ECMWF Progress in tropical cyclone forecasts

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Linus Magnusson and colleagues

ECMWF

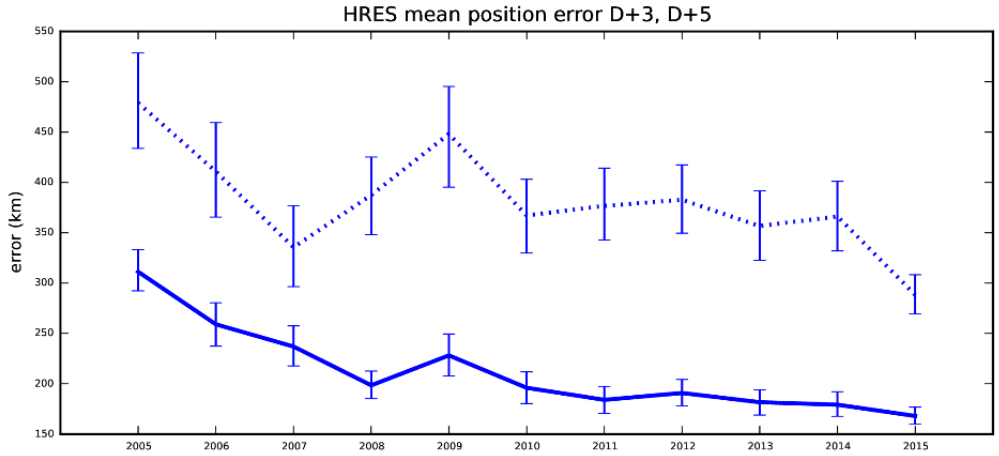
TC Forecast performance

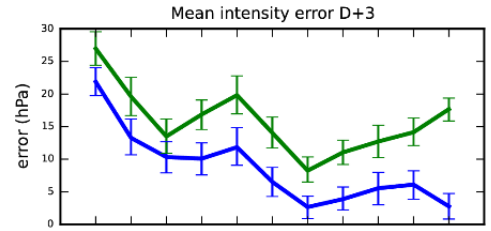
Position

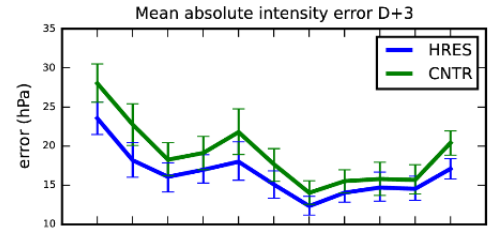
Central pressure

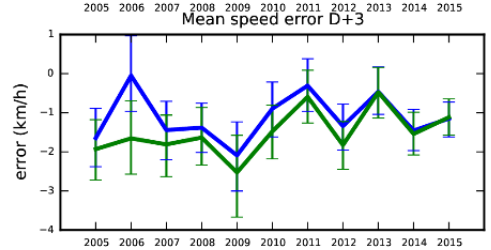
Speed

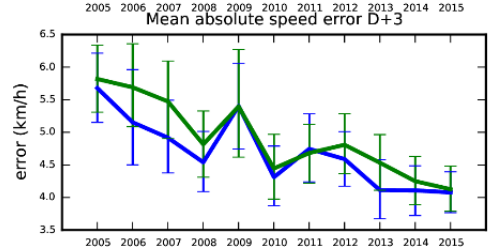
ENS position error/spread

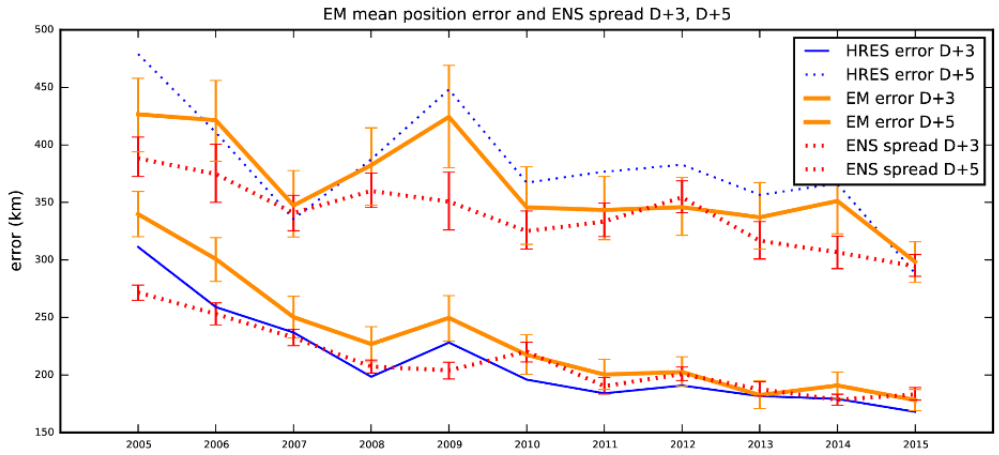












New model upgrade 8 March 2016

Data Assimilation

EDA configuration:
Resolution TL639 forecast/outer loop, TL191/TL191inner loops.
Timesteps 900s outer loop, 1800s inner loops.
Simplified linear physics used in first inner loop.
New climatological B's evenly sampled from ~41R1 TL399 EDA's every 5.5 days Jan-Oct 2014.
Compute hybrid B by adding samples from latest EDA forecast (weight 0.3) to static climatological B (weight 0.7).
Cycling flow-dependent errors and B =>
=> Saving on iterations in first minimization (70 down to ca. 30) by disabling randomization.
Background error covariance calculation 5 times faster due to hybrid B (fewer states) and code optimizations.
4DVAR configuration:
Inner loop resolutions TL255/TL319/TL399.
Timesteps inner loops 1200s/1080s/900s.
Conventional data:
Implementation of Sonntag saturation vapour equation in observation operators.
Assimilation of aircraft humidity.
Increased use of BUFR TEMP, SYNOP and drifter data (BUFR gradually replacing alphanumeric by blacklist changes).
Surface analysis:
Introduce BUFR SYNOP in LDAS (T2m, RH2m and snow).
Introduce a new ssa blacklist.
Introduce lapse rate for T2m altitude correction.
Technical infrastructure to enable operational assimilation of SMOS data (passive).
COPE: Contributions to observation pre-processing, including Sonntag eqn.
AEOLUS: Aeolus L2B/C processing and L2/Met PF scripting changes. Passive and bit-identical if Aeolus off.
Optimizations: Further optimization of the data assimilation suite and IFS.
OOPS: Further technical development.

Satellite Section

Activate F-18 humidity sounding channels over ocean and extend all-sky assimilation to snowy land surfaces
Passive code updates to allow FY3-C monitoring
Passive code updates to allow all-sky ATMS
RTTOV coefficient files for microwave instruments: move to 54 levels and improved 22 GHz spectroscopy
AMSU-A sensor & situation dependent observation errors (v I)
AMSU-A sensor & situation dependent observation errors (v II)
CRIS activation - g98u g98v
Improved IASI aerosol screening -
GPSRO observation error increased 25%
Preparations for passive AMV monitoring
AMV blacklist relaxation
Extend acceptable GEO zenith angle from 60 to 64 degrees (greater high latitude coverage)
Allow Meteosat mid-height IR winds
Hourly time-window shift for GOES
Additional bit-reproducible changes
RTTOV v11.2 technical upgrades (but not v11.2 changes that induce numerical differences)
Meteo France / L-F Meunier technical upgrades including performance fix to RTTOV coef reading
Minor change to MWRI thinning parameters (not active unless MWRI is monitored)
Preparations for all-sky infrared
AMSU-A new obs errors tidied up and read from file

Ensemble Prediction

Prepare SKEB for horizontal resolution upgrade and spectral viscosity (passive)
Enable computation of singular vectors on cubic grid (technical/passive)
New ozone scheme (Monge-Sanz et al., 2011, ACP) (passive)
Changes for relaxation and multi-year runs (technical)
Revised options for vertical diffusion in stratosphere (passive except for type longrange)

Marine Prediction

Wave model:
Unstructured grid option.
Optimisations for the input/output.
Technical changes to move wave data assimilation in a different trajectory
Ocean model:
IFS-NEMO coupled model changes + NEMOVAR assimilation changes

Numerical Aspects

Increase 3 to 5 iterations for SL departure points
Redefine convective adjustment timescale by grid area
Algorithmic and structural improvements in the mass fixing package.

