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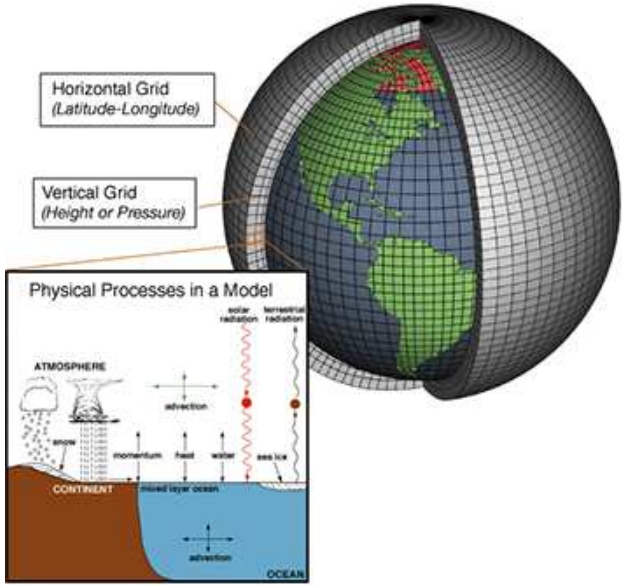
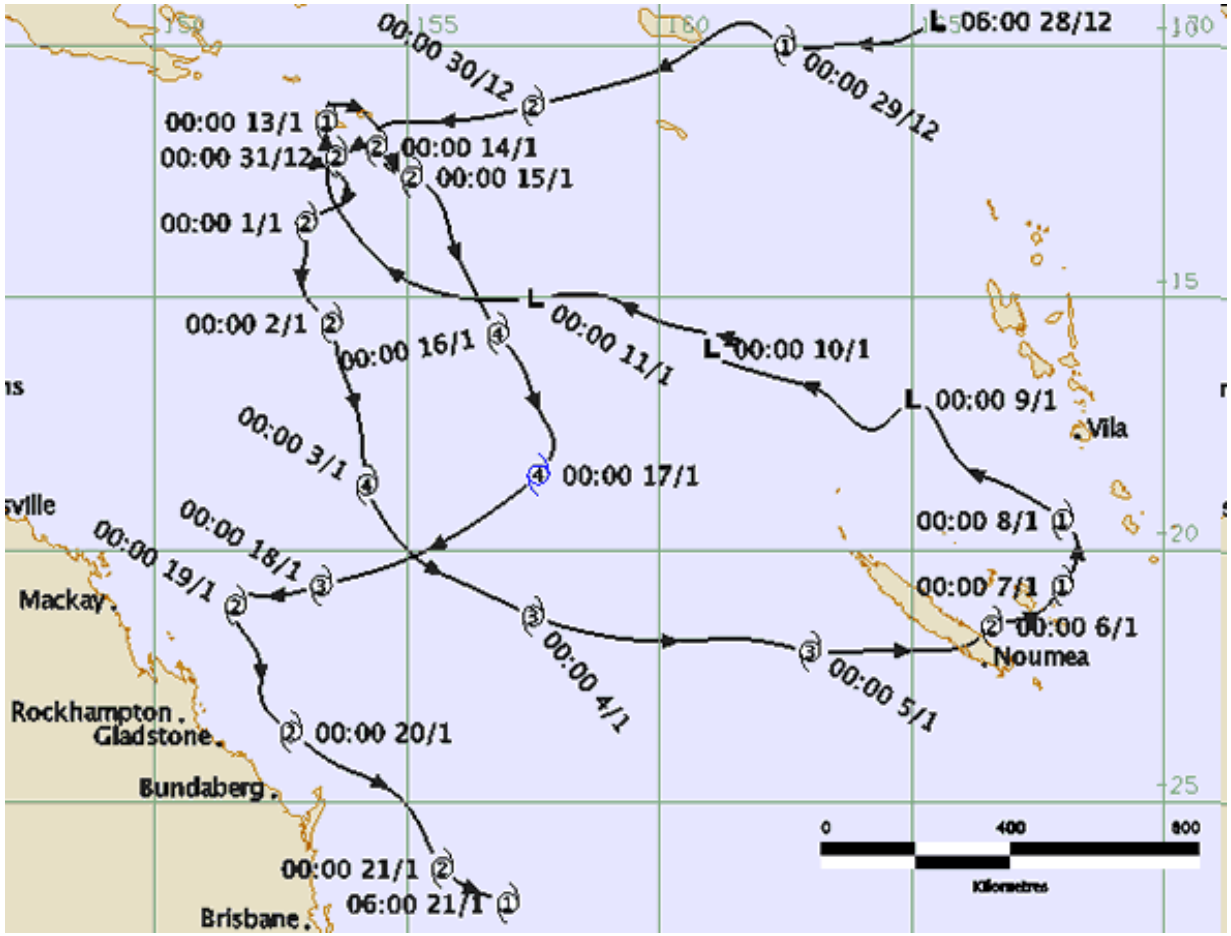
NWP for Tropical Cyclone forecasting

- NWP upgrades
- Track forecasting
  - Consensus
  - Ensembles





Rewa, 1993/94
http://www.bom.gov.au/cyclone/history/rewa.shtml

Models : ECMWF

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- https://software.ecmwf.int/wiki/display/FCST/Implementation+of+IFS+cycle+43r3

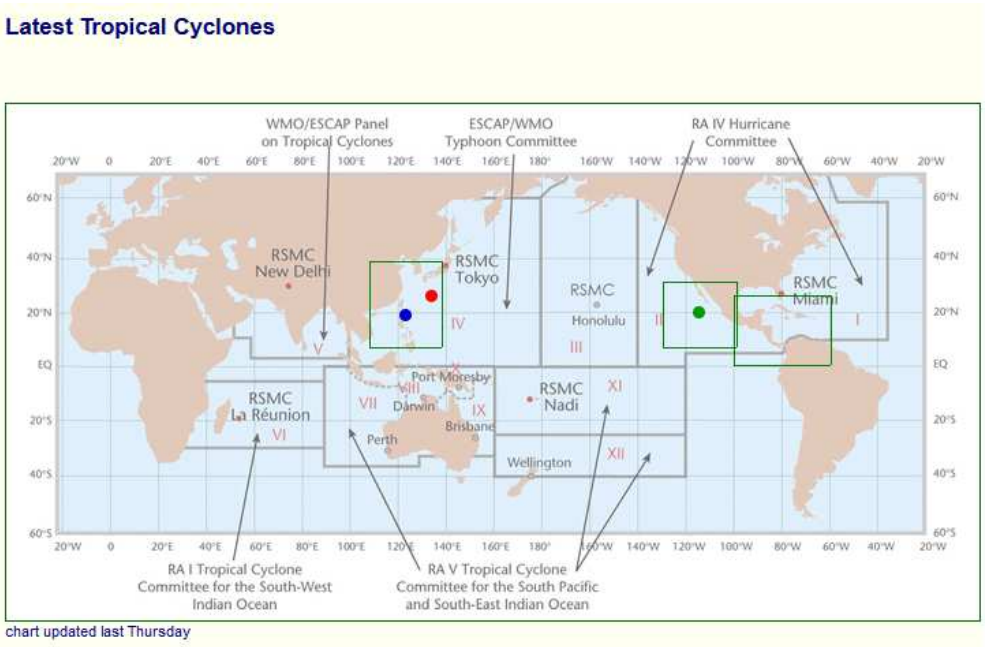
Deterministic 9km resolution; twice per day, 137 levels to 10 days

Ensemble forecast (EPS): twice per day 51 members **18 km**

91 levels to 15 days ahead

Mon/Thurs 00UTC extended to 1 month ahead

(Monthly Forecast 18/36km)



Model upgrades : ECMWF

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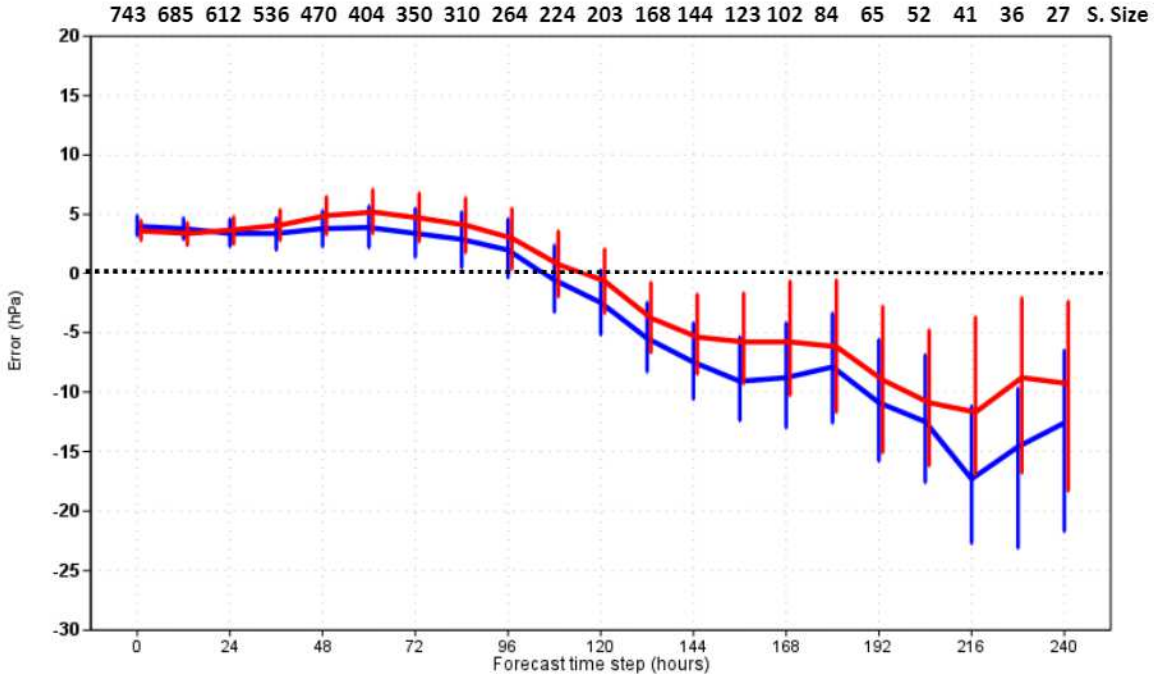
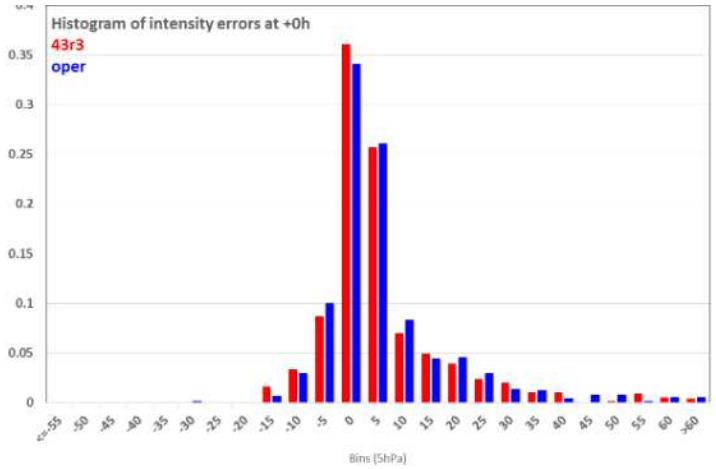
- https://software.ecmwf.int/wiki/display/FCST/Implementation+of+IFS+cycle+43r3

