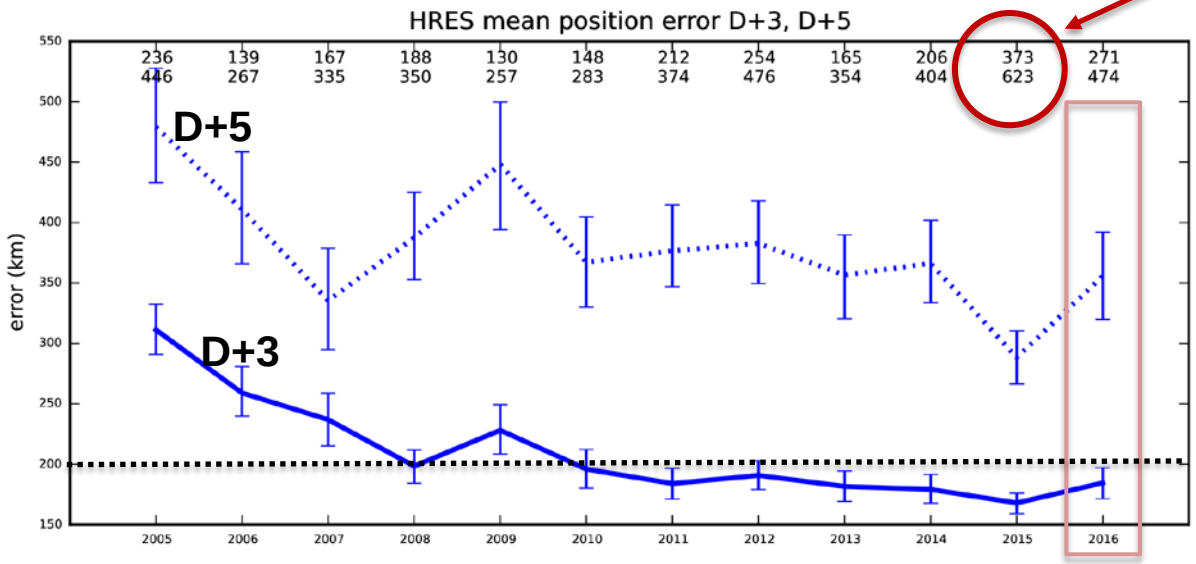
TC Forecast Performance [All Basins, 1-year period ending in 30 Nov]

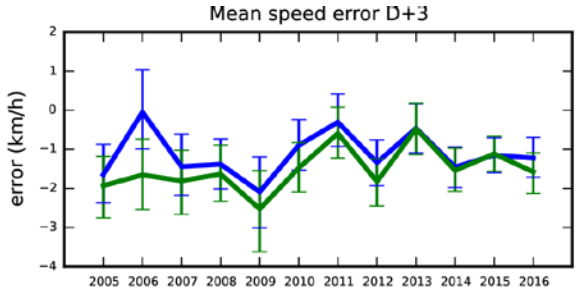
Position (HRES)

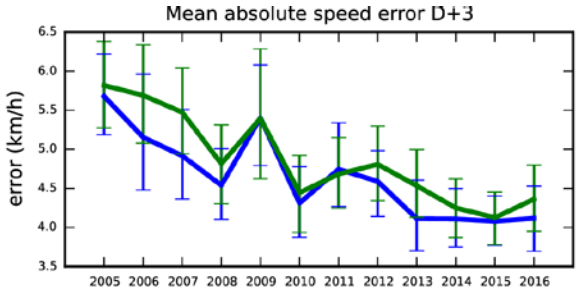
Unusually active Pacific TC season

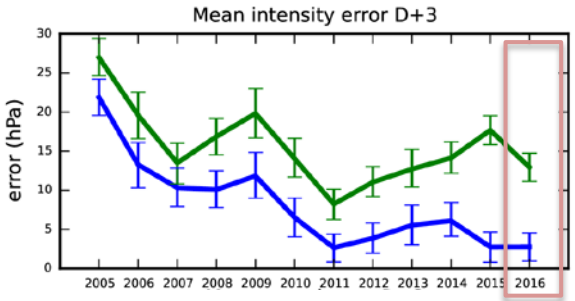
Speed

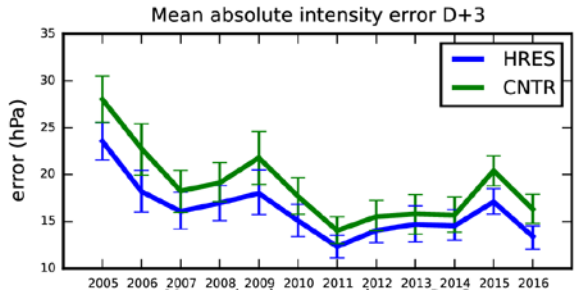
Current Operational IFS:
HRES T_{Co}1279 (~9km)
CNTR T_{Co}639 (~18 km)