Physical Aspects

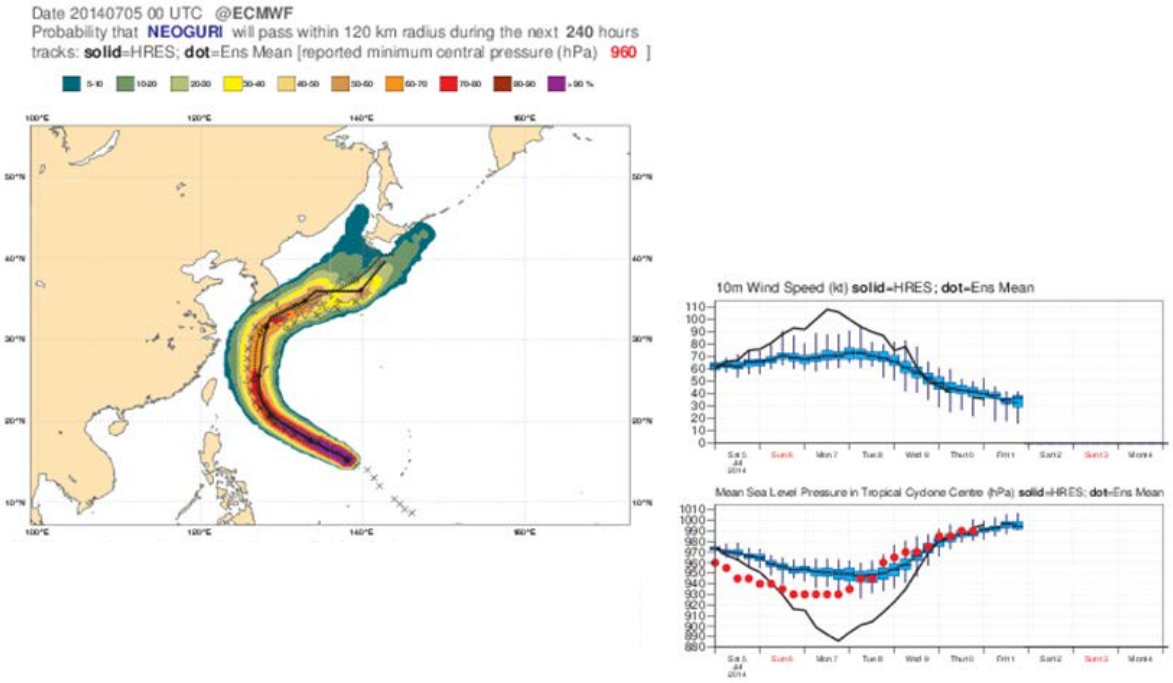
Radiation-surface LW/SW updating
Radiation-surface LW tiling
Surface snow fixes
New freezing rain physics and additional diagnostic for accumulation
VDF/convection cleaning and detrainment of snow
Resolution dependent non-orog GWD
Increased erosion rate for convective points
TL/AD non-orog GWD
TL/AD snow fix
Updates for Single Column Model
TL/AD surface & VDF
New snowfall sublimation and ice deposition physics options (passive)
New MACC aerosol climatology (passive as switched off)
Lake fractional ice + update lake "soil" T
Increased roughness over snow/veg
Option for CRM superparametrization
Changes to allow Single precision

Chemical Aspects:

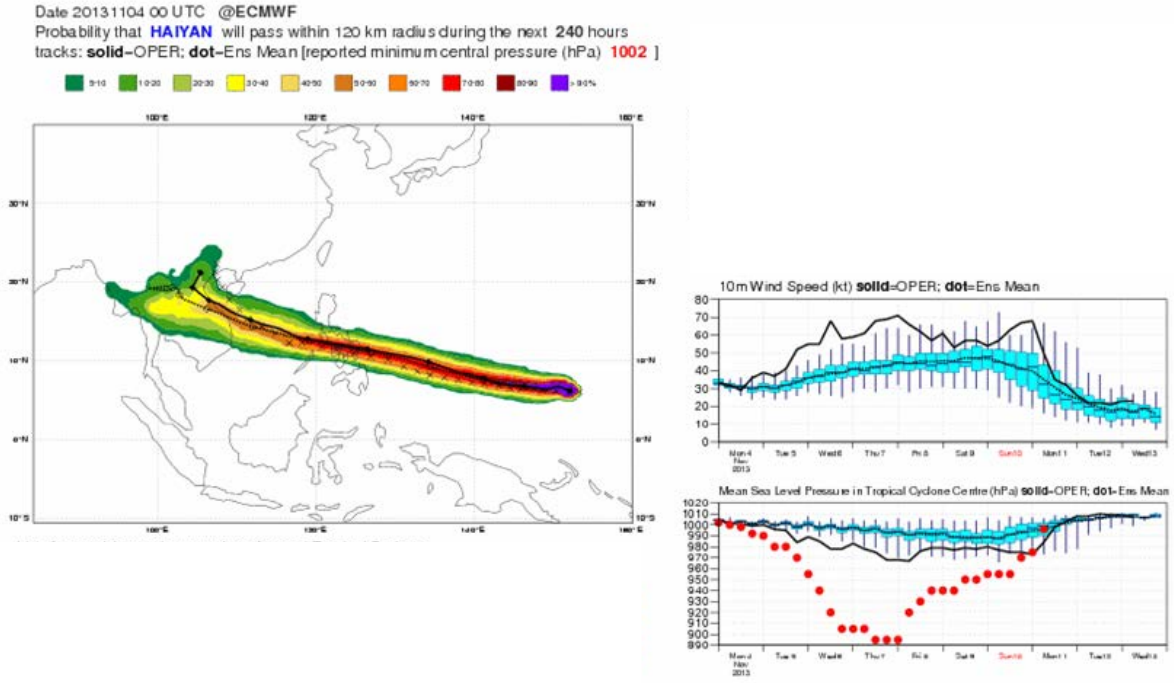
Removal of all code related to coupled chemistry set-up; Composition-IFS (C-IFS) now only configuration.
Implementation of new UV processor providing better UV forecasts
Various model improvements for C-IFS
Assimilation of new satellite data (GOME-2 SO2 (for volcanic eruptions), PMAP AOD (being monitored), MODIS Deep Blue AOD, AATSR AOD)
Improvements to aerosol model (mass fixer introduced, better use of fire emissions, SO2 emissions same as for chemical model)