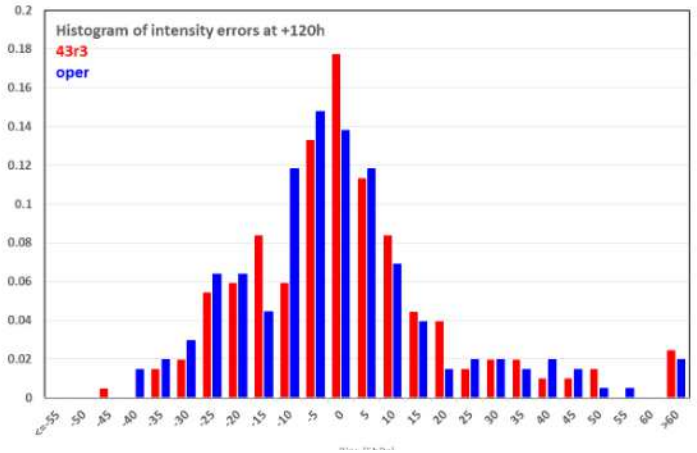
July 2017 upgrade – slight improvement (res same)

Mean TC intensity forecast error

TC intensity forecast error between **43r1** and **43r3**
Level of confidence 95% (boostrap)







Model upgrades : GFS

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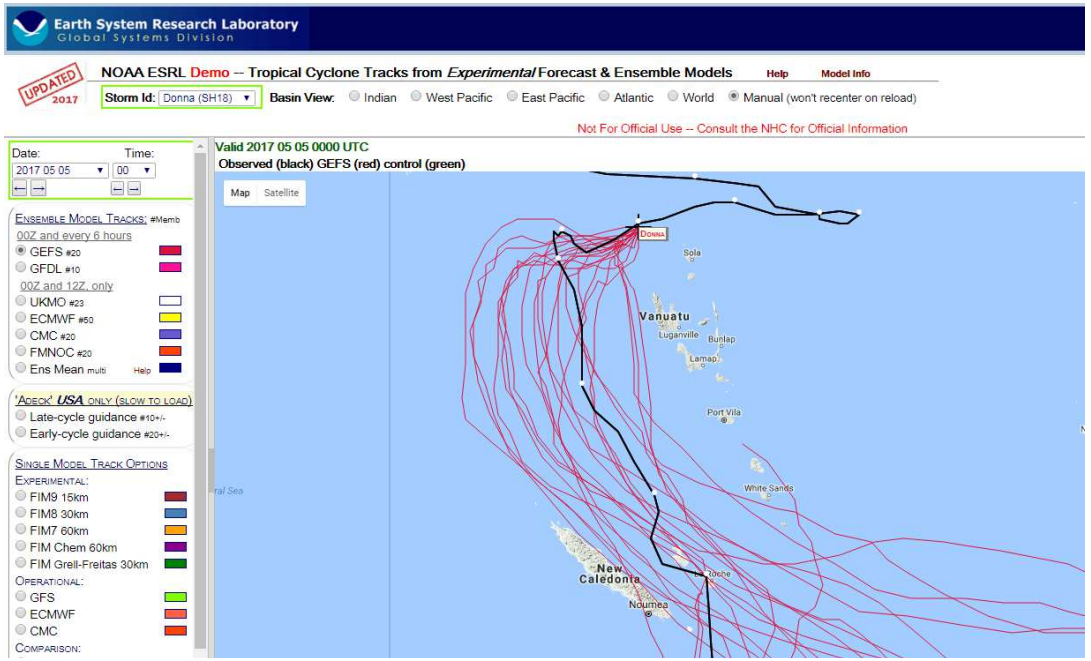
National Weather Service
NCEP Central Operations

http://www.nco.ncep.noaa.gov/pmb/changes/

Skill similar to ECMWF
Global model run at ~13km resolution to +240h
Availability of GFS ensembles? 21 members
Recent upgrades not indicating much improvement for TCs
Widespread availability from different sites e.g. https://ruc.noaa.gov/tracks/



Model upgrades : UK

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Met Office

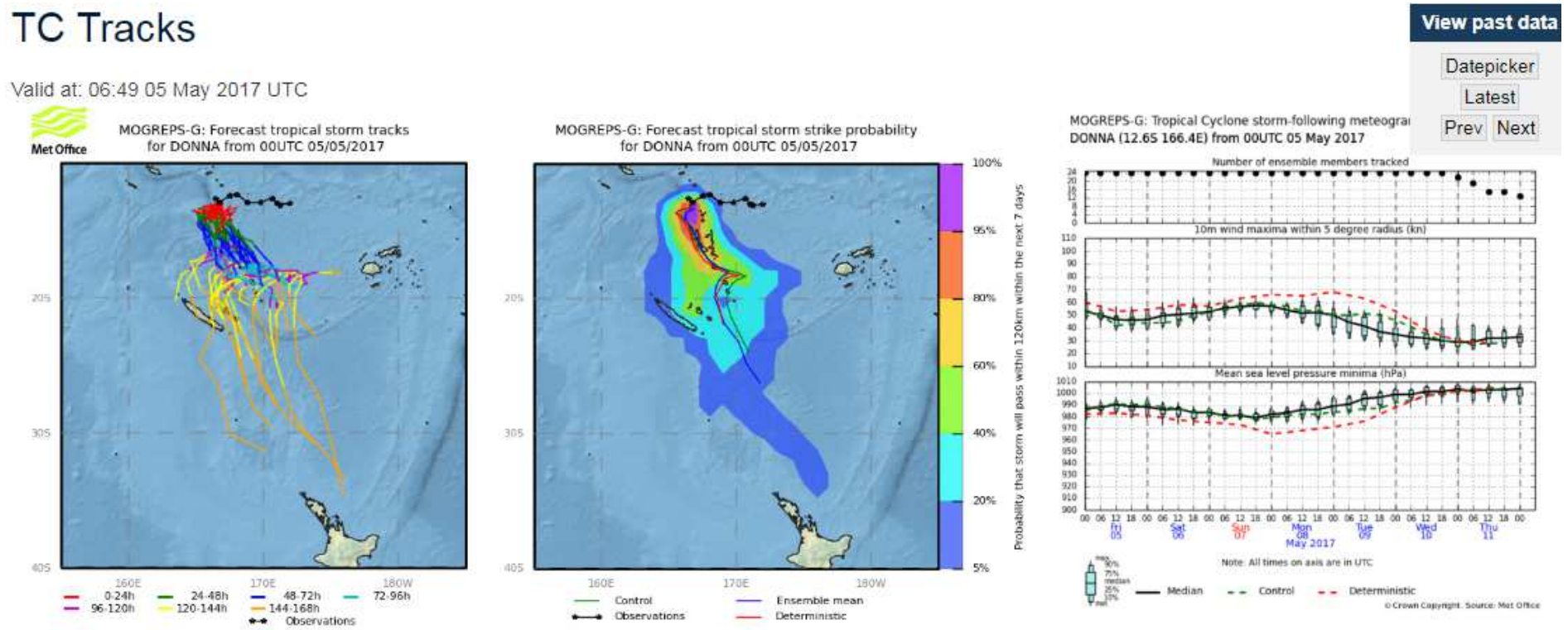
http://www.metoffice.gov.uk/research/modelling-systems/unified-model/weather-forecasting

Skill near to EC and GFS since major 2014 upgrade

July 2017 upgrade: Deterministic: 17km (TBC if now lower)

Ensembles: 36 members at 20km resolution (previously 24 a

Available on SWFDDP site: http://swfddp.metservice.com/global-ukmo-pacific-tc-data/tc-tracks



Model: HWRF

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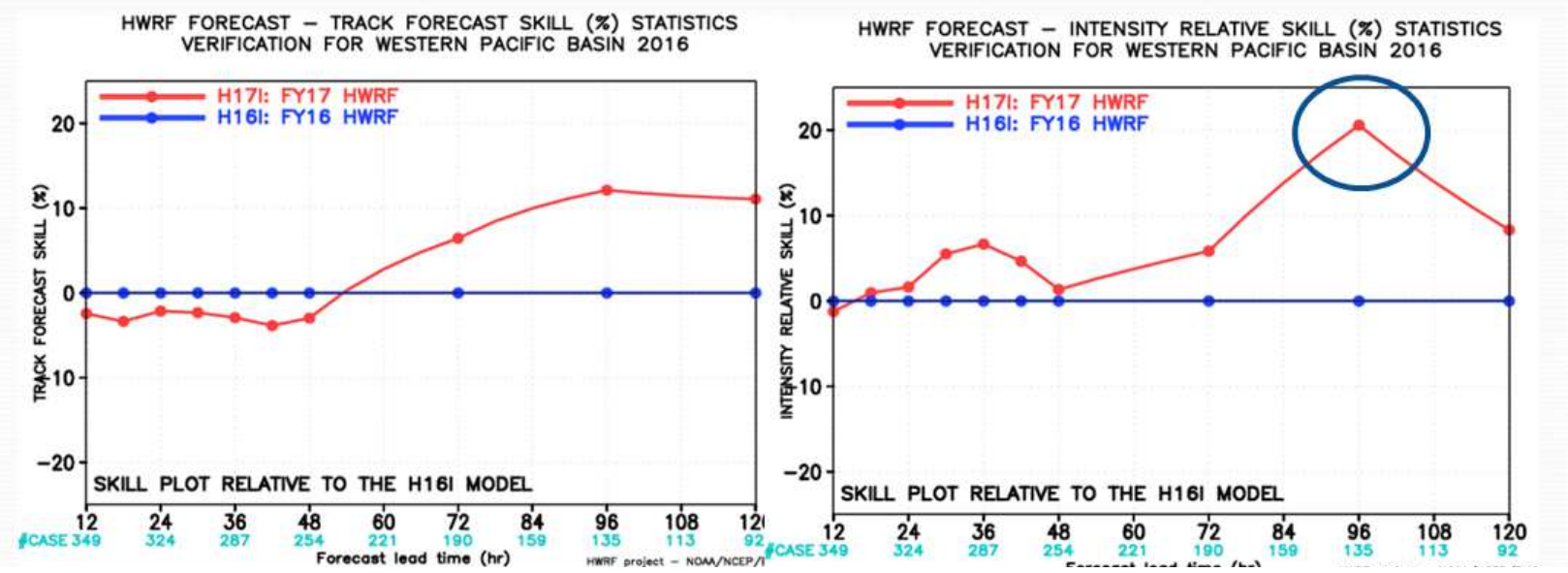
http://www.emc.ncep.noaa.gov/gc_wmb/vxt/HWRF/index.php