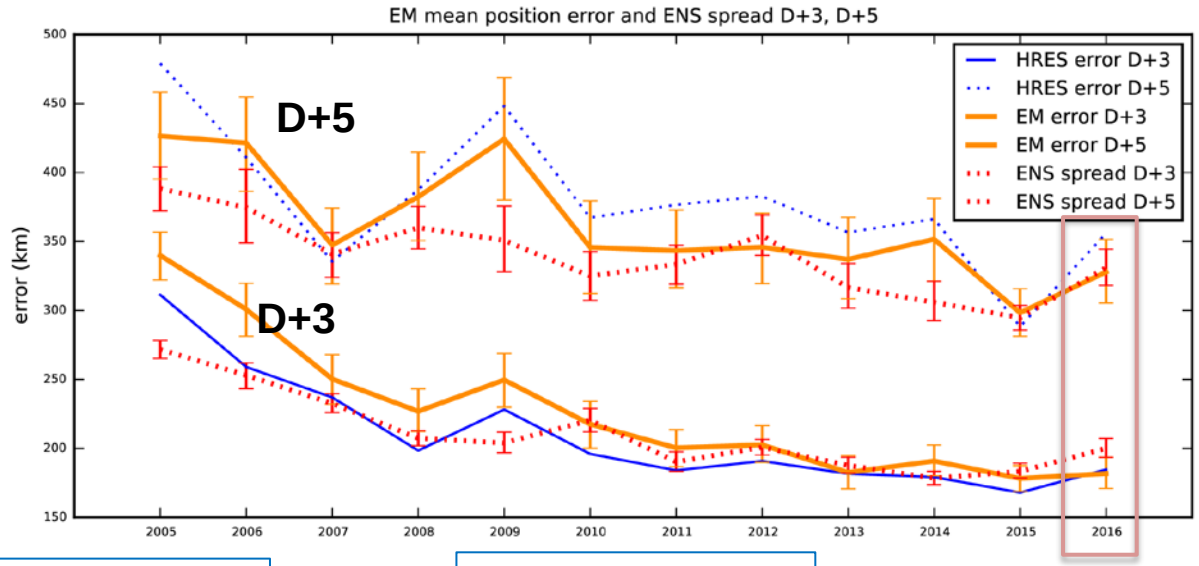












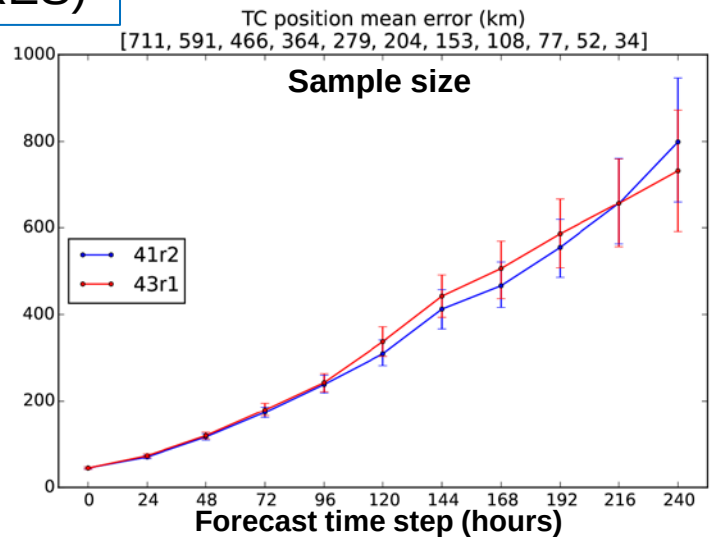
Central pressure

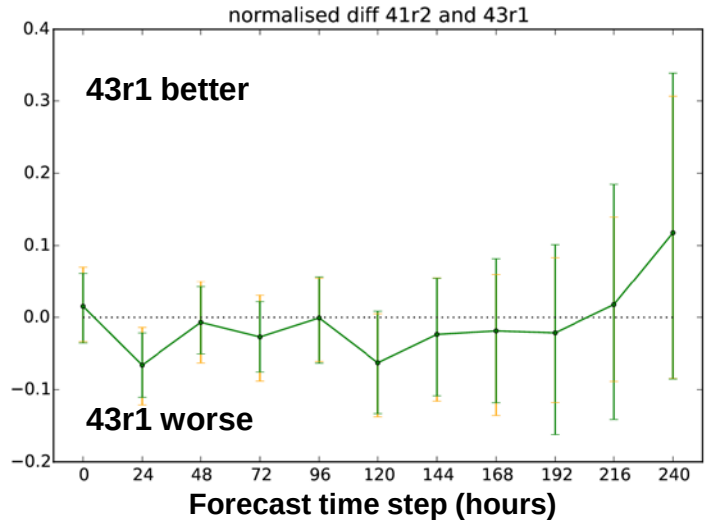
Position (ENS)

Recent Changes in IFS model:
22-11-2016 cycle 43r1
08-03-2016 cycle 41r2 (resolution)
12-05-2015 cycle 41r1

TC forecast performance between operational HRES (43r1) and previous cycle (41r2)

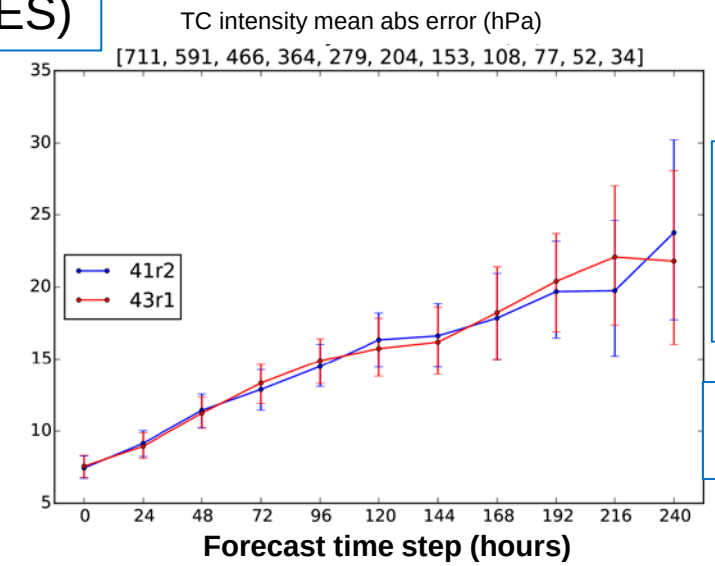
Position (HRES)





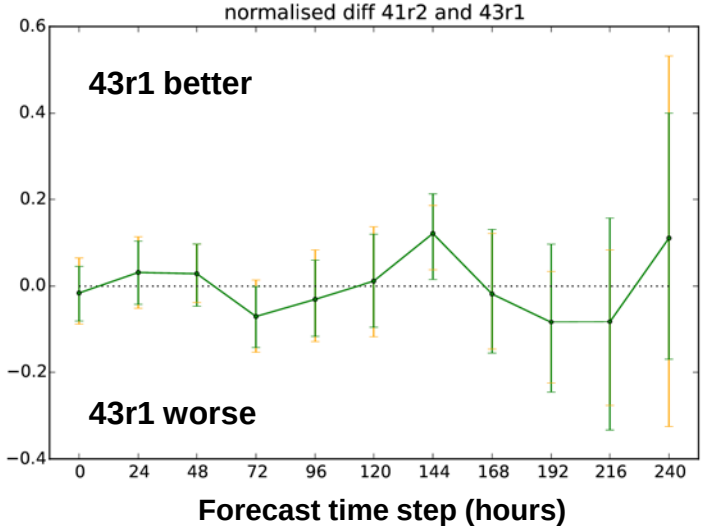
95% confidence interval (wiskers)

Intensity (HRES)



All Basins & homogeneous samples

Current Operational IFS:
HRES $T_{Co}1279$ (~9km)



Last model upgrade/Next model upgrade [Highlights]

Planned model changes can be found at: https://software.ecmwf.int/wiki/display/FCST/Planned+changes+to+the+forecasting+system

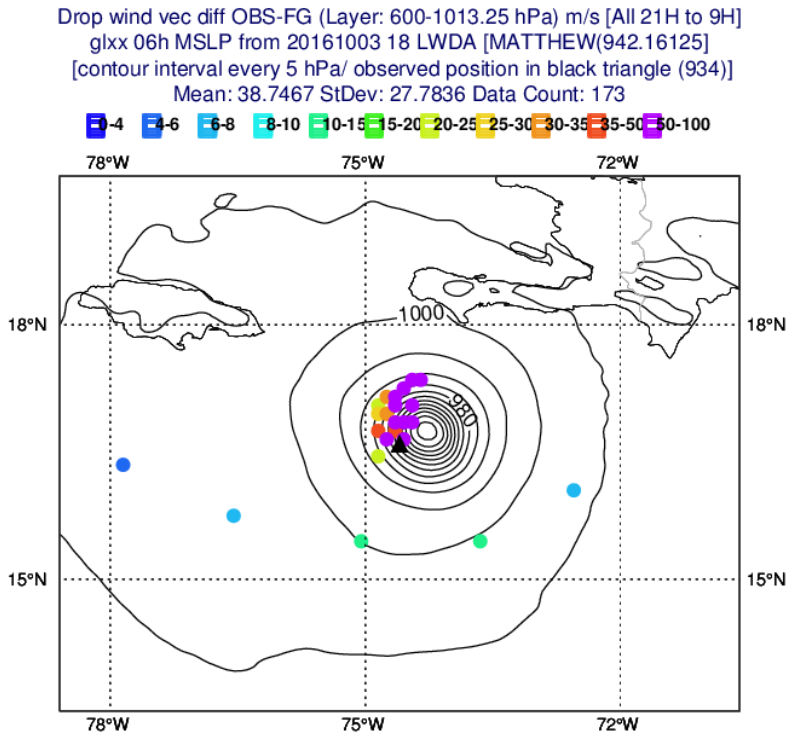
IFS 43r1 (22Nov2016)	IFS 43r3 (this Summer)
Assimilation • The sea-surface temperature (SST) perturbations used in the EDA have been upgraded • The EDA-derived background error estimates used in 4DVARare now computed at spectral resolution T_L399 (previously T_L159) and a new wavelet-based filtering algorithm is used to control sampling noise.	**Assimilation** • Bug fix in the first soil layer temperature analysis • Wavelet filter for EDA humidity variances
Observation • Radiance assimilation will now take the viewing geometry more fully into account, by evaluating the radiative transfer along slantwise paths (instead of vertically). • The channel selection for the hyperspectral infrared instrument CrIS has been revised (now uses 117 rather than 77 channels)	**Observation** • QC for GPS-RO • Consolidate use of microwave sounder channels over land and sea ice • Code for Constrained Variational Bias Correction for radiances
Model Changes • A new CAMS ozone climatology is now used, consisting of monthly means of a re-analysis of atmospheric constituents (CAMSiRA) for the period 2003 to 2014. • Changes to boundary layer cloud for marine stratocumulus and at high latitudes. • Modifications to surface coupling for 2 metre temperature.	**Model Changes** • New radiation scheme • New aerosol climatology (CAMS) • Mixed-phase convection allowing super cooled water in the convection scheme
Medium Range ENS • The horizontal and vertical re by ENS is increased from 1 de (ORCA025Z75). • An interactive sea-ice model introduced so that sea-ice cover evolves dynamically. Previously it was persisted for 15 days; over the next 30 days of the forecast, it was relaxed towards the climatology of the previous 5 years. • Ocean initial conditions are taken from ORAS5 instead of ORAS4	

On 7 March (last week), ECMWF started disseminating medium-range probabilistic forecasts to its users 40 minutes earlier than before.