Two different cases…

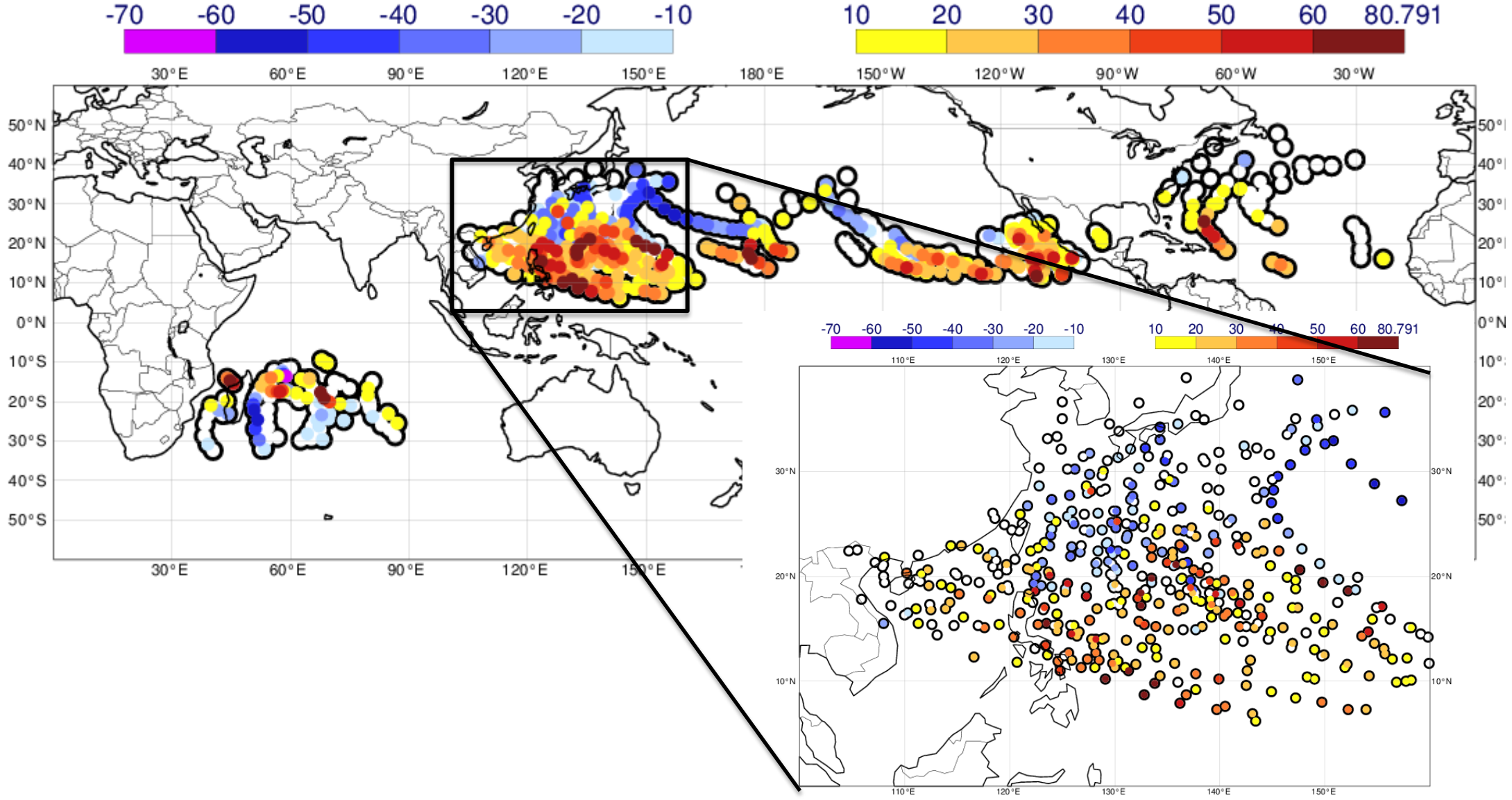
Neoguri (2014)



Haiyan (2013)



Central pressure error 48h forecasts 2013-2015

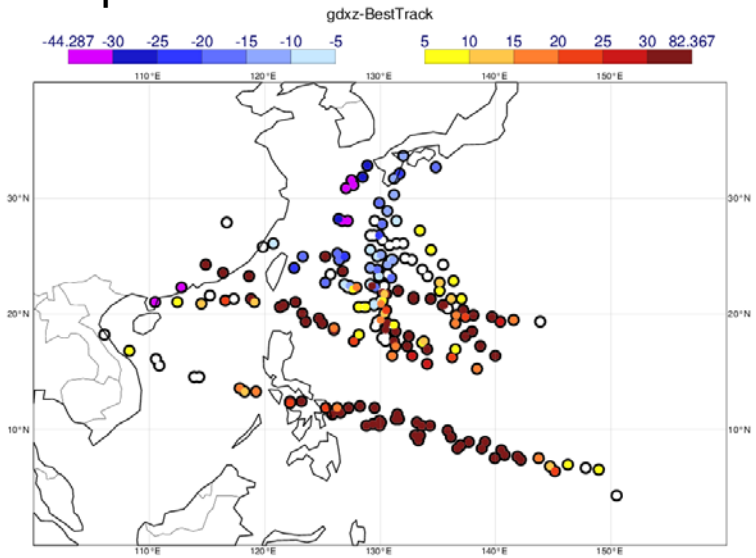


Test cases

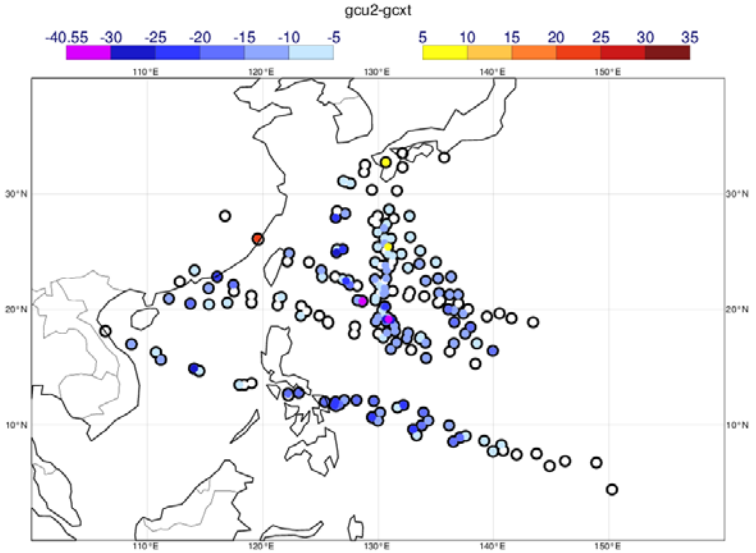
TL1279 41r2

All forecast steps with position error less than 500 km considered.

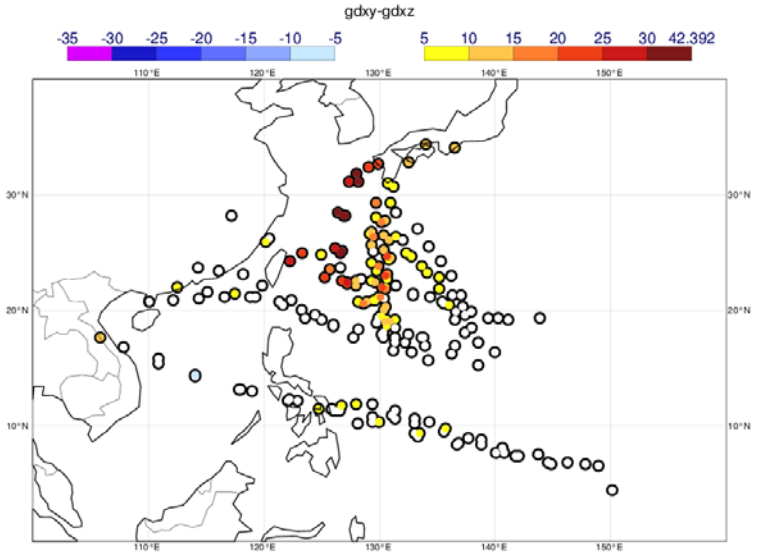
Central pressure error for 16 km uncoupled



Effect of resolution (9 km -16 km)