nested within GFS with variable resolution – higher for core 8/6/2km – yes 2km for inner core!
Run for all systems globally can run 7 TCs at once inc. lows
Intensity results encouraging.
2017 Upgrade: ongoing improvement in track and intensity though likely NH (ocean coupling) is better than SH



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Model upgrades : HWRF

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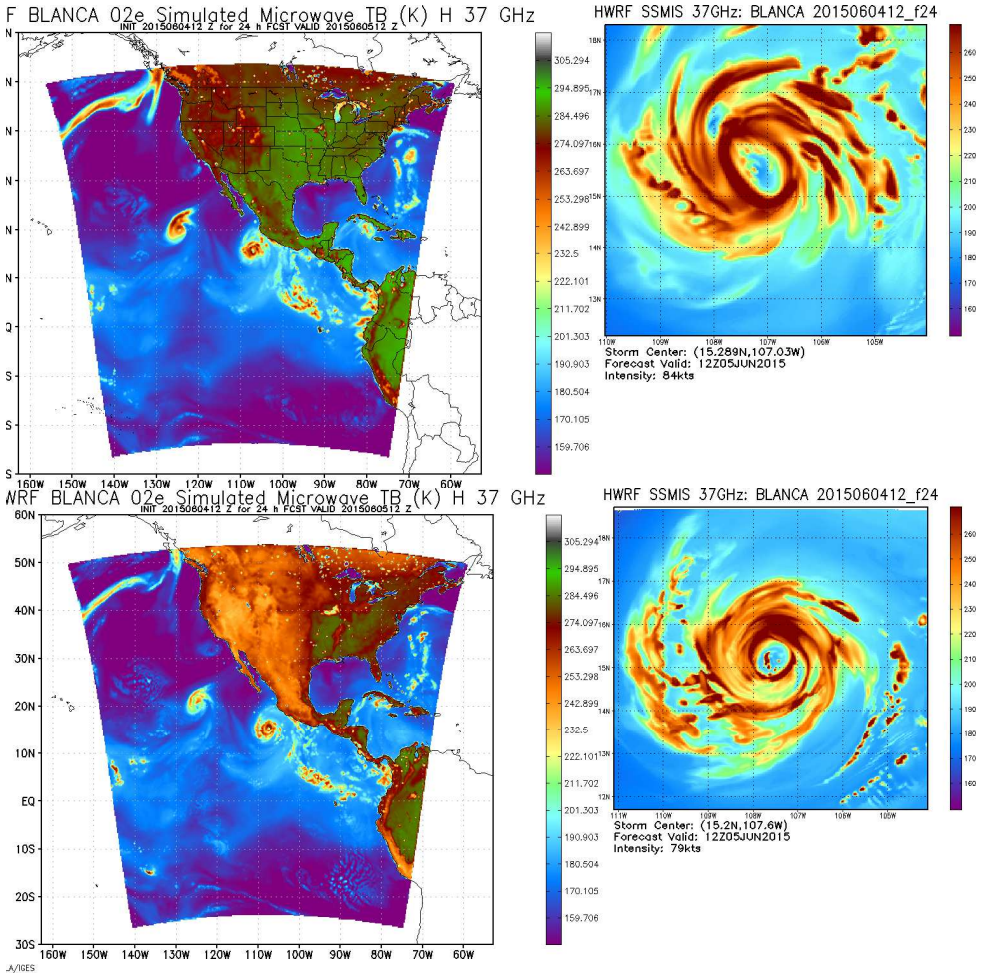

Blanca 2015
3km run

2km run, more symmetric and smaller sized storm

Courtesy: V. Tallapragada, NCEP

ACCESS NWP

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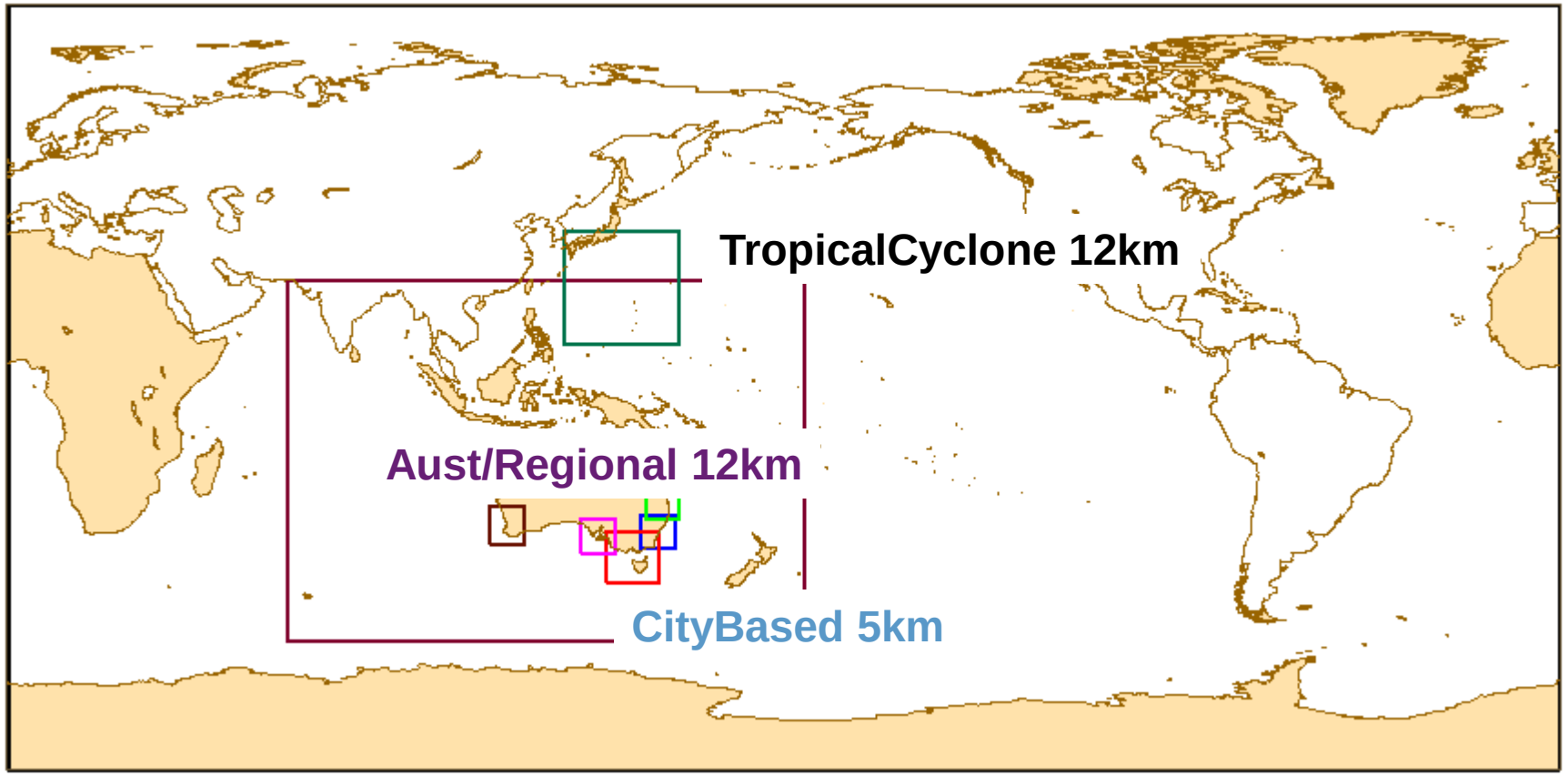
ACCESS
The Australian Community Climate and Earth-System Simulator

ACCESS-G Global (~25km)
ACCESS-TC variable domain 12km resolution for TCModule tracking
http://www.bom.gov.au/australia/charts/viewer/index.shtml



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Models : the others
JMA, COAMPS, GFDN/L, NAVGEM and others

JMA: ~20km resolution; trailing other globals in Aust region

COAMPS: Experimental CTCX 5km resolution
Nested in NAVGEM

GFDL: nested in GFS – Skill here?