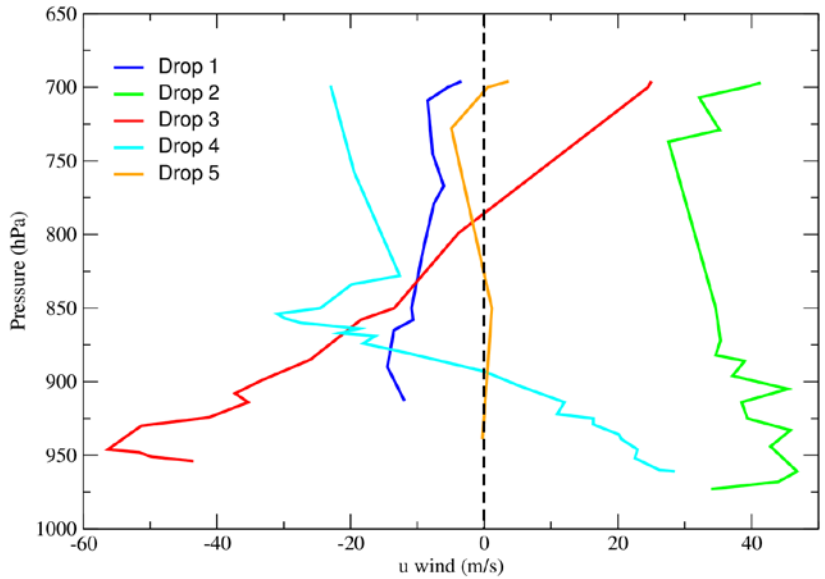
Tropical Cyclone Initialisation – known issues I

Matthew
04/10/2016

MSLP background (CI 5hPa)
Wind vector departures (colour symbols)
TC position (▲)

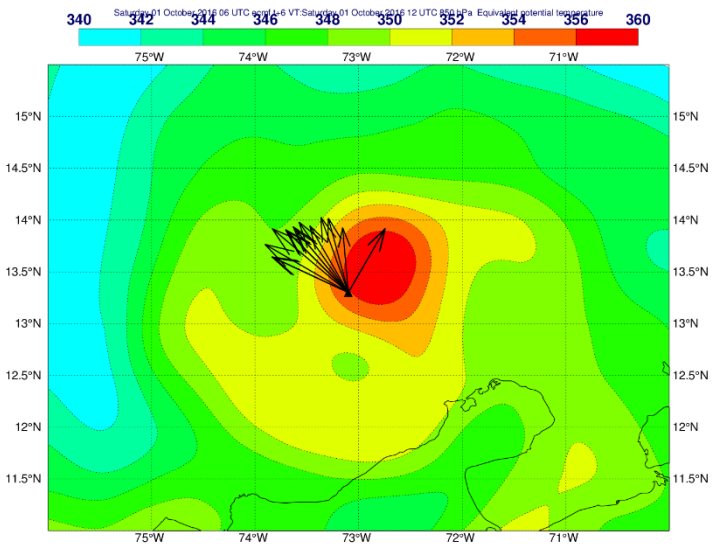


Dropsondes, U wind 01/10/2016 12UTC



Dropsonde data are assimilated assuming a fixed horizontal position and time, which makes more difficult to use them.

Known issues I - near eyewall dropsondes



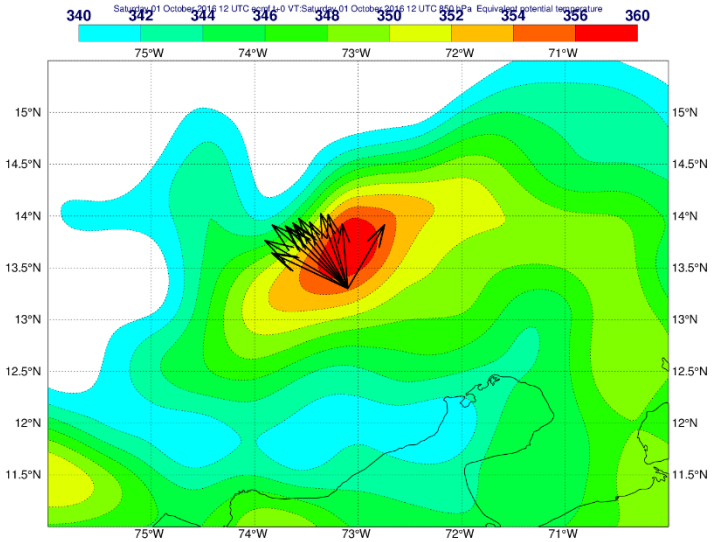
Matthew, 2016-10-01 12UTC

Wind vectors drop #3

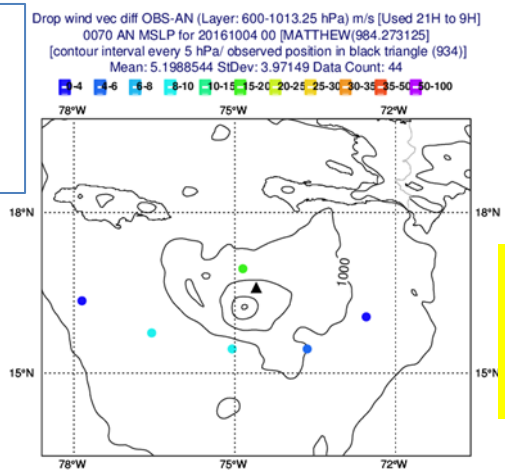
LWDA +6h theta-e (θ_e) 850 hPa (shade)

ANALYSIS

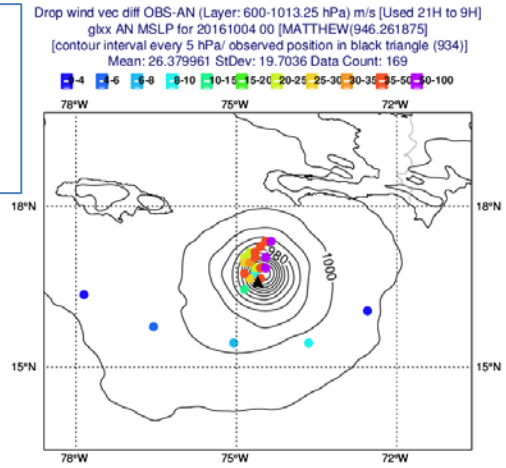
Analysis adjusts towards approximate thermal wind balance, generating a “frontal” deformation



Operational ANALYSIS (43r1)
MSLP background (CI 5hPa)
Wind vector departures (colour symbols)
TC position (▲)
VT: 20161004 00Z