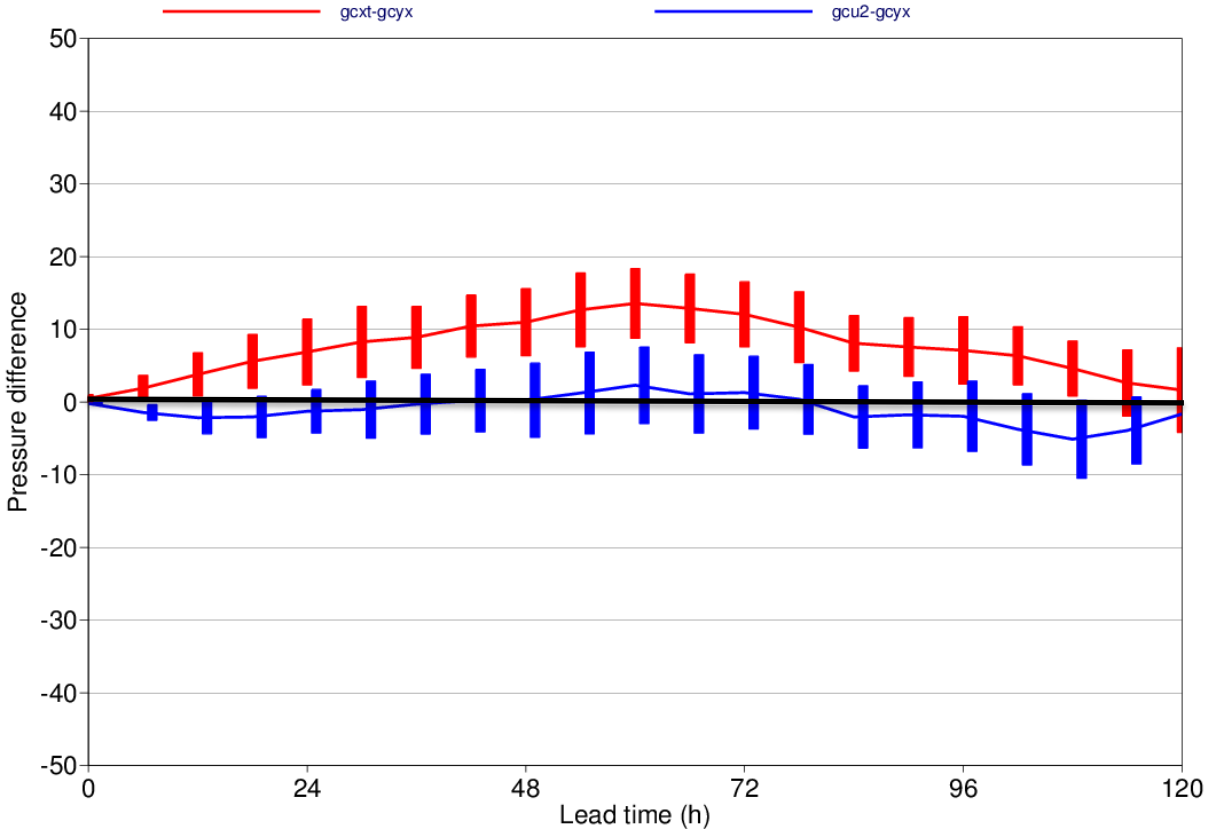
Effect by coupling



Physics change in 41r2 – impact on test cases

HRES

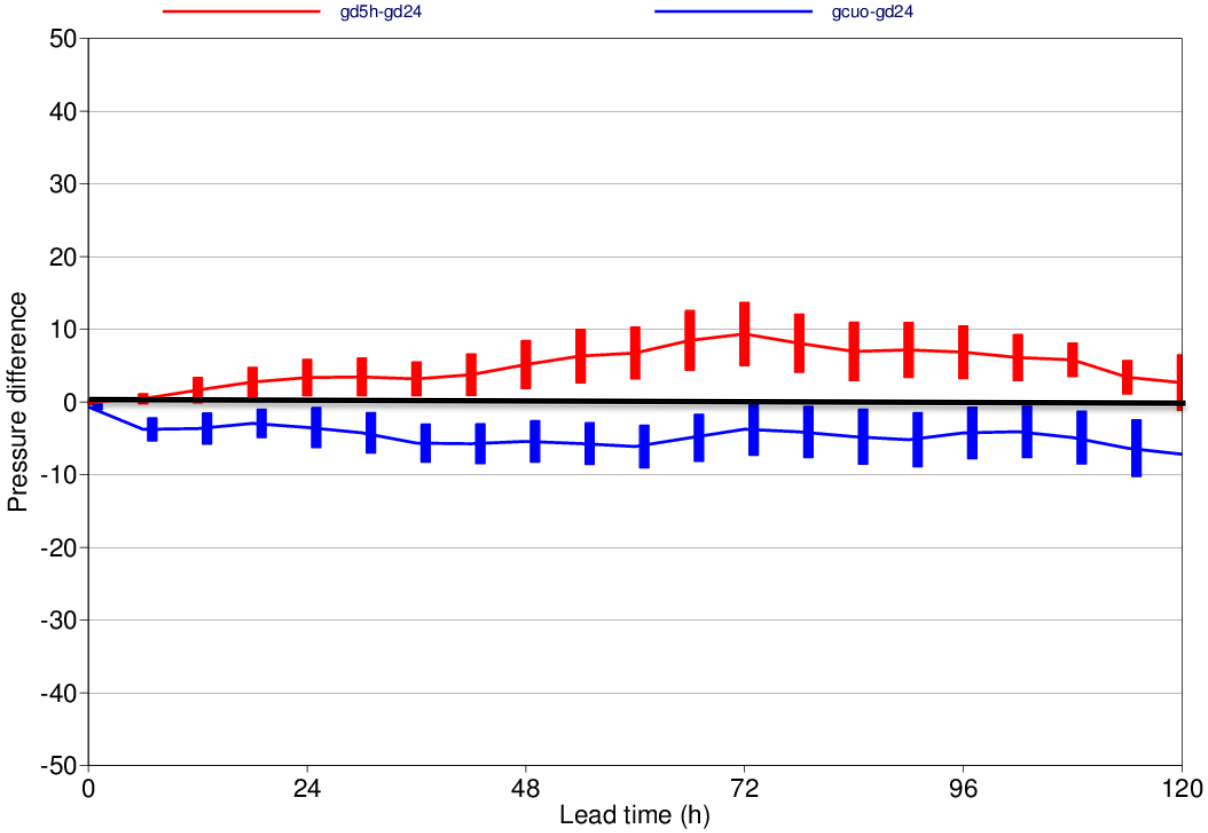
TL1279 41r2 –TL1279 41r1



TCo1279 41r2 –TL1279 41r1

ENS

TL639 41r2 –TL639 41r1

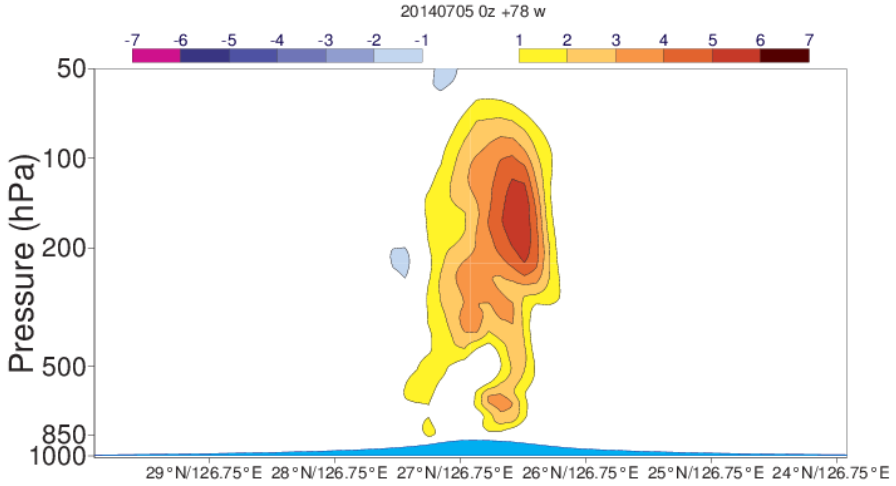


TCo639 41r2 –TL639 41r1

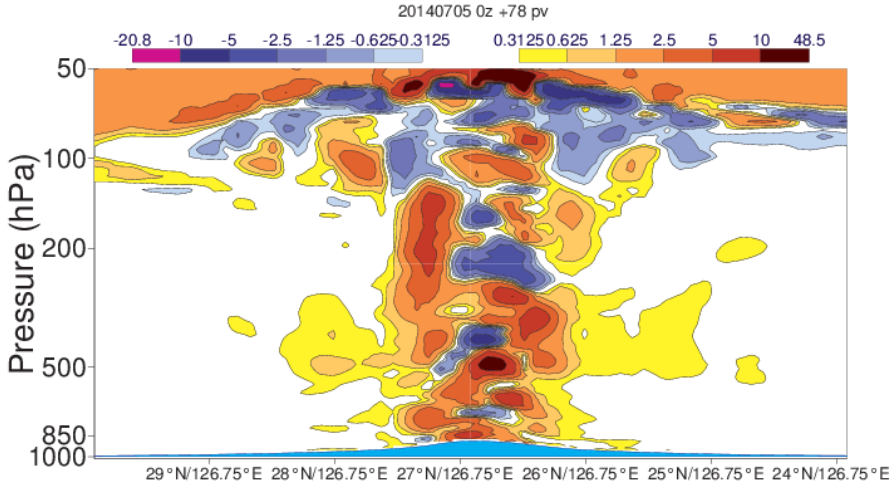