GFDN: GFDL version nested in NAVGEM

NAVGEM: US Navy Global model still has some skill but trails

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Verification: Track JTWC 2016 in WPAC (update) [typical for all basins]

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GFS/
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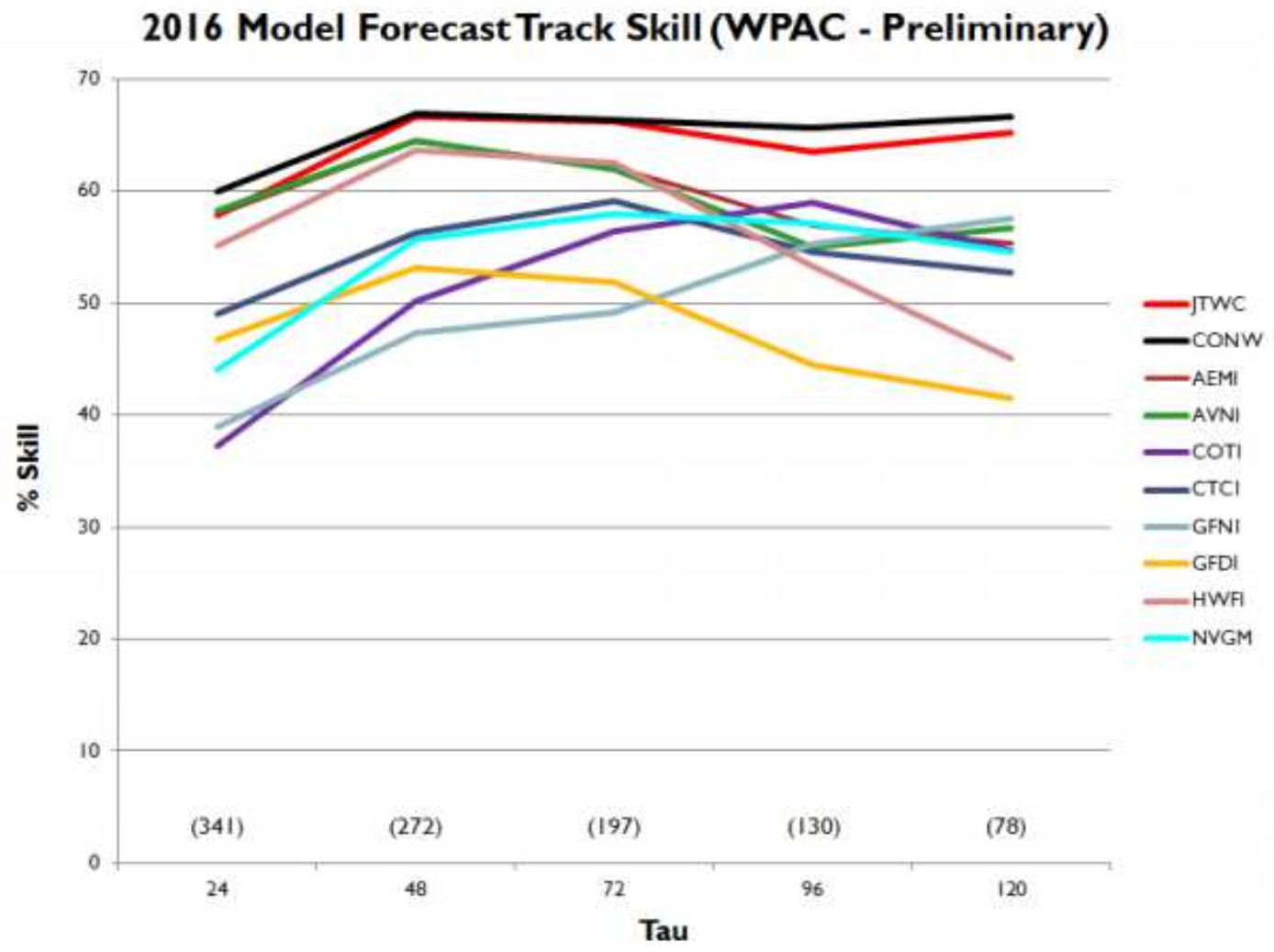
~50n



WC
N
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RF

y: JTWC

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Track Forecasting – The Australian Consensus approach

How to choose what goes in?

NRL approach to test a model: compare result if you take the model out from the consensus. Does it add value?

Standard members – nine models

EC + GFS + HWRF + UK + ACCESS-TC (Tier 1)

+ COAMPS(TX) + JMA + GFDL/GFDN* + NAVGEM (Tier 2)

For tropical lows greater selective approaches;

Using previous runs of EC/GFS/HWRF/UK case by case basis;

Occasional erratic behaviour by GFDN and COAMPS;

GFS/JMA ensemble mean used by JTWC

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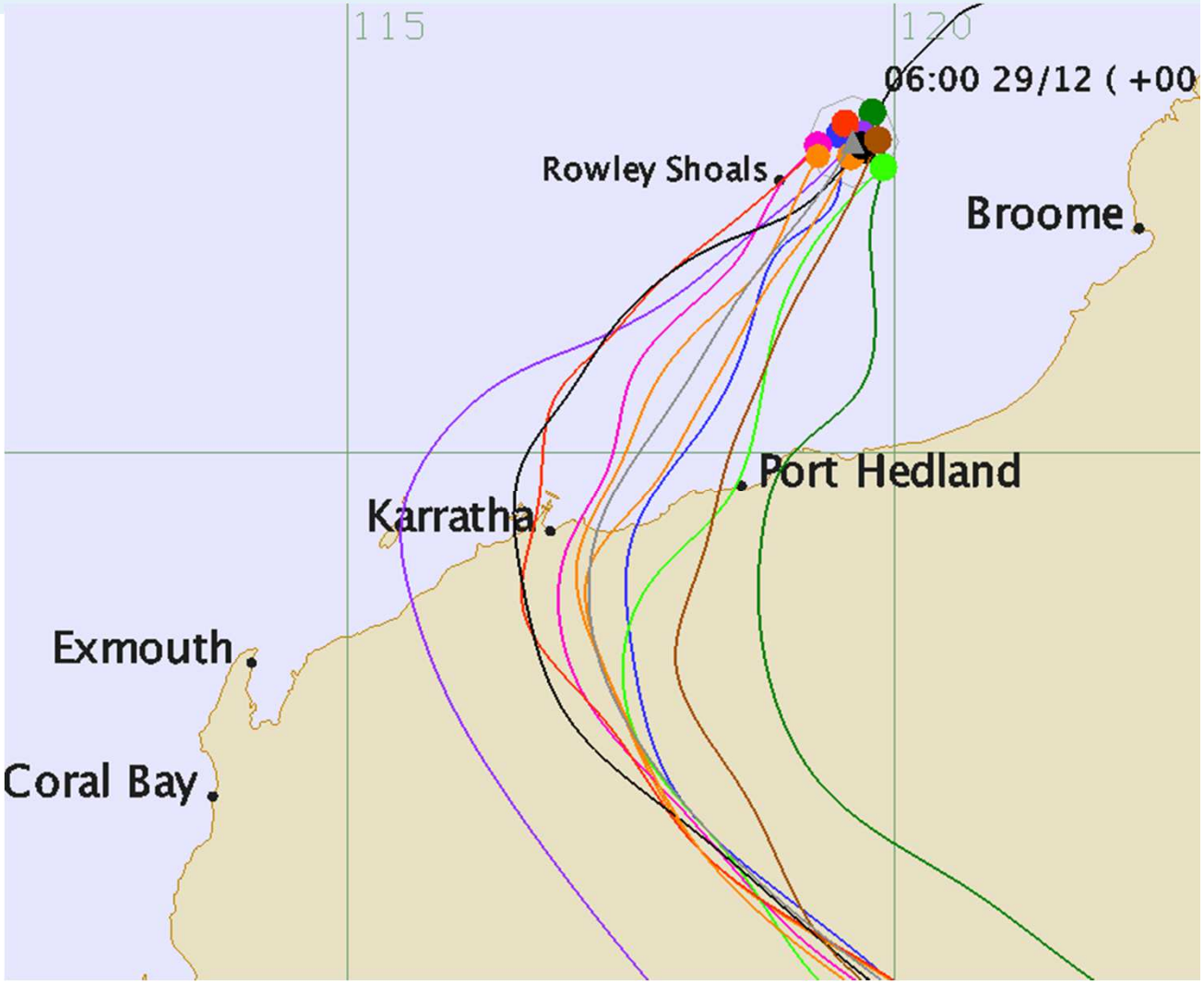
The BoM Consensus approach
Non-SELECTIVE (NCON) – robust most of time

TC *Christine*:

Model position check



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The BoM Consensus approach
Non-SELECTIVE (NCON) – robust most of time

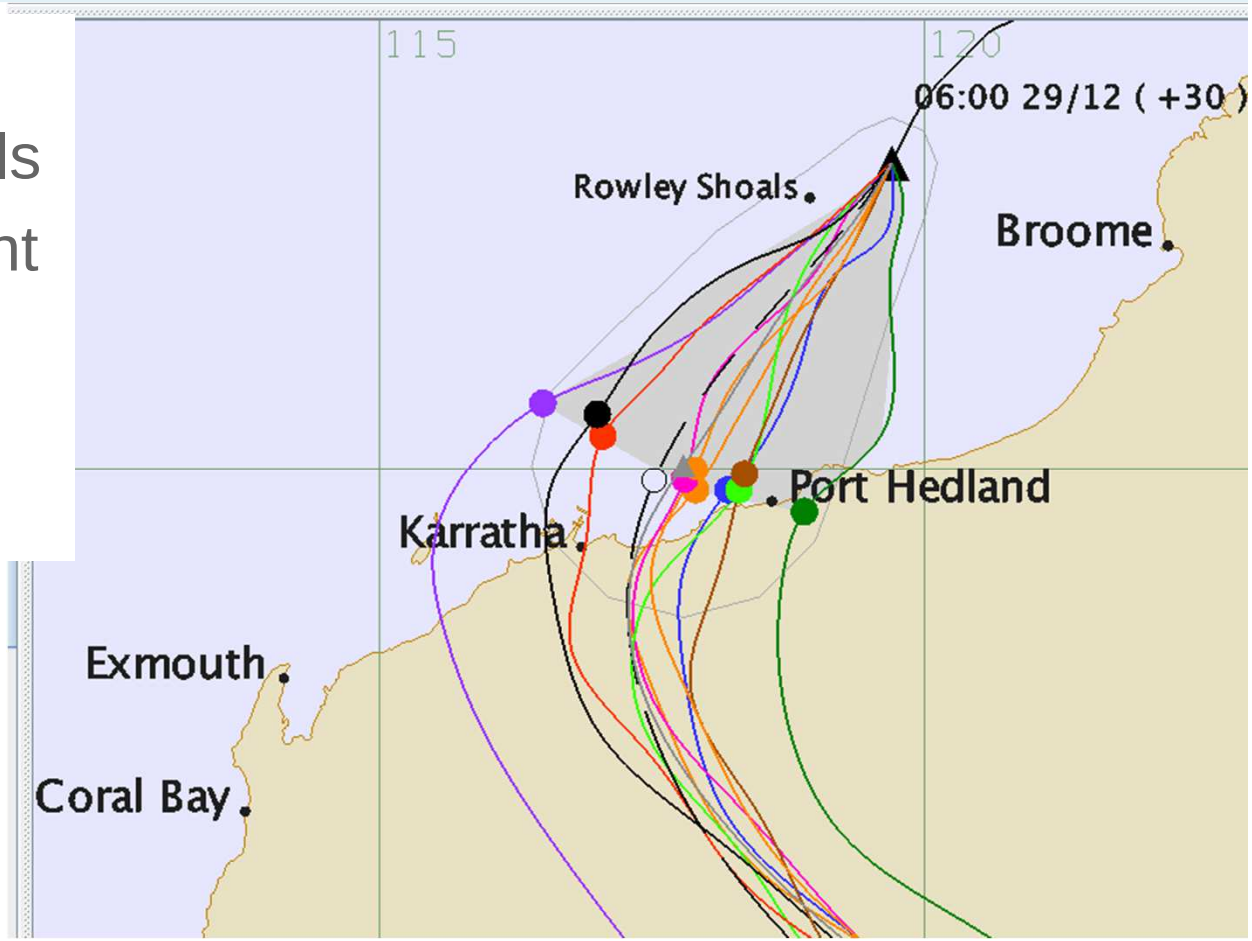
TC *Christine*:

spread in shifted models

Tier 1 models consistent

cf climatology (grey)

cf previous forecast (dashed)