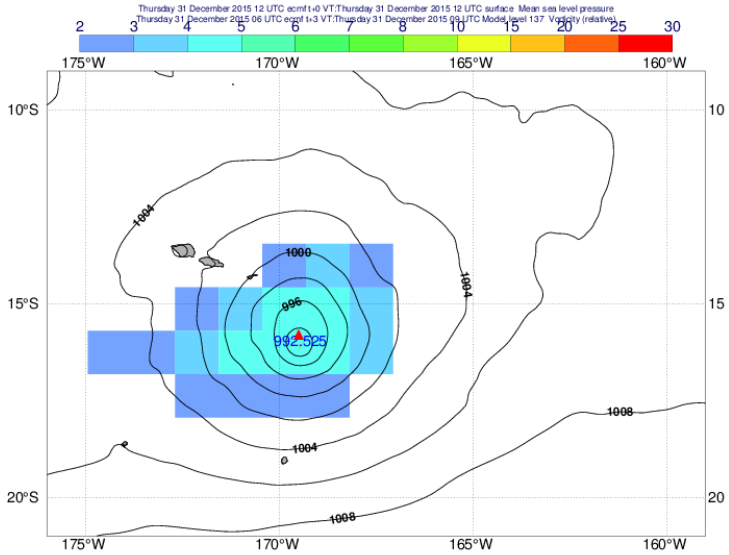
ANALYSIS (43r1) <u>with Adaptive Obs errors</u>
MSLP background (CI 5hPa)
Wind vector departures (colour symbols)
TC position (▲)
VT: 20161004 00Z

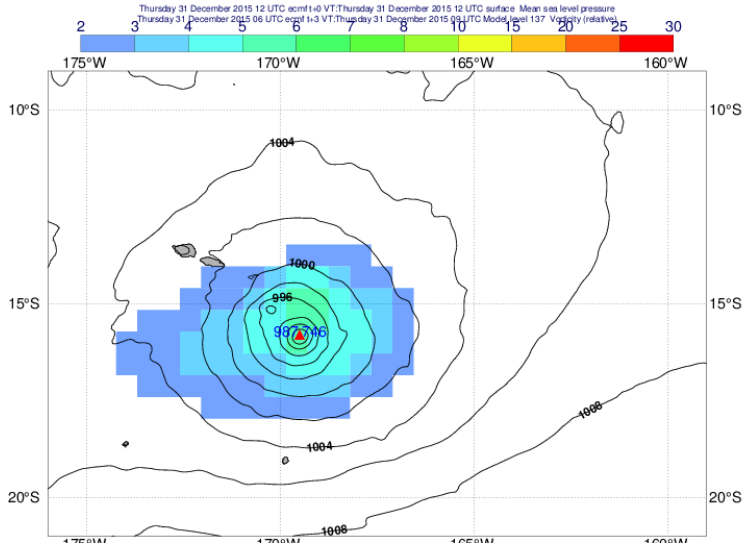


The inclusion of track (position/time) droposonde metadata in the BUFR reports may benefit the TC assimilation in the future.

Known issues II – Double centres in TCs

41R1
TL399 EDA
TL159 Errors

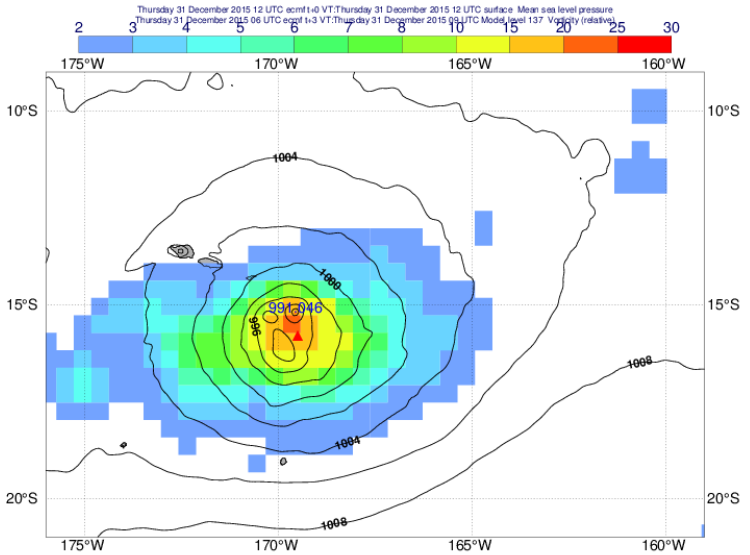




41R2
TCo639 EDA
TL159 errors

Ensemble **D**ata **A**ssimilation consists of 25 members

TC ULA 31-12-2015 12Z
ANALYSIS MSLP (CI 2 hPa)
EDA-derived background errors (shades) of lowest model level vorticity

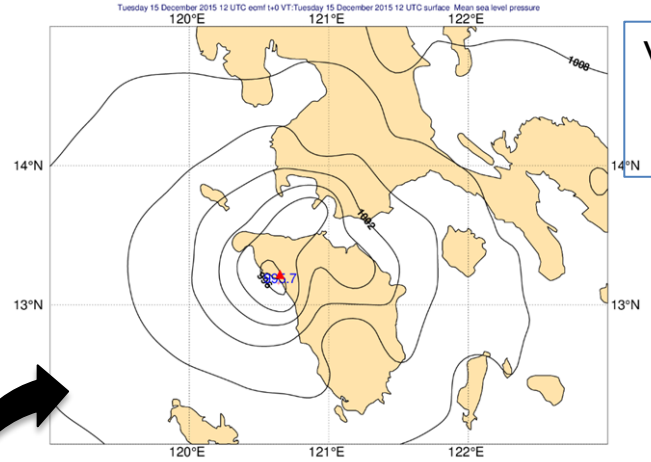


43R1
TCo639 EDA
TL399 errors

Occasionally, the background errors pdfs show multi-modal patterns near TCs
This seems to be connected to the increase of resolution of background errors estimates

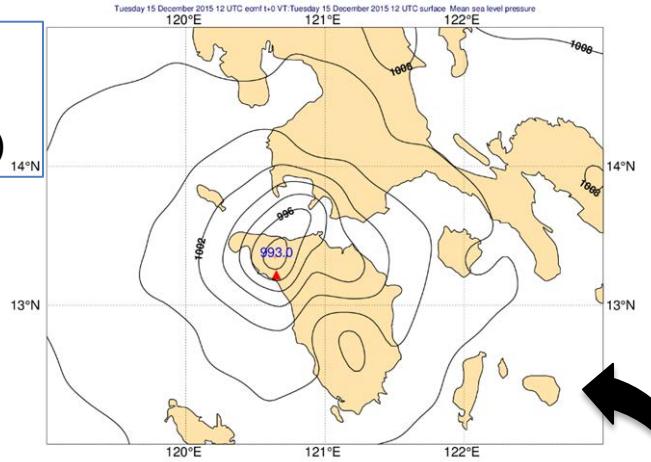
Known issues II – Double centres in TCs

43r1 (Operational, TL399 BG)

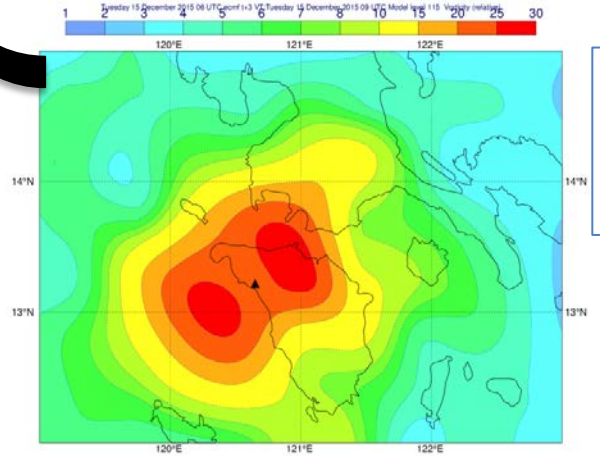


VT: 20151215 12UTC
MSLP **AN** (CI 2 hPa)
TC report position(▲)

43r1 (w/ TL159 BG errors)