TC Neoguri

TL1279 41r1 +78h (north-south x-sect)

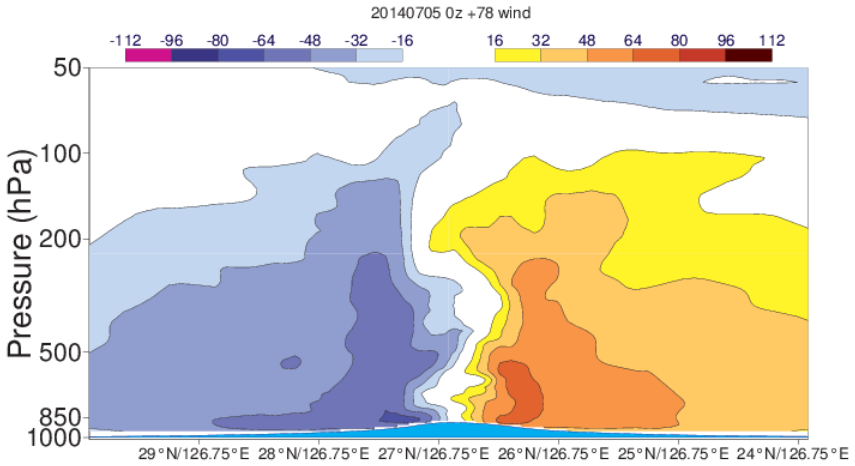
Vertical velocity (m/s)



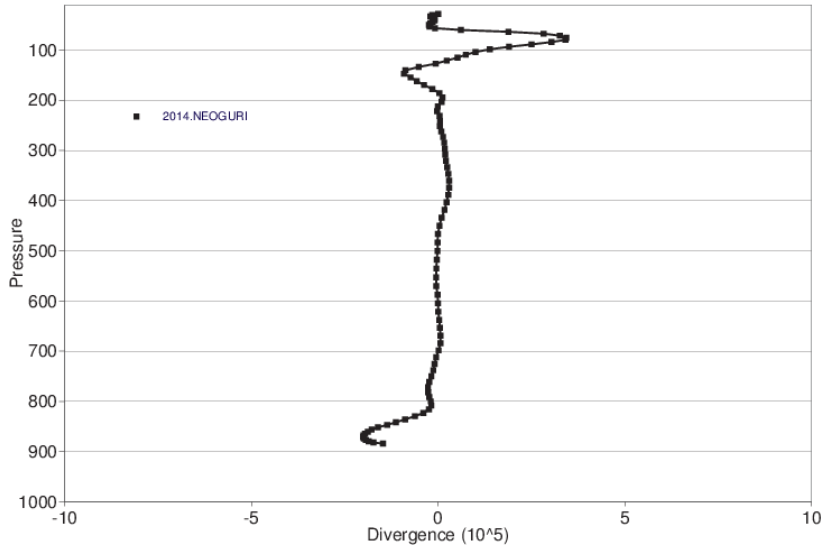
Potential vorticity



Zonal wind speed

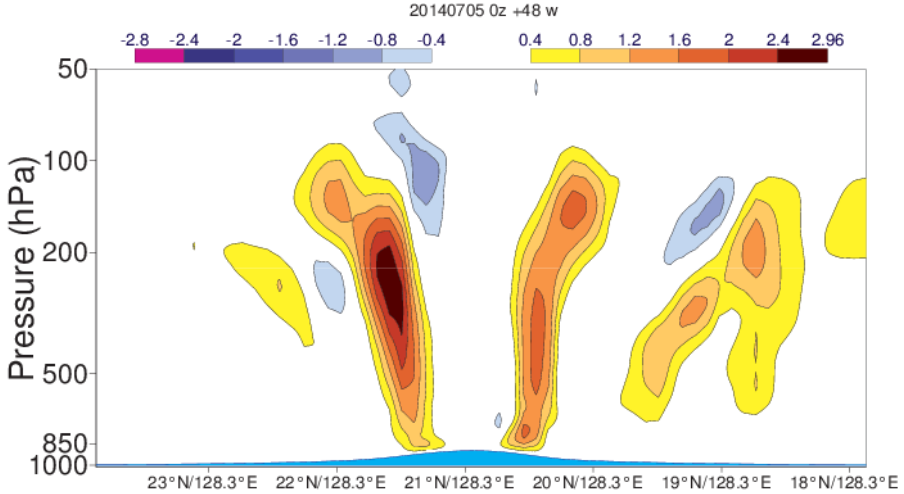


Divergence from core

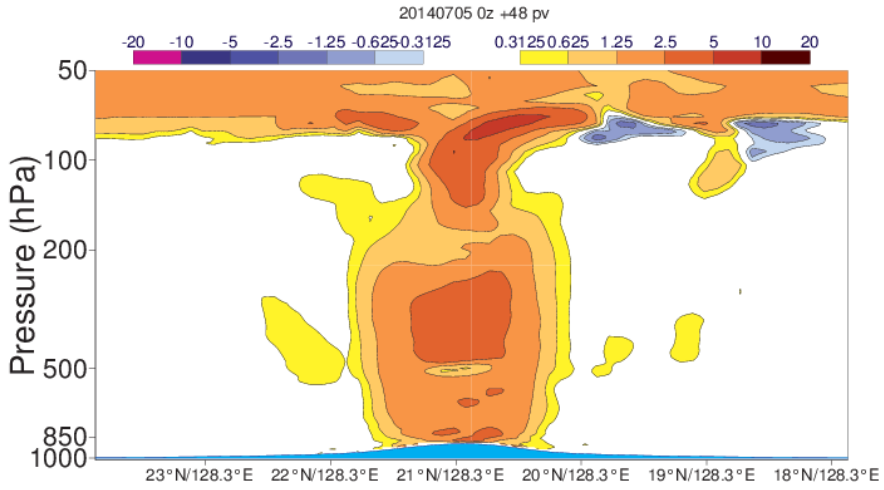


TL1279 5 itr- 200s +48h (894 hPa)