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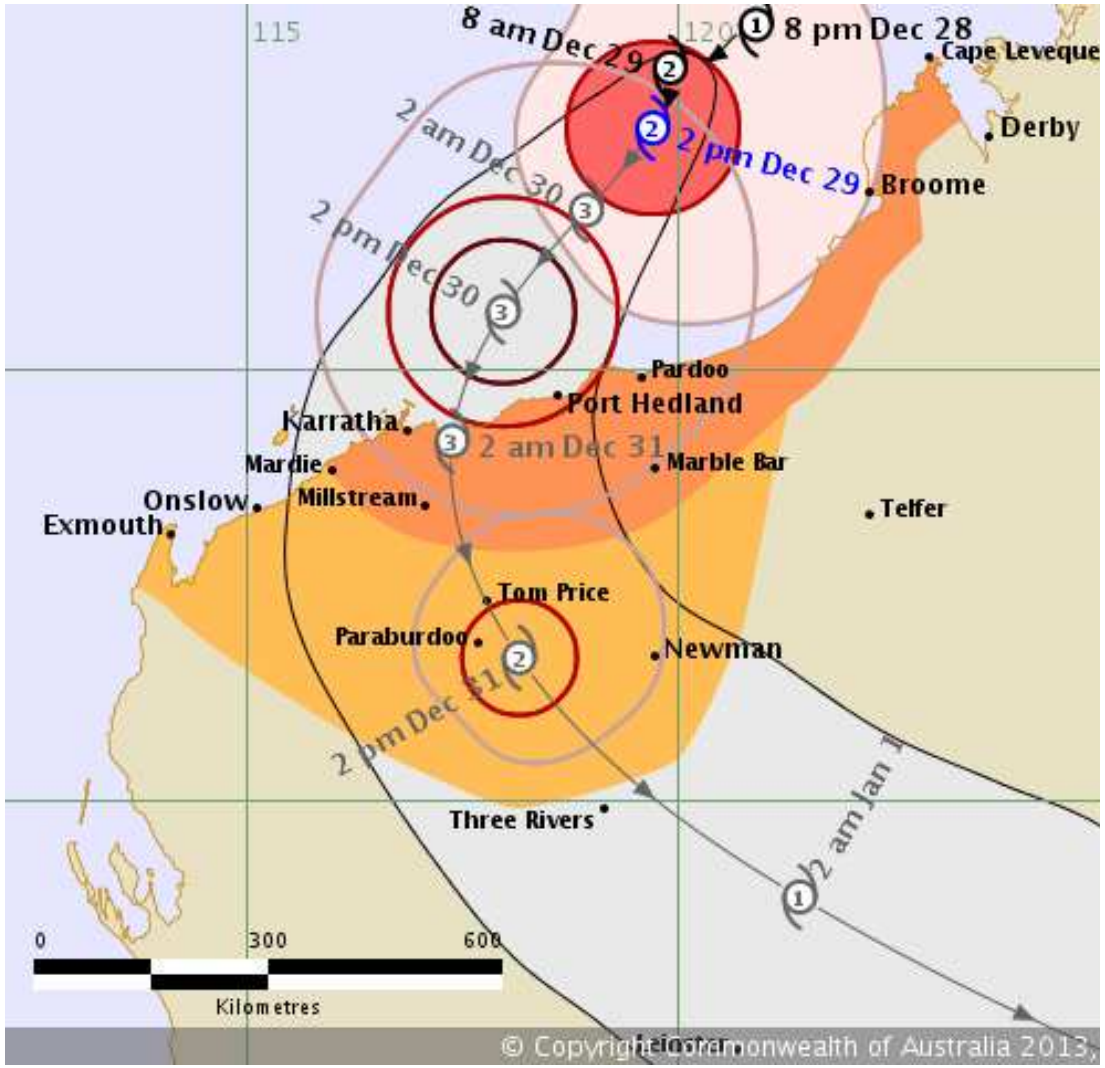
Input to Forecast Track Map

TC *Christine*:

Uncertainty and gales shape watch/warning areas



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The BoM Consensus approach
SELECTIVE (SCON)
Will *Quang* hit Exmouth??

COAMPS (green) +UK/GFDL(to east)

others inc. EC/GFS/A-TC further west

JMA (light green) further west

Question: Should we

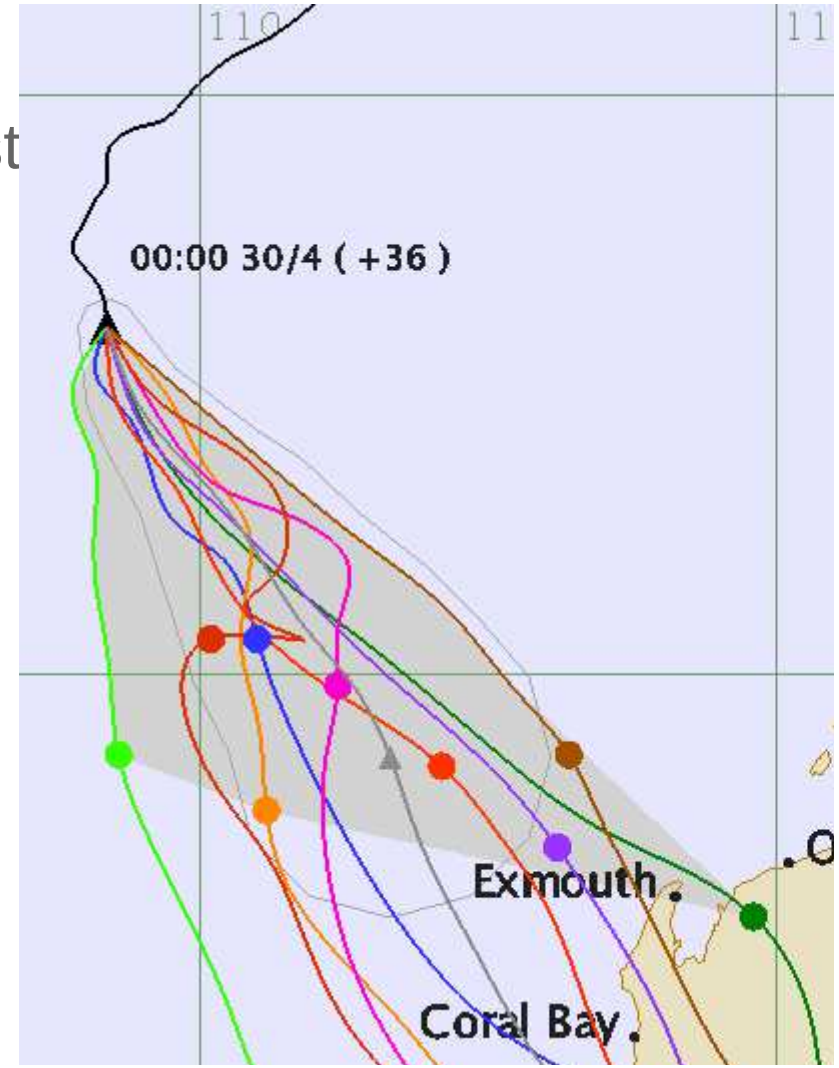
1. discard COAMPS as the outlier?

OR

2. Just take the consensus of all?

Or

3. …?