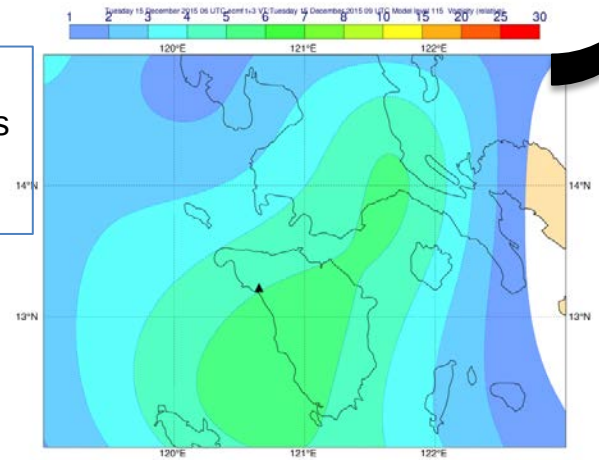


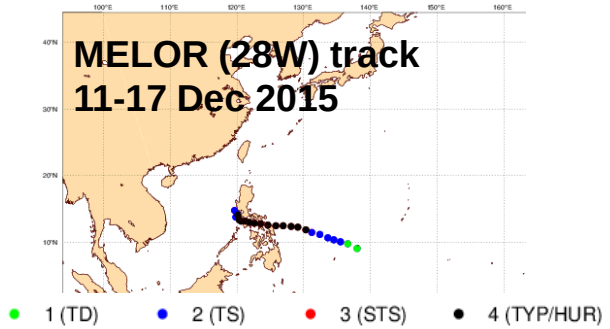
43r1 TL399



VT: 20151215 09UTC
Vorticity Background Errors
~850hPa (shades)
TC report position (▲)

43r1 TL159

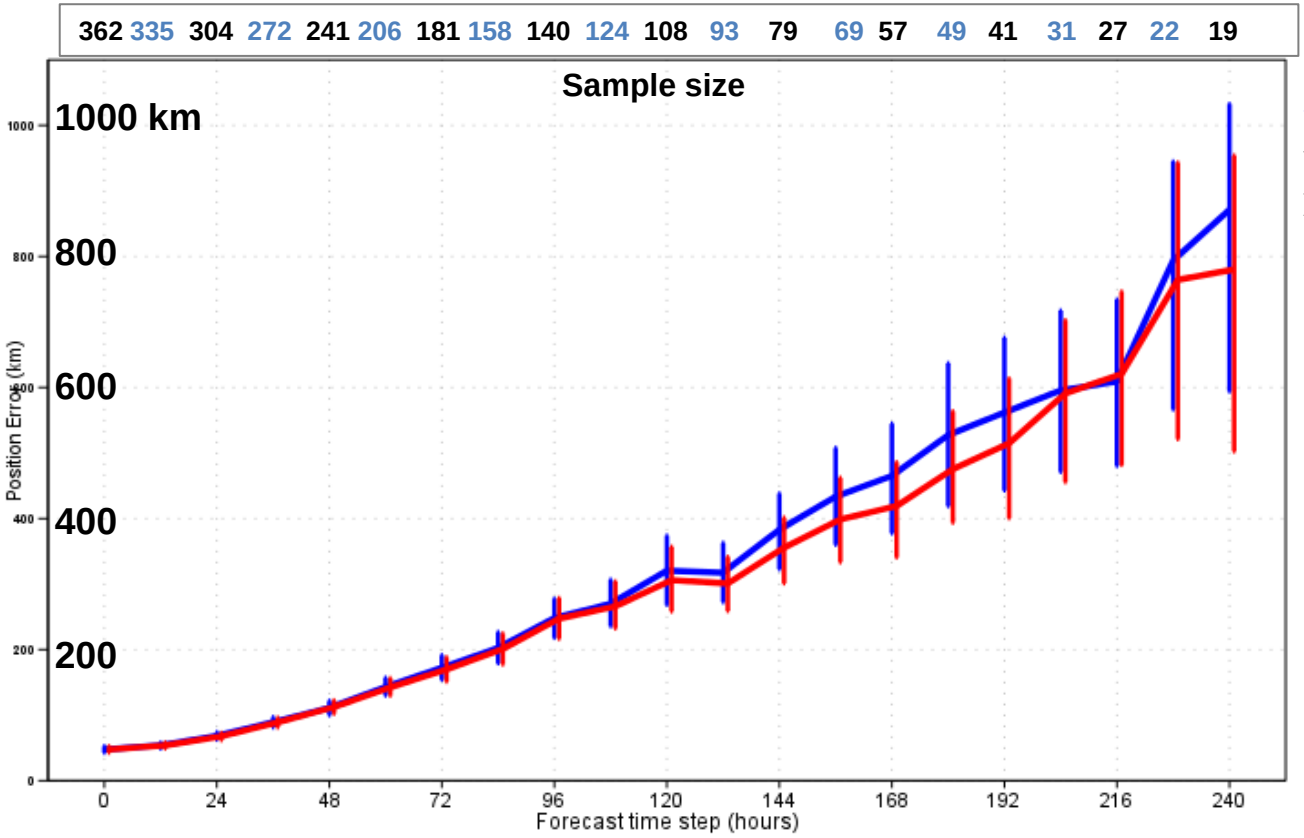




Spatial structure of background errors determine to a large extent structure of analysis increments

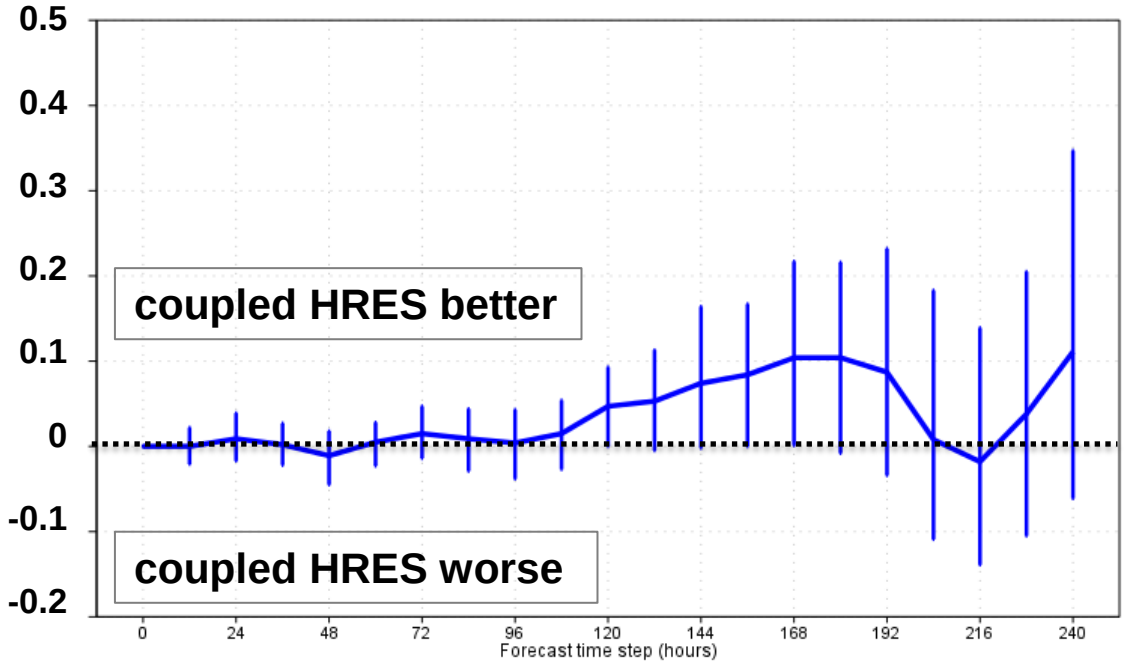
Incremental 4D-Var can only cope with moderate amounts of non-Gaussianity and non-linearity

Atmosphere-Ocean Coupled model (Full Coupling)