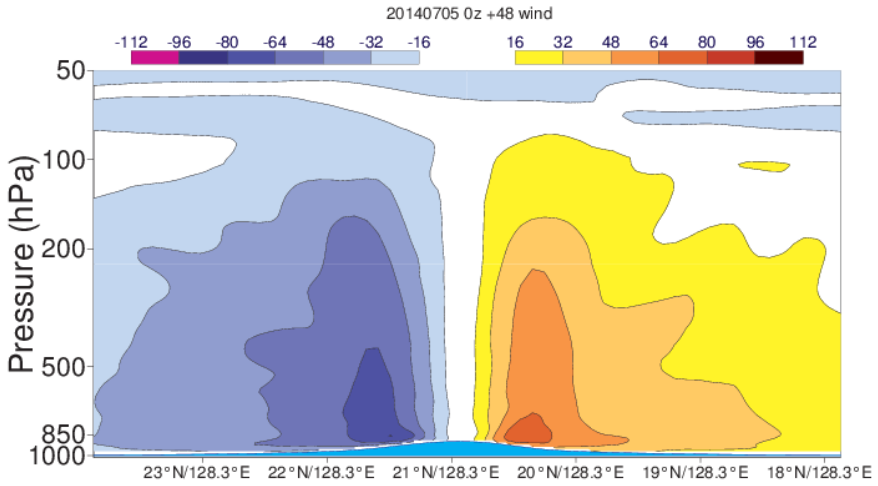
Vertical velocity (m/s)



Potential vorticity



Zonal wind speed



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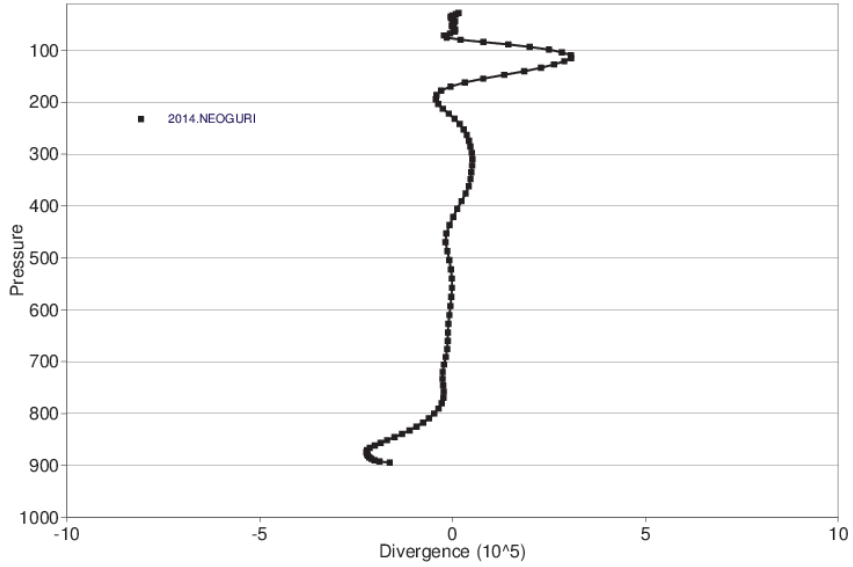
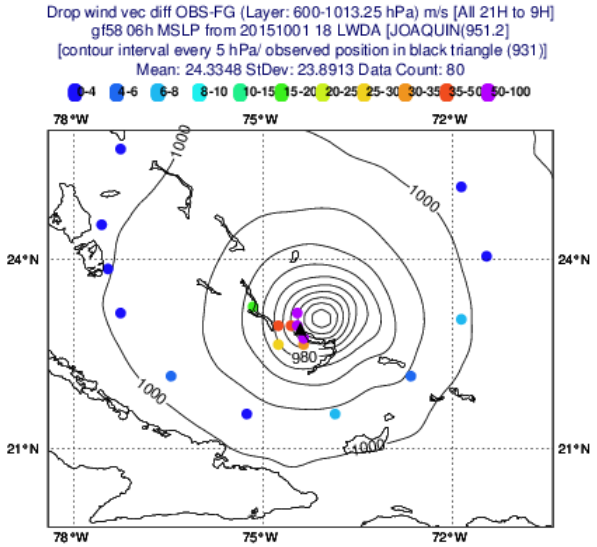
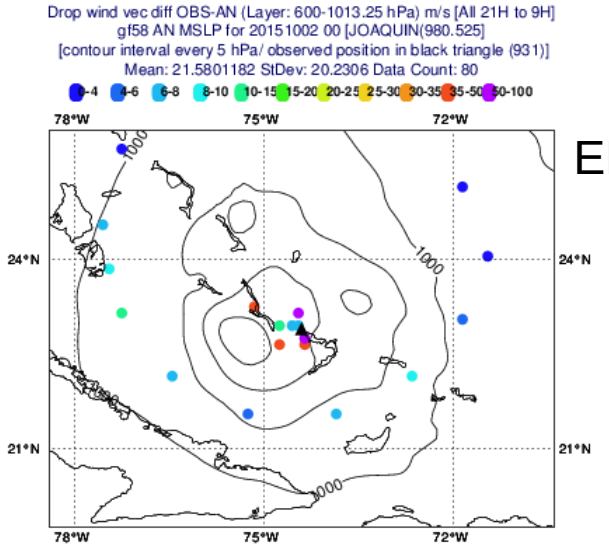


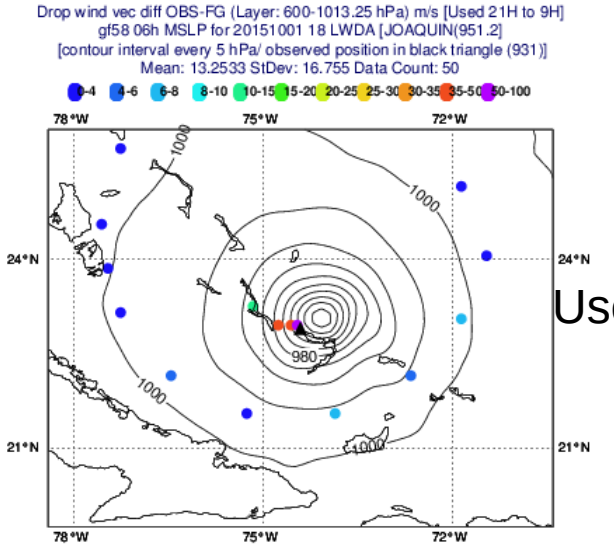
Impact of wind obs from drop sondes



All data



EDA “0069”



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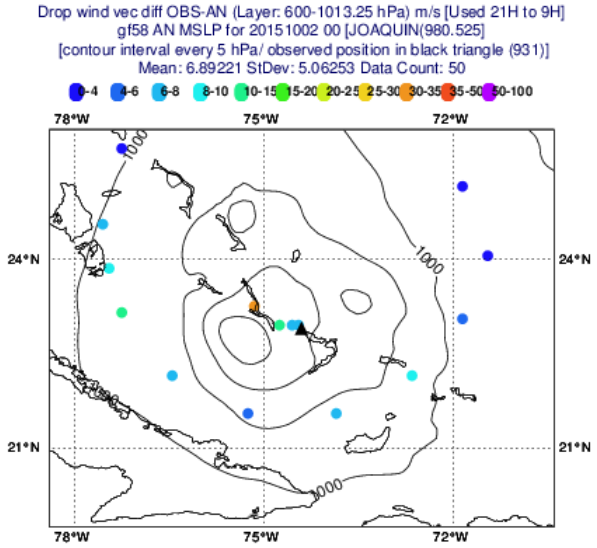