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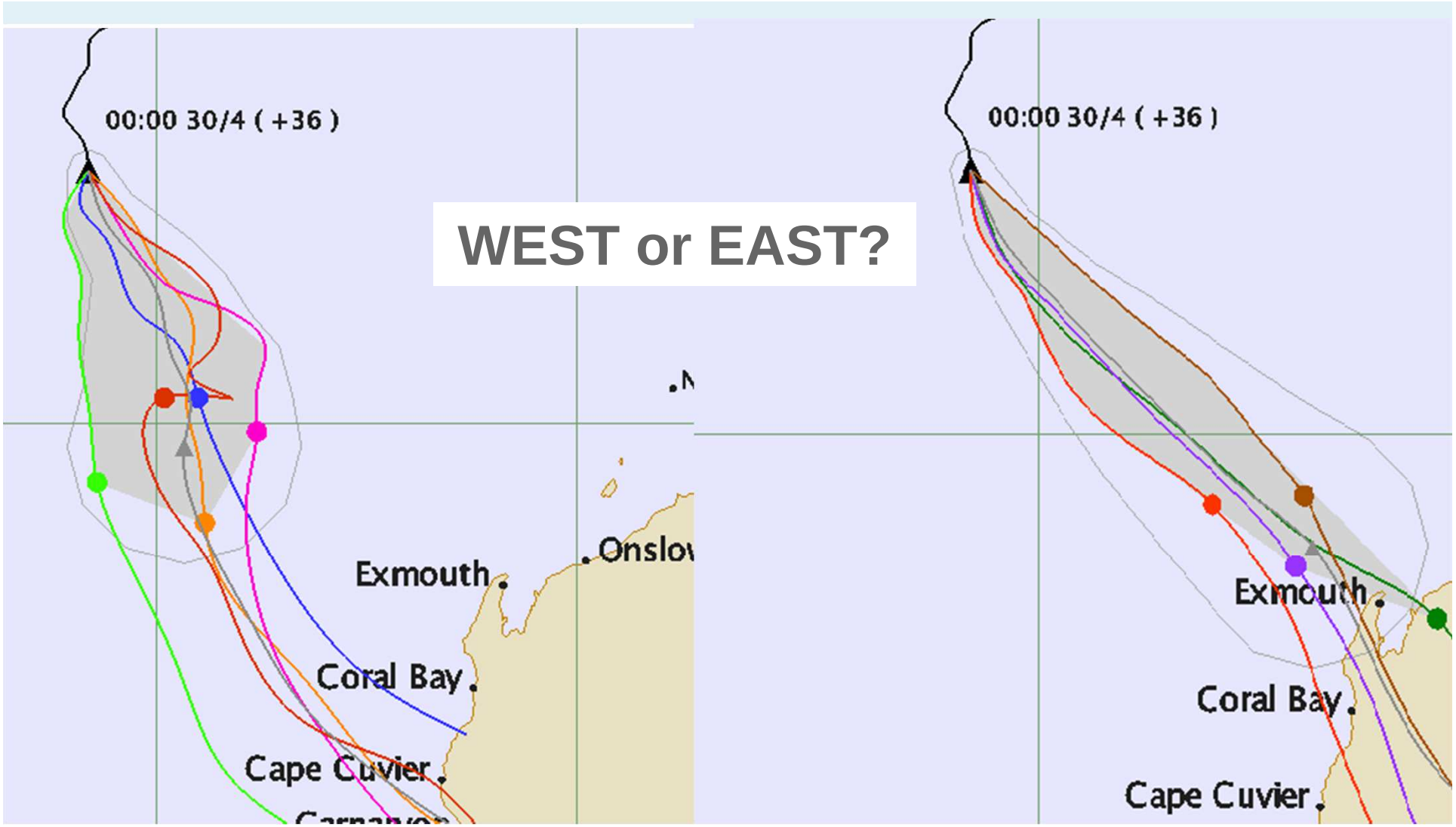
The BoM Consensus approach
SELECTIVE (SCON)
Will *Quang* hit Exmouth??



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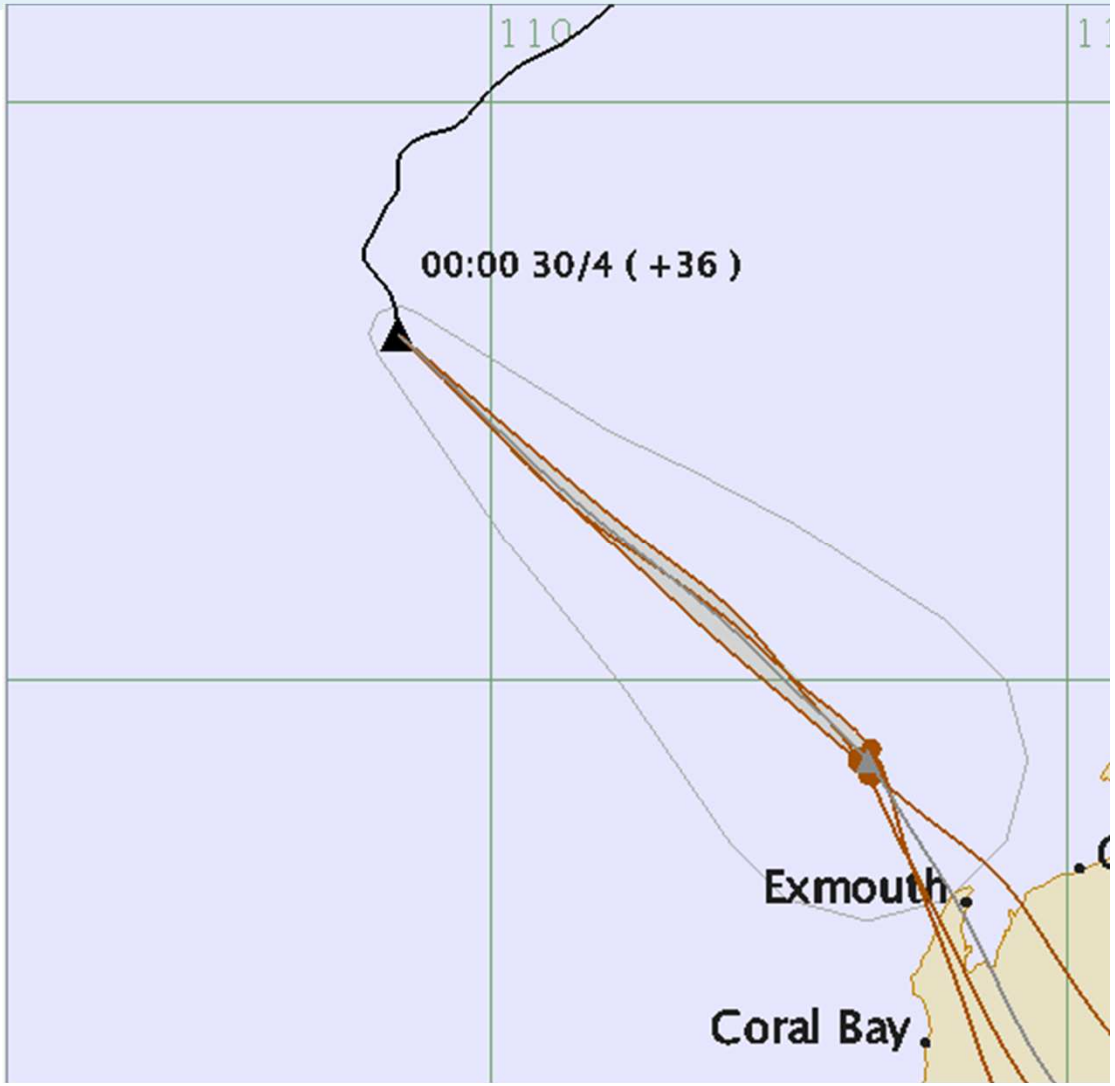
The BoM Consensus approach
SELECTIVE (SCON)
Will *Quang* hit Exmouth??

UK last three runs for consistency



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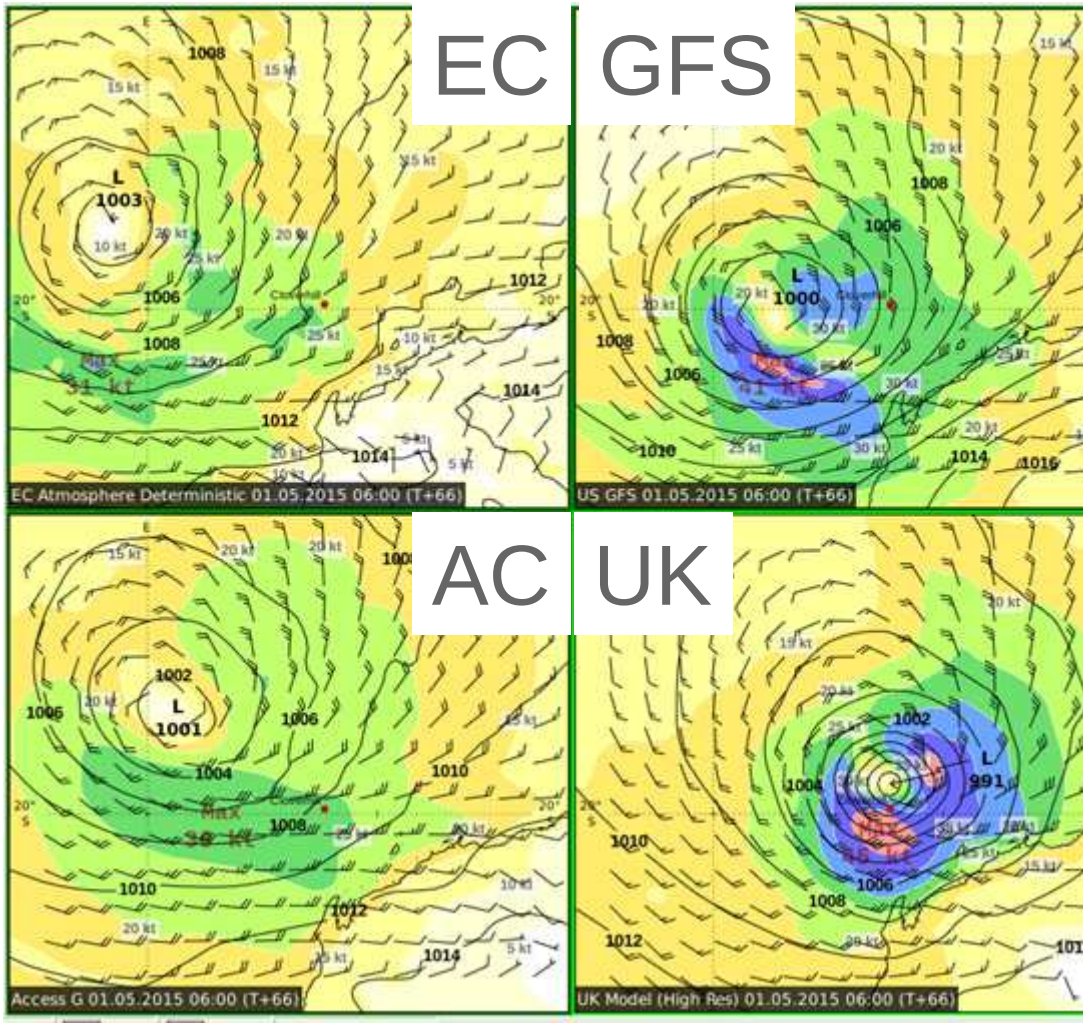
Track Forecasting – The BoM Consensus approach SELECTIVE (SCON)

Quang: bias to UK (to east)

sfc wind comparison at +66h

UK stronger being steered by deeper NW'ly flow than other models

JMA also weak – outlier to be discarded?