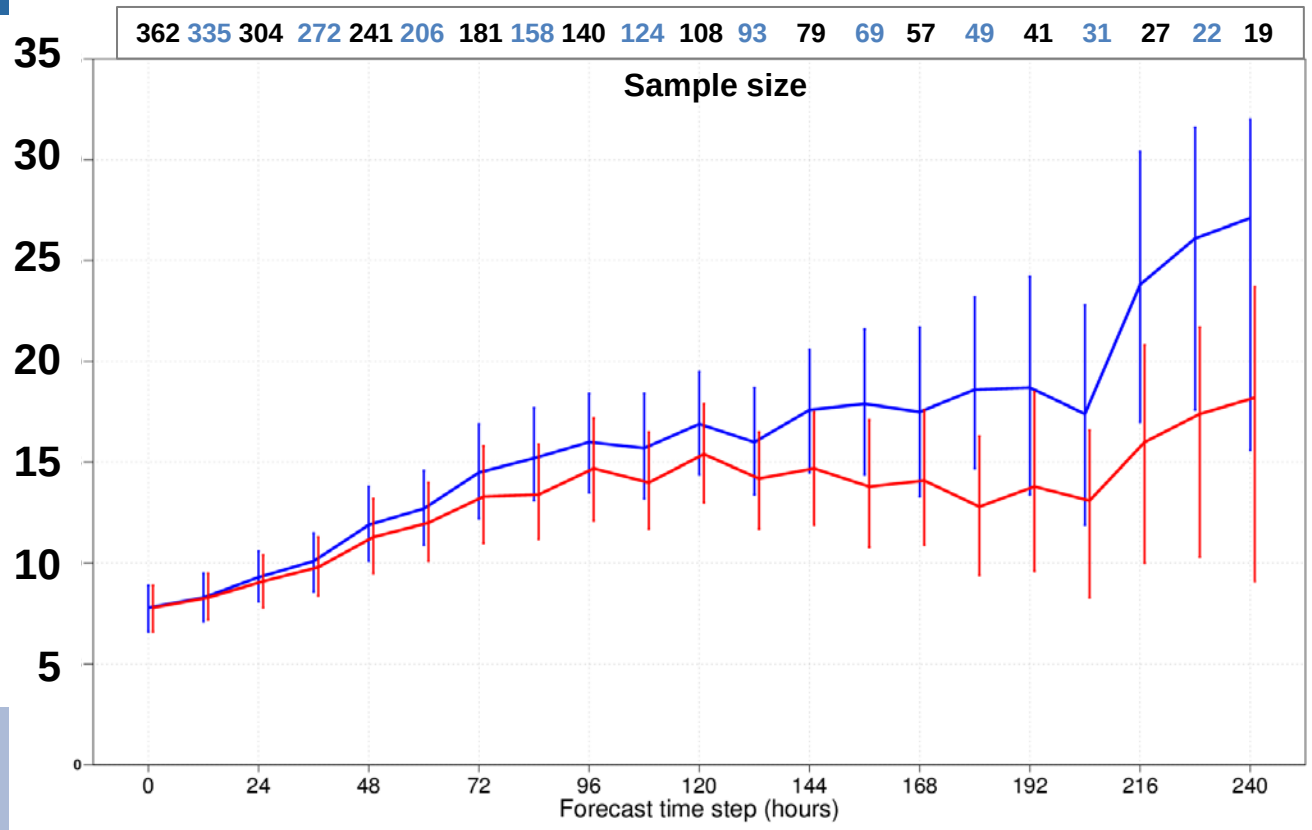
Uncoupled & **Coupled** HRES (~9 km) TC forecast of the mean position error (km)
VT: 2016-05 to 2017-01 (homogeneous samples/all basins)
Bars: 95% confidence interval

Normalised difference between Coupled and Uncoupled HRES



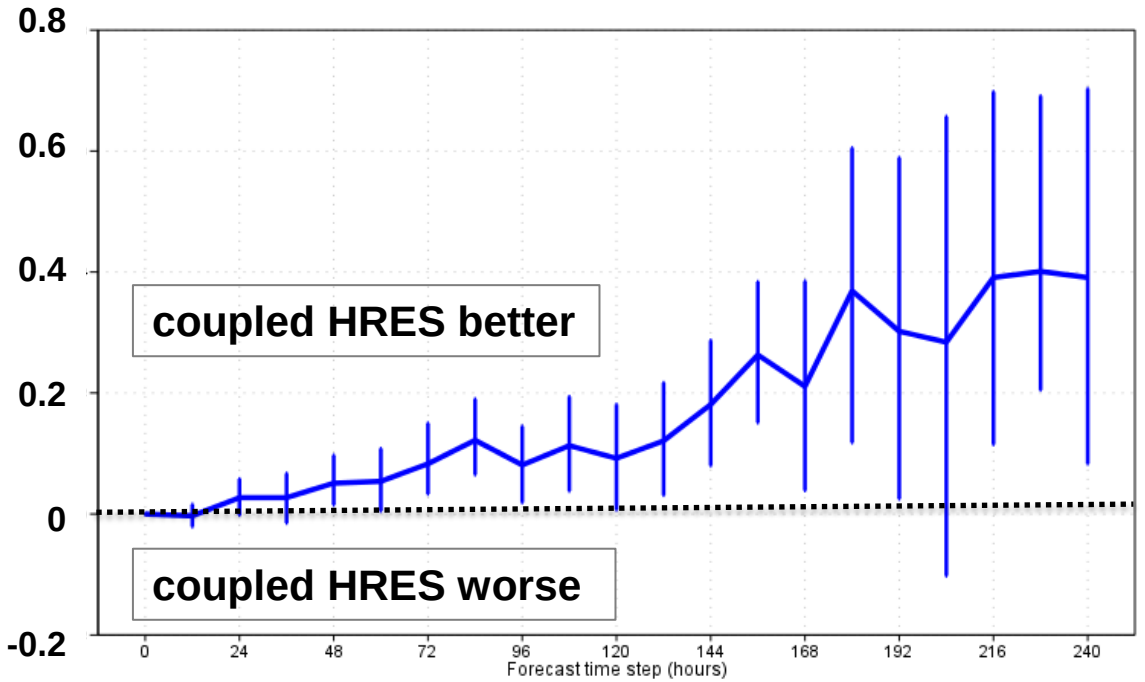
An investigation of the performance of IFS coupled atmosphere-ocean model in NW Pacific by K Mogensen et al. can be found in a tech memo at http://www.ecmwf.int/sites/default/files/elibrary/2017/16980-tropical-cyclone-sensitivity-ocean-coupling.pdf

Atmosphere-Ocean Coupled model (Full Coupling)