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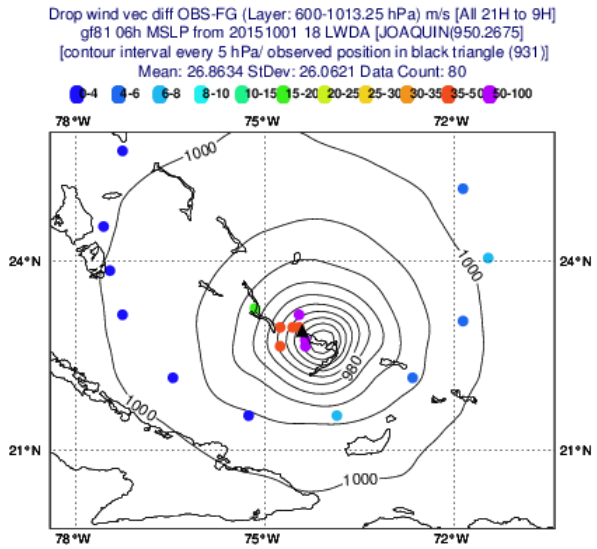
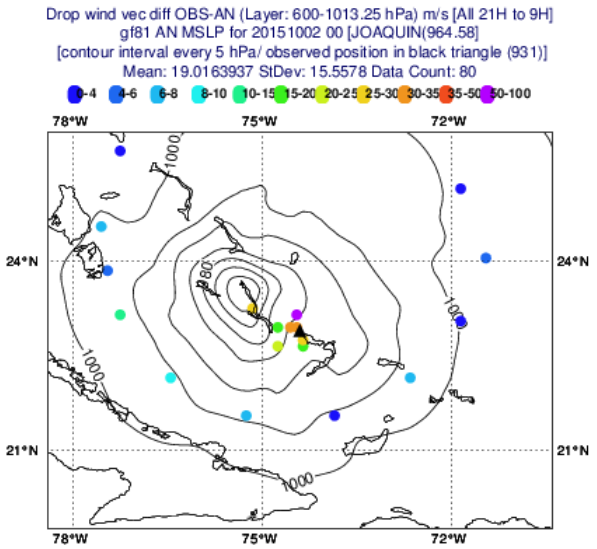
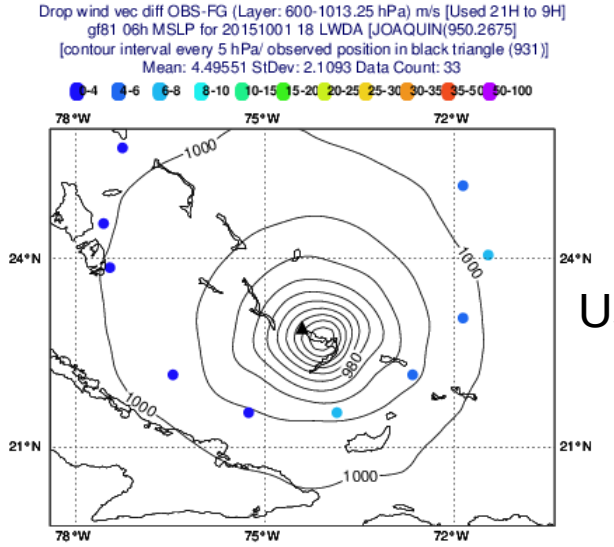


All data



EDA revised QC



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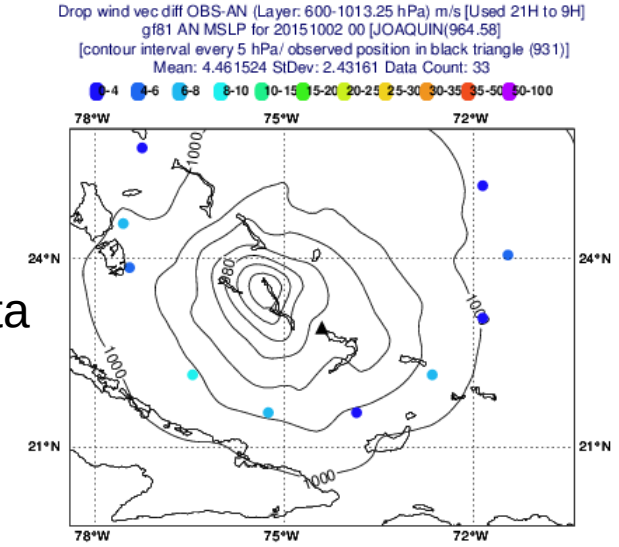
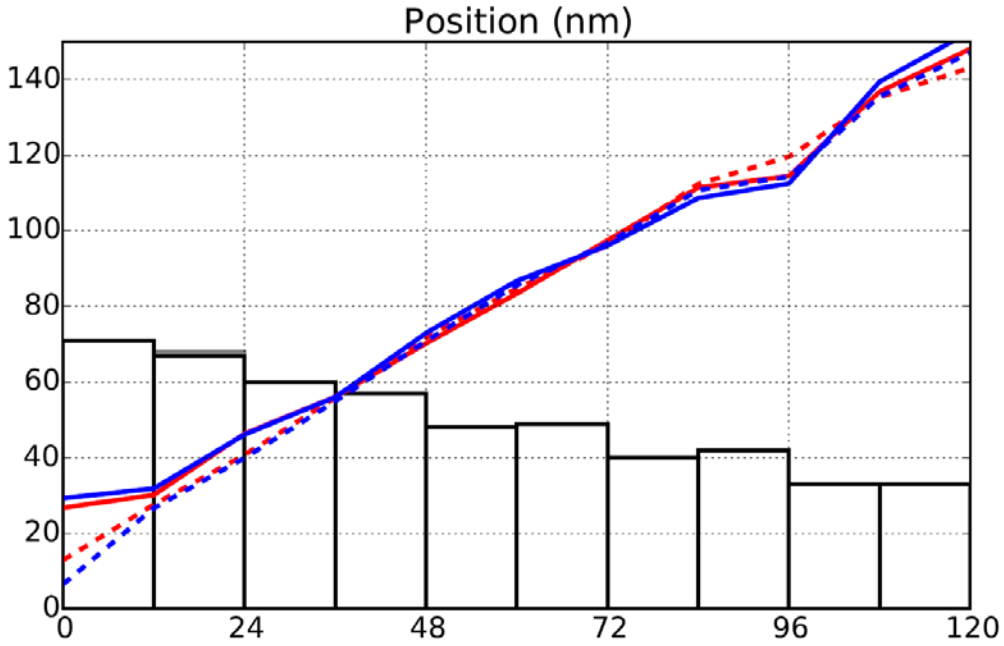
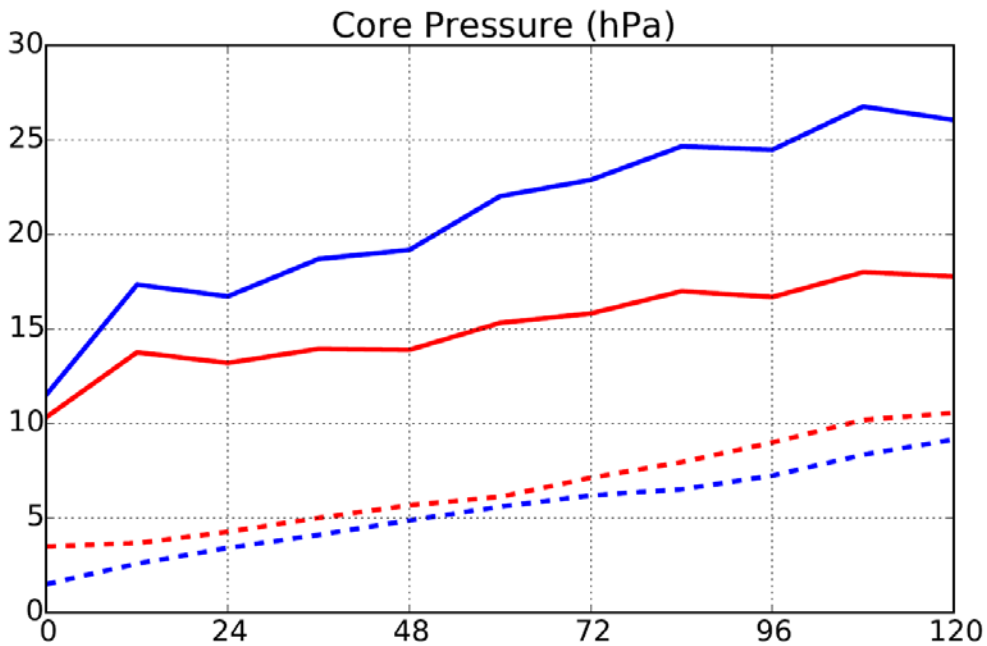