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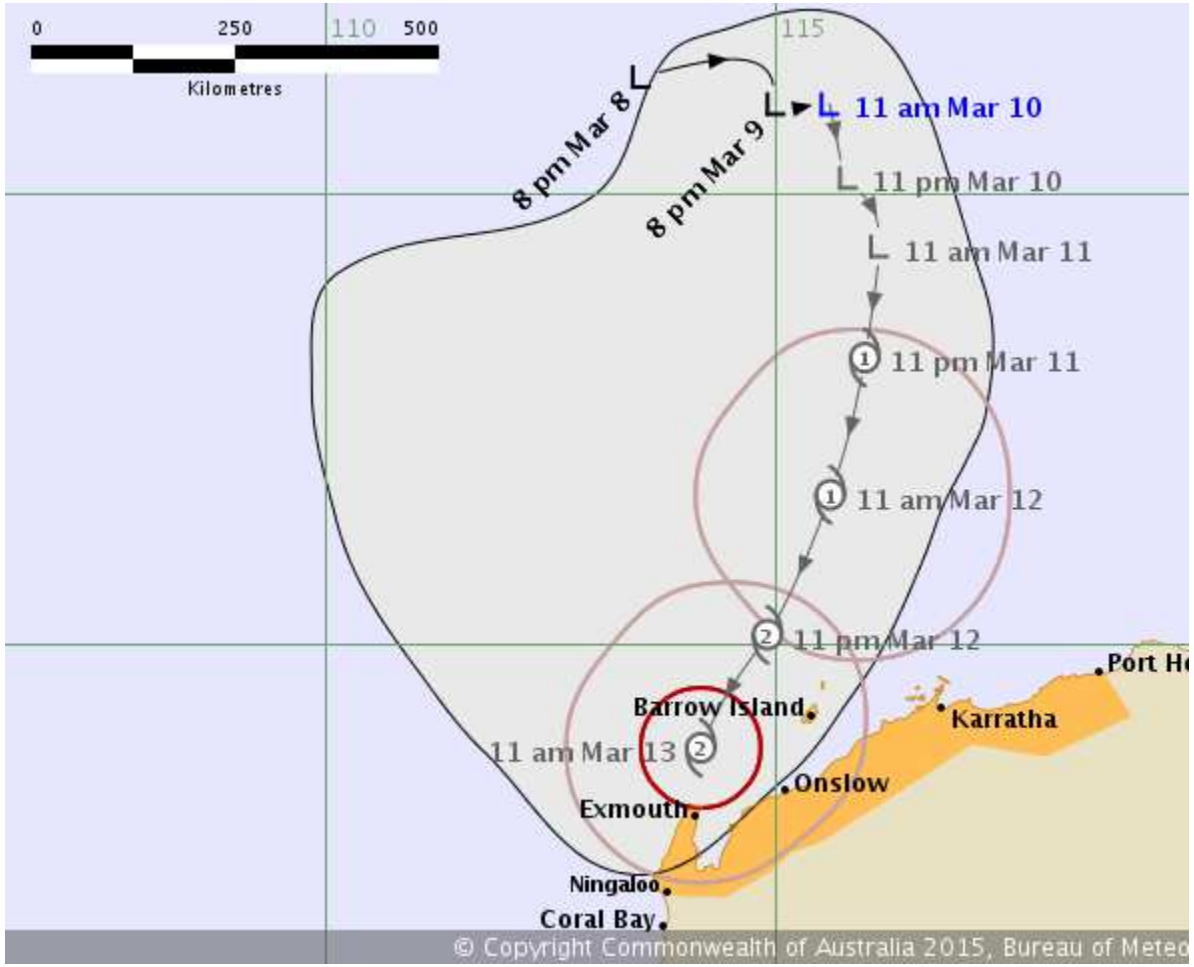
The BoM Consensus approach
SELECTIVE (SCON)

When to be selective: High spread, can explain model behaviour

pre-*Olwyn*:

bias to EC and UK

Uncertainty bulge for other scenarios



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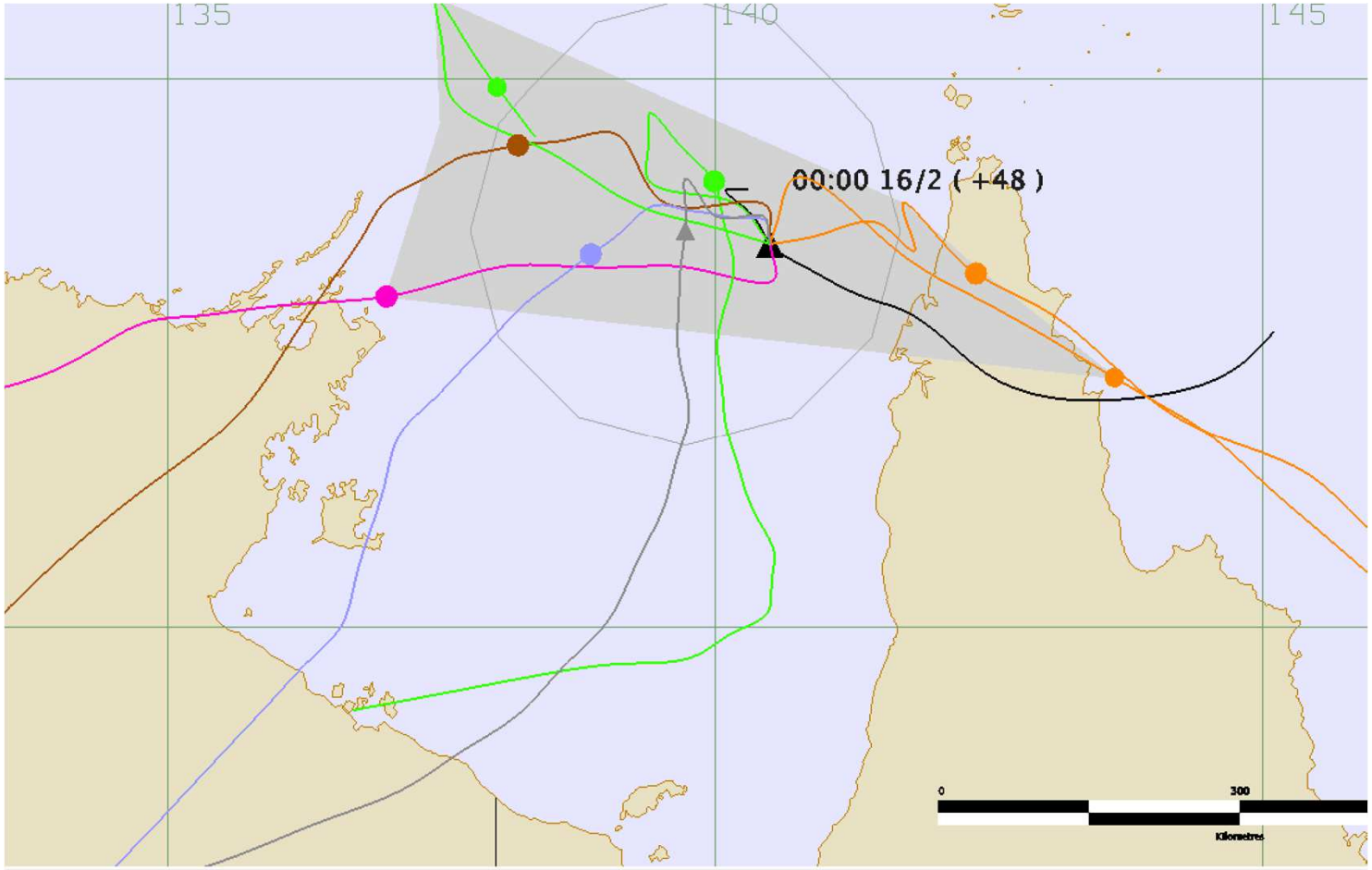
Track Forecasting – The BoM Consensus approach SELECTIVE (SCON)

Ex-TC Lam: high spread in models – EC Vs GFS/UK !



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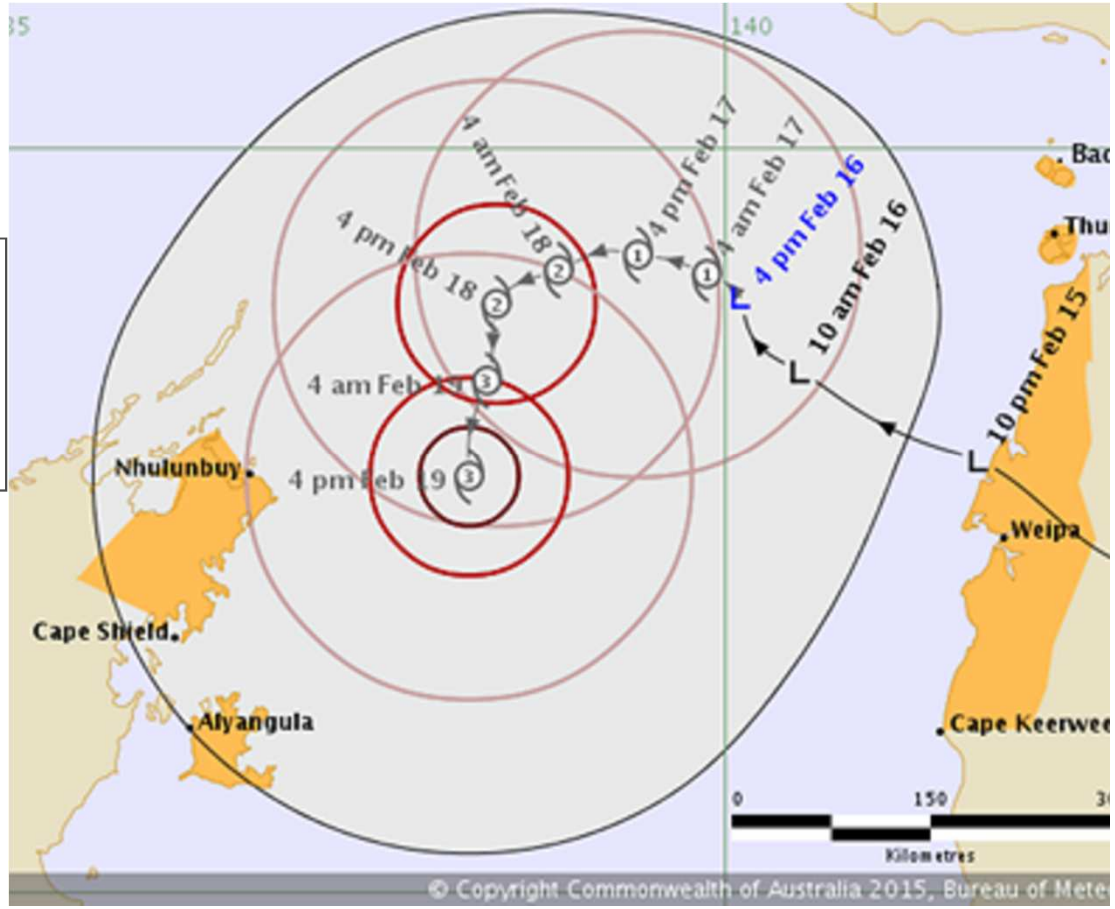
Track Forecasting – The BoM Consensus approach SELECTIVE (SCON)