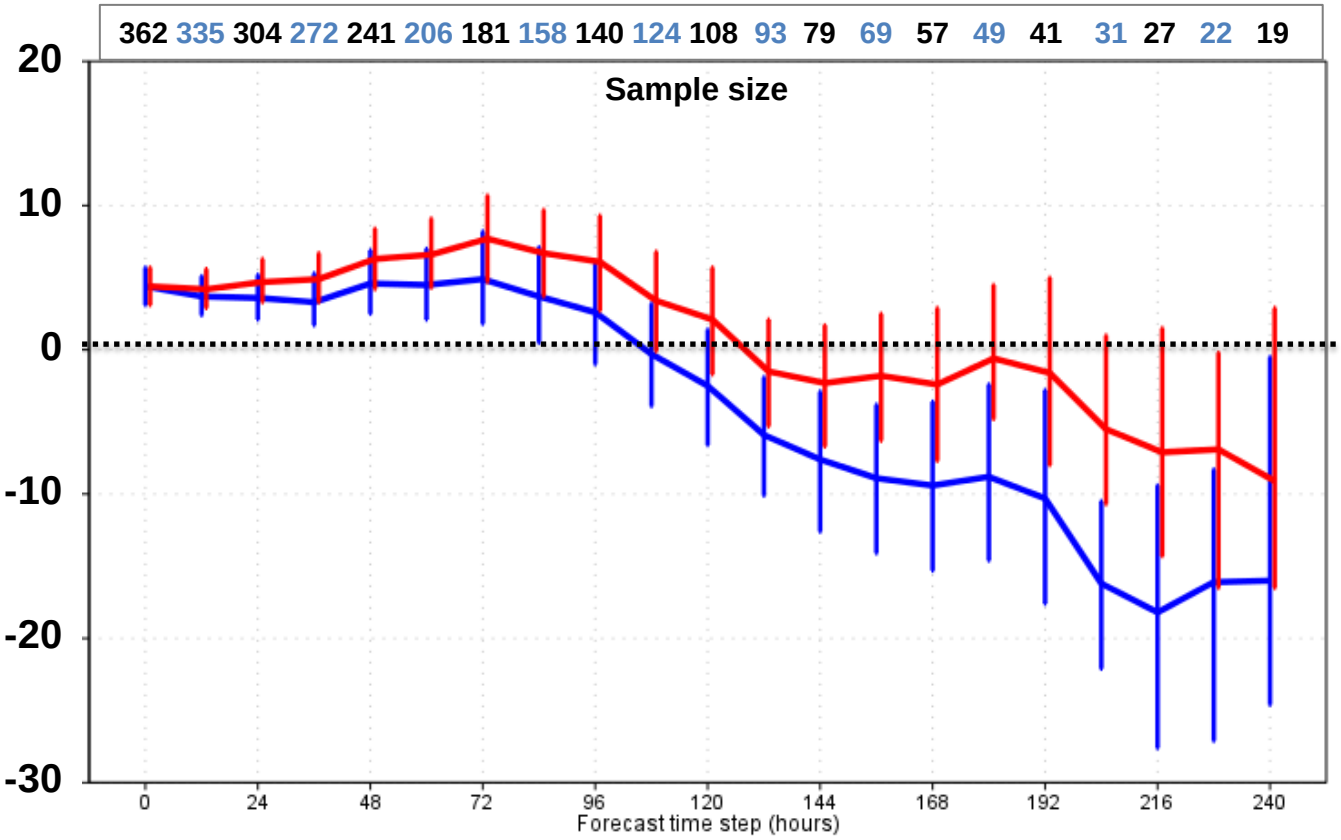


Uncoupled & **Coupled** HRES TC forecast of the mean absolute intensity error (hPa)
VT: 2016-05 to 2017-01 (homogeneous samples/all basins)
Bars: 95% confidence interval

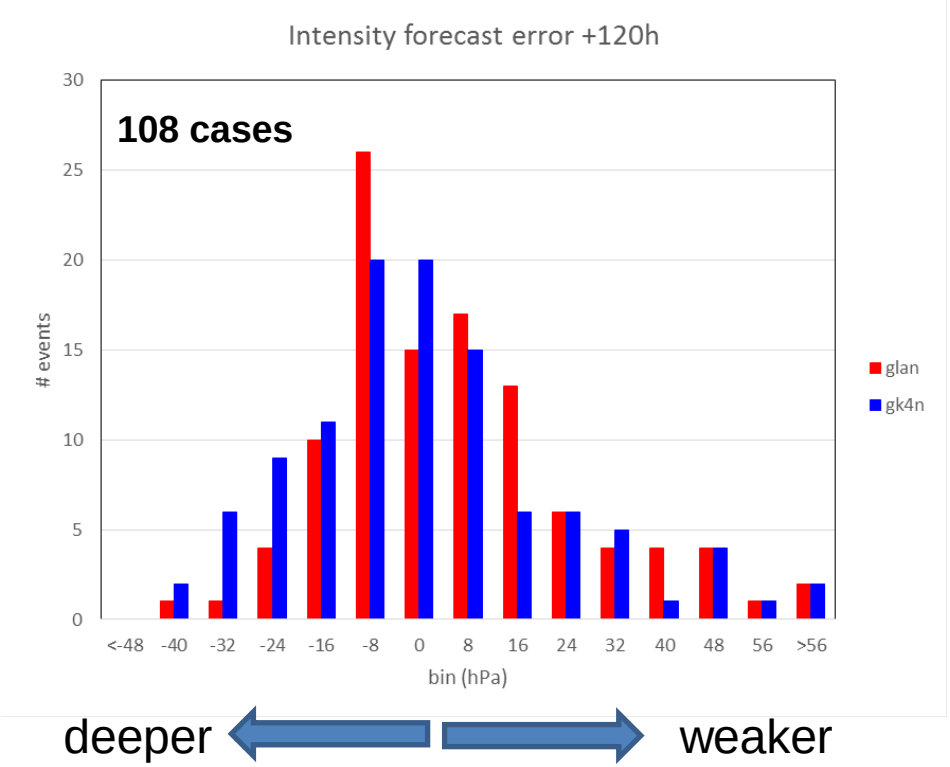
Normalised difference between Coupled and Uncoupled HRES



Atmosphere-Ocean Coupled HRES (Full Coupling)

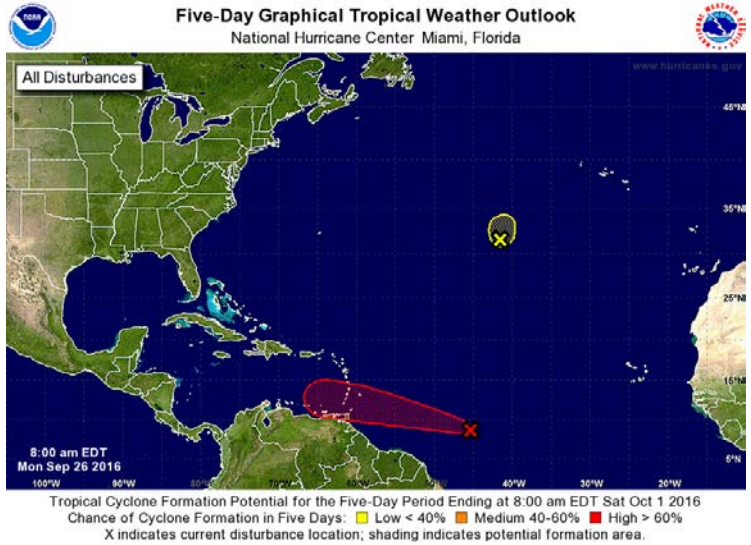


Uncoupled & **Coupled** HRES TC forecast of the mean intensity error (hPa)
VT: 2016-05 to 2017-01 (homogeneous samples/all basins)
Bars: 95% confidence interval

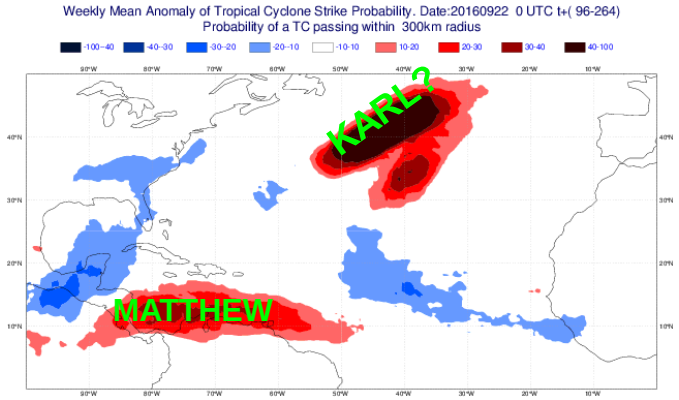


To assess the impact of “partial coupling” atmosphere-ocean configuration (HRES) before implementation in operations (work in progress).