41r2 ENS

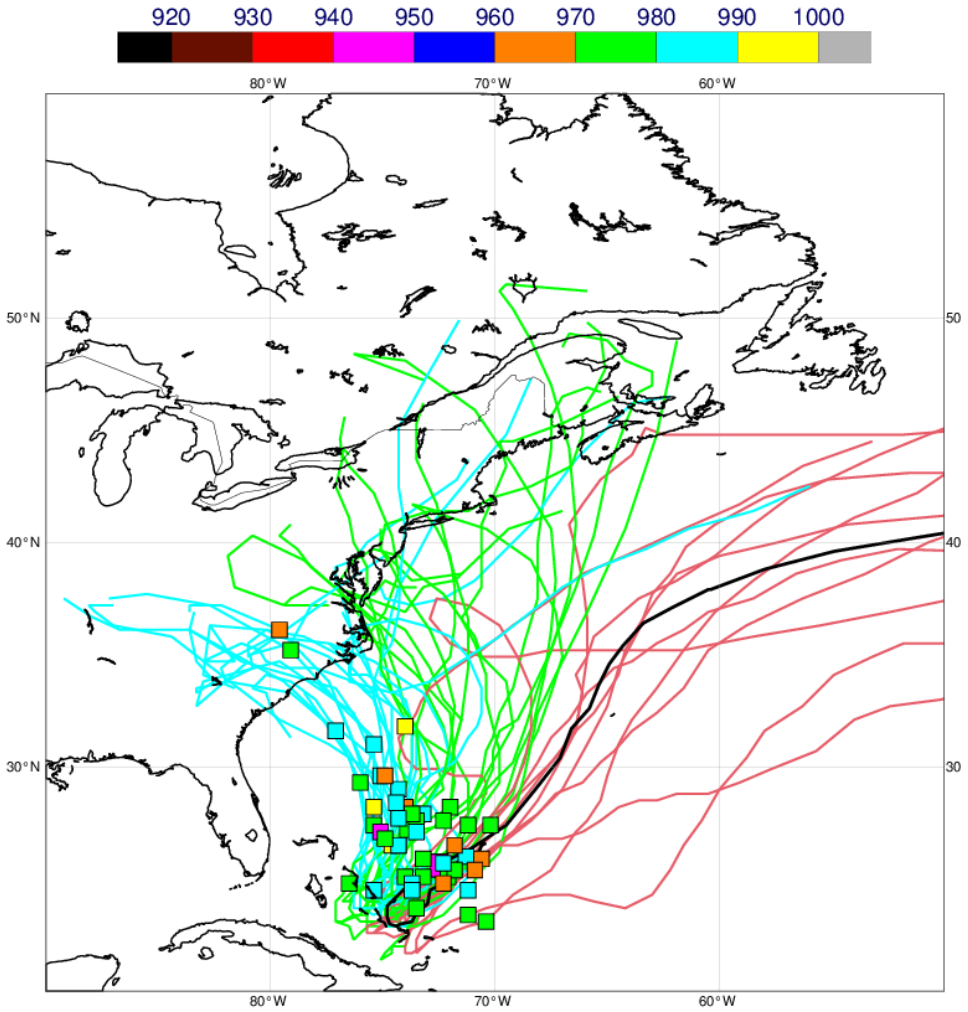

Position (nm)
140
120
100
80
60
40
20
0
0
24
48
72
96
120


Core Pressure (hPa)
30
25
20
15
10
5
0
0
24
48
72
96
120

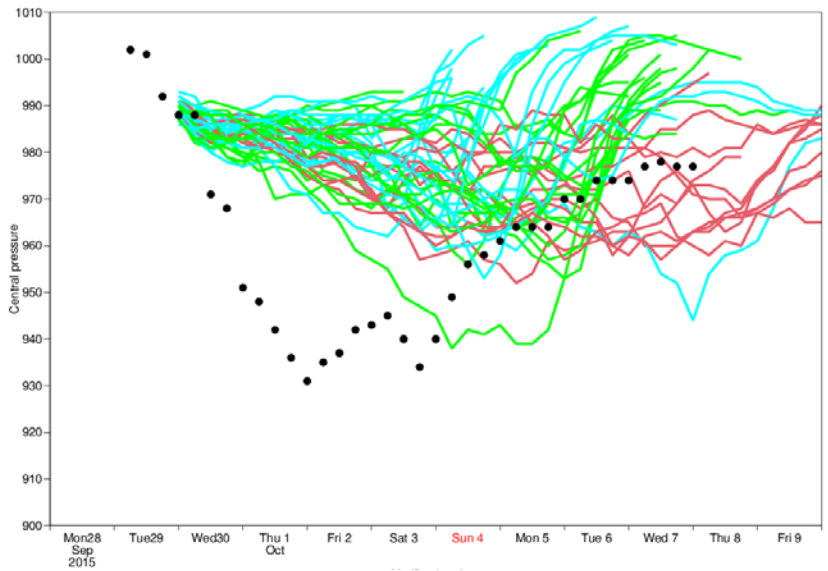
30 September 00UTC - ECMWF

Southern group – blue, Middle group – green, Eastern group - red

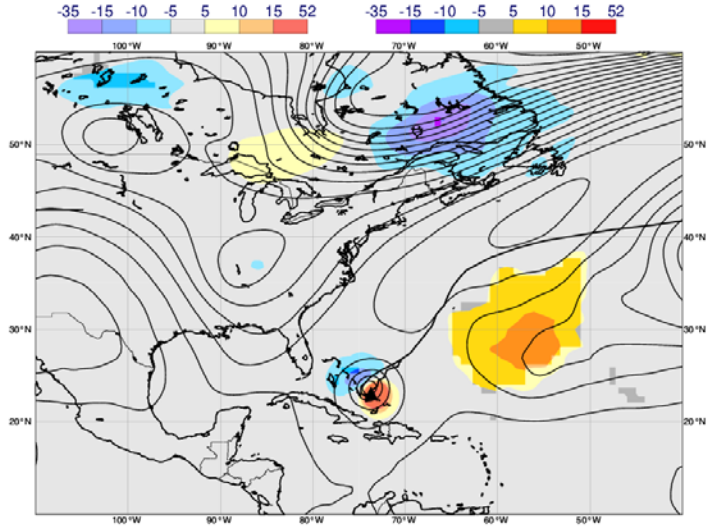
Symbols indicating position at 3 Oct 12z



Central pressure



Z500 difference at 1 Oct 12z South - East



Future developments: strategy to 2025

- Earth System model at all time ranges: Atmosphere, land surface, oceans
- Integrated ensemble at high resolution
- Dynamical core – Scalability
- Model physics – scale awareness (convective parametrization)
- Data assimilation: Hybrid 4DVar and ensemble
- Improved diagnostics

- Forecast targets by 2025
  - Ensemble predictions of **high impact weather up to two weeks ahead**
  - Seamless approach, aiming towards predictions of **large scale patterns and regime transitions up to four weeks ahead** and global-scale anomalies up to a year ahead