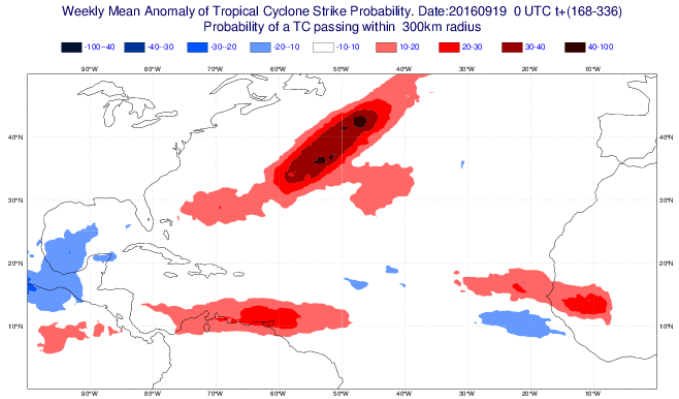
ECMWF TC Products



26 Sept 2016



22@00 Day 11

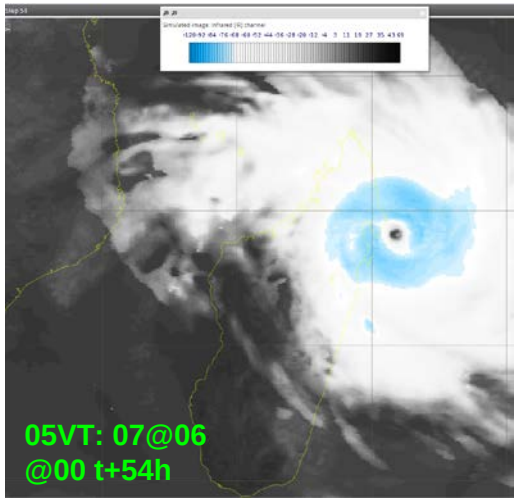


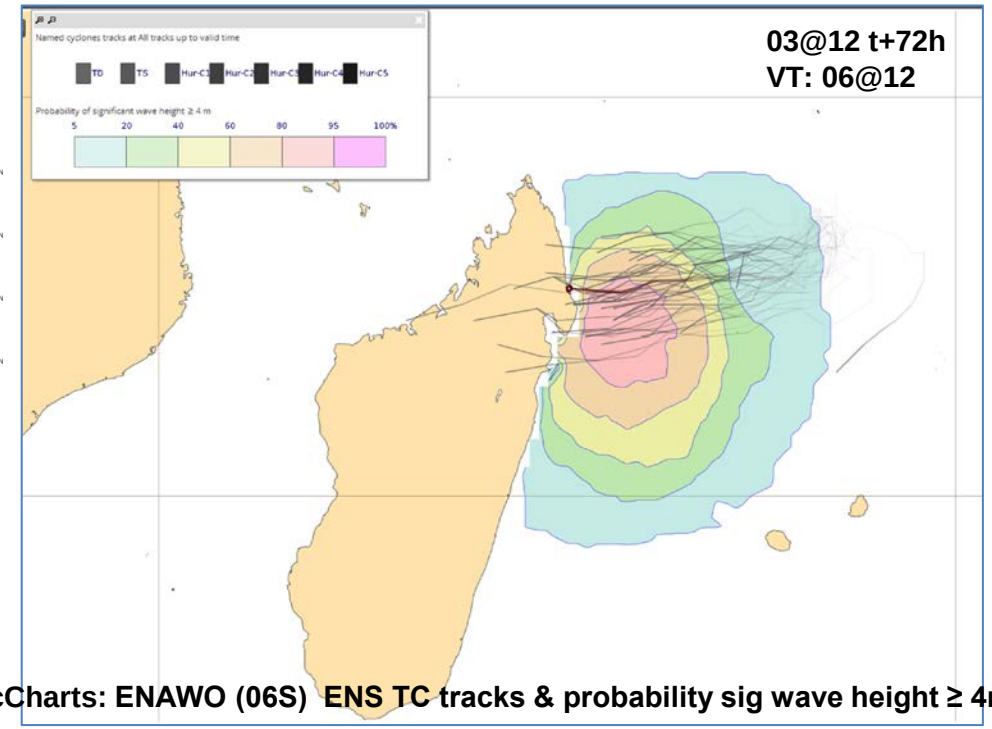
19@00 Day 14

Weekly mean anomaly of TC strike Probability (based on Model Climate TC frequency)

Emphasize the regions of enhanced/reduced TC activity

ecCharts: Sim. Satellite Image (IR channel) HRES ENAWO (06S)

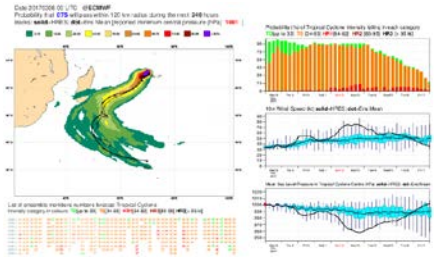


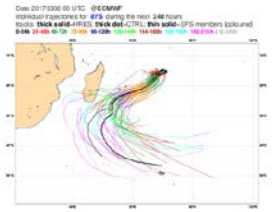


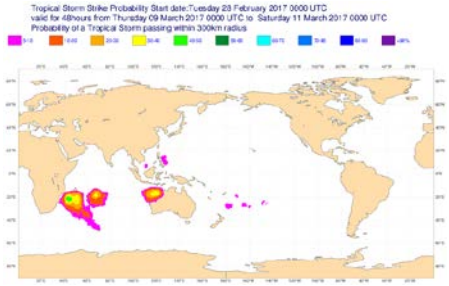
ecCharts: ENAWO (06S) ENS TC tracks & probability sig wave height ≥ 4m

ECMWF TC product list

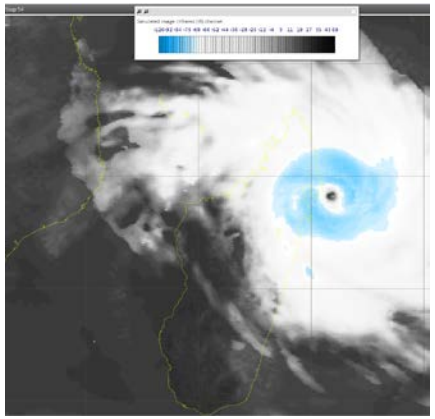
(in graphical layout and/or binary format)



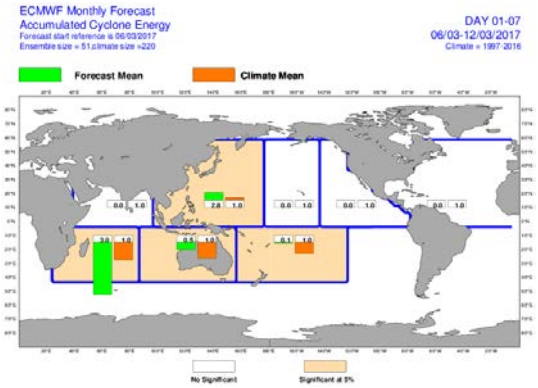


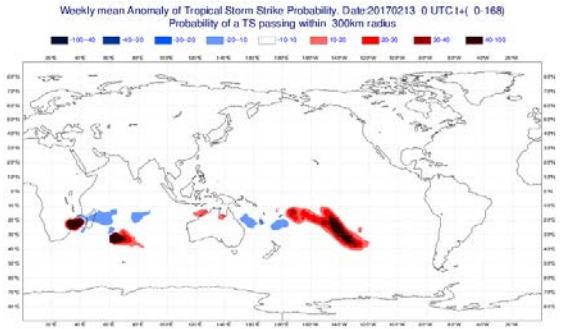


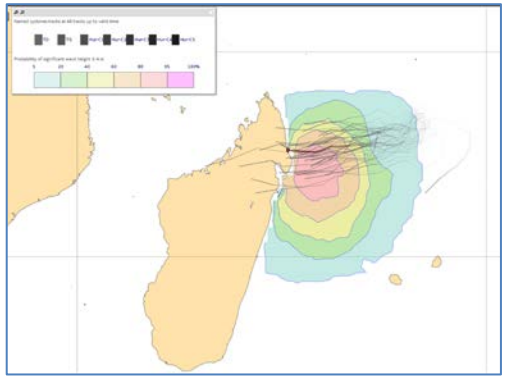
- Medium range forecast
  - Track forecasts up to +240h (HRES and ENS) for existing tropical cyclones and TCs that develop during the forecast
  - Strike probability maps (genesis) for TCs, TSs & HRs up to +240h



- Extended range forecast (up to 32 days)
  - Weekly mean strike probability of TCs, TSs & HRs
  - Weekly mean probability anomalies of TCs, TSs & HRs and Model Climate.
  - Weekly mean ACE and Storm Frequency by TC basin







Thank You