Track map: high uncertainty – watch Qld and NT side of Gulf but EC treated as 'unlikely'

Note: when being selective ensure reasoning is documented



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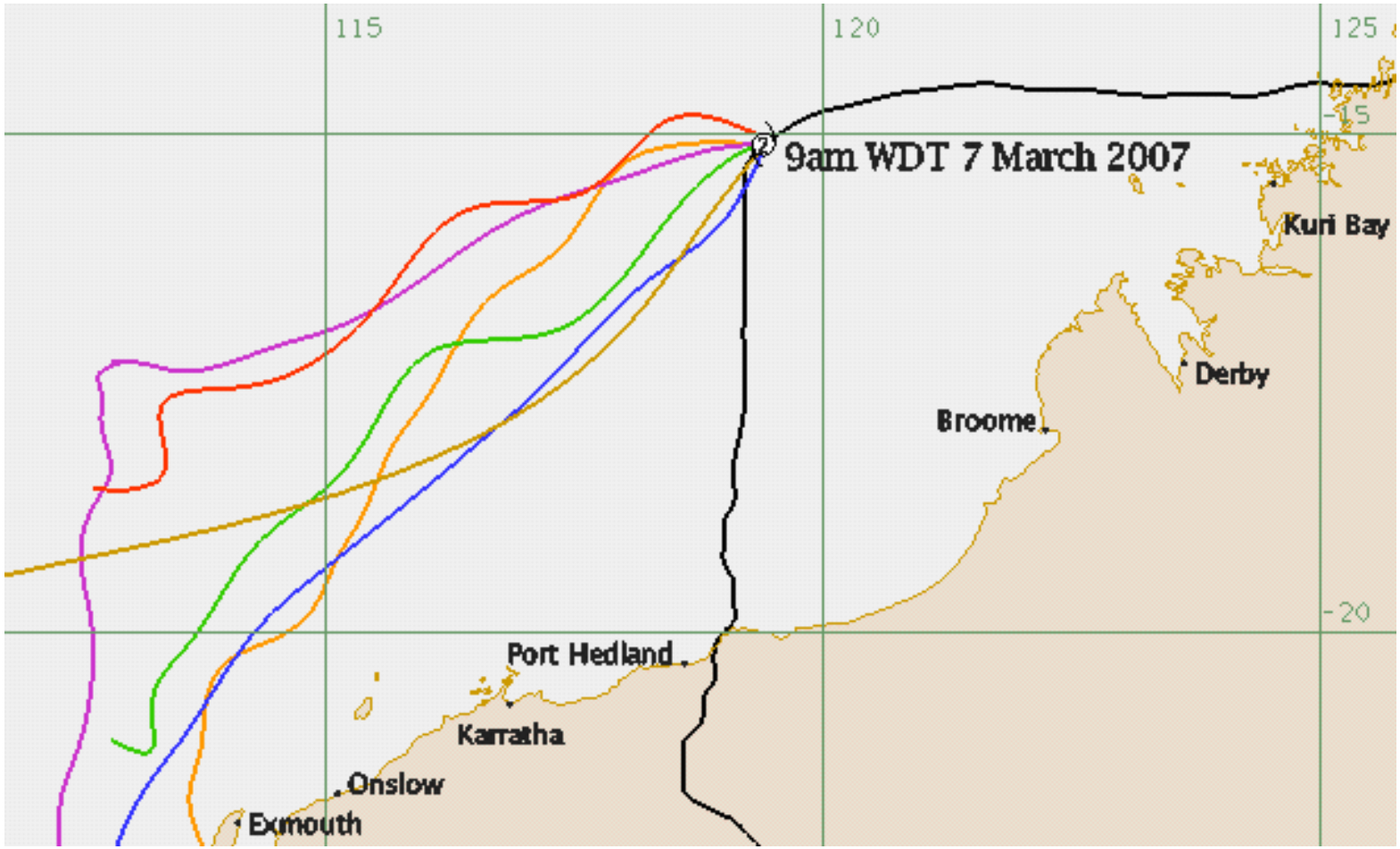
Track Forecasting – BEWARE
Don't ever be complacent

Sometimes nature doesn't go by the NWP rules



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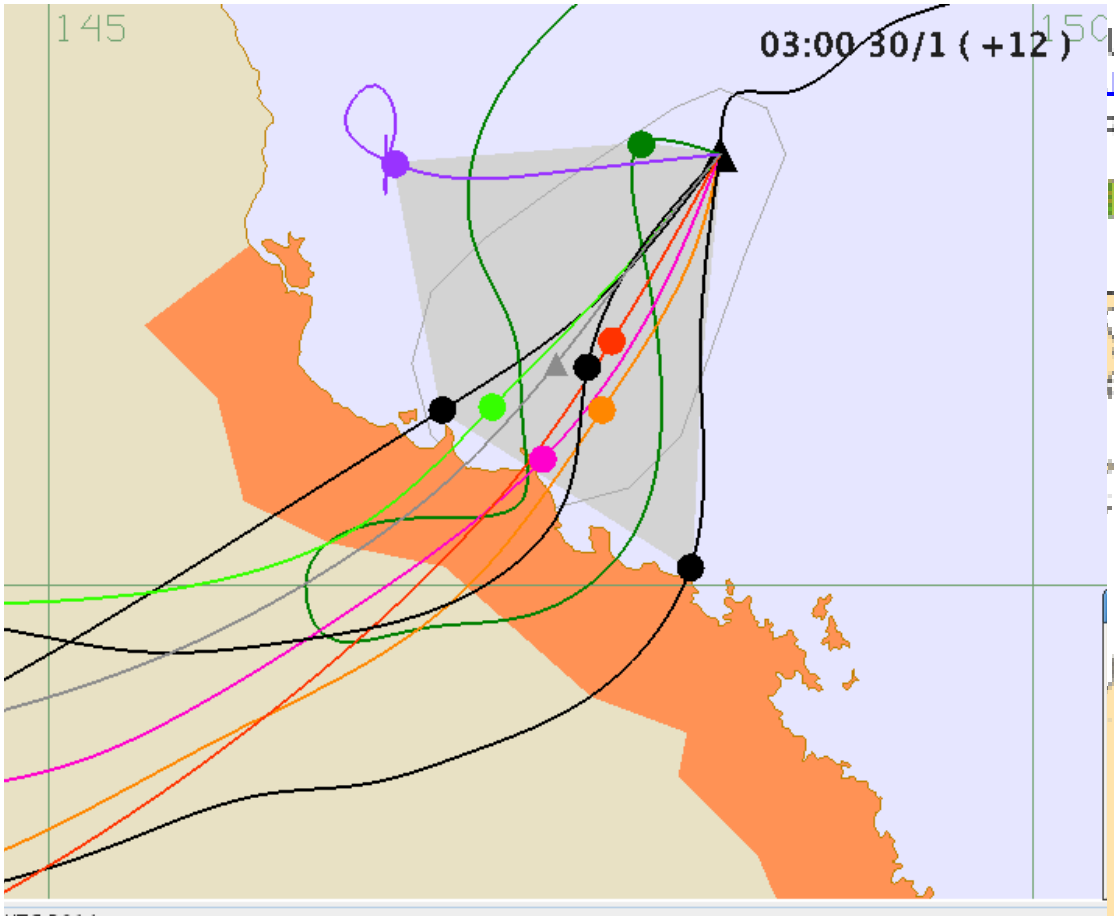
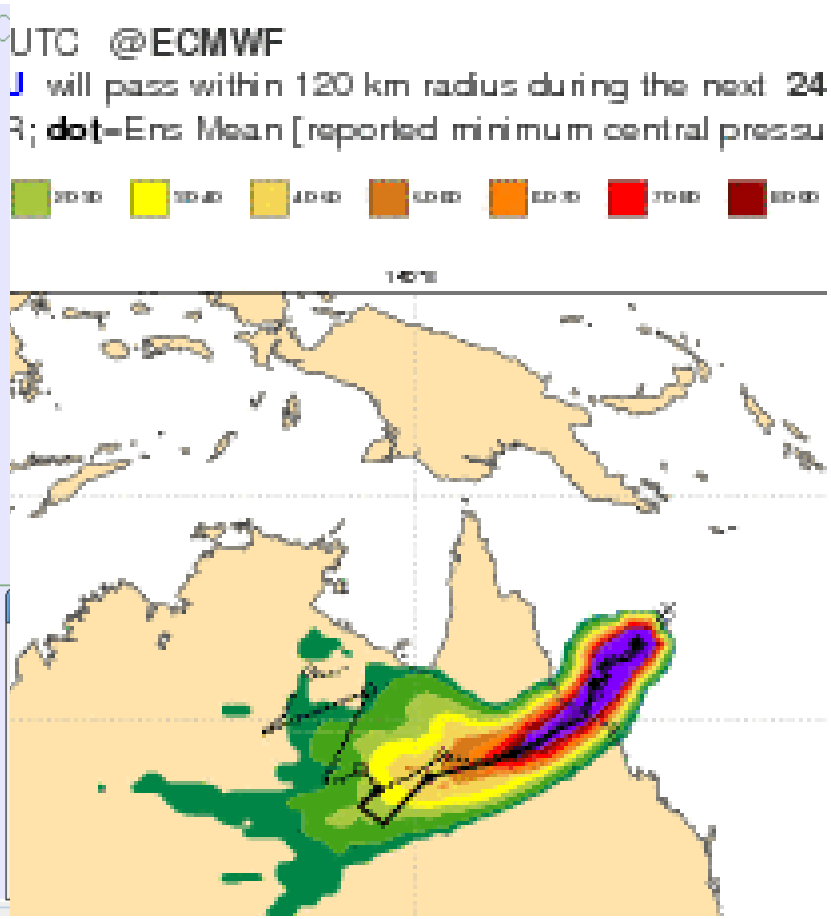
Track Forecasting – BEWARE
Don't ever be complacent

Changes in track close to coast – timing consequences for landfall storm tide e.g. Dylan, Marcia, Yasi…Trochoidal motion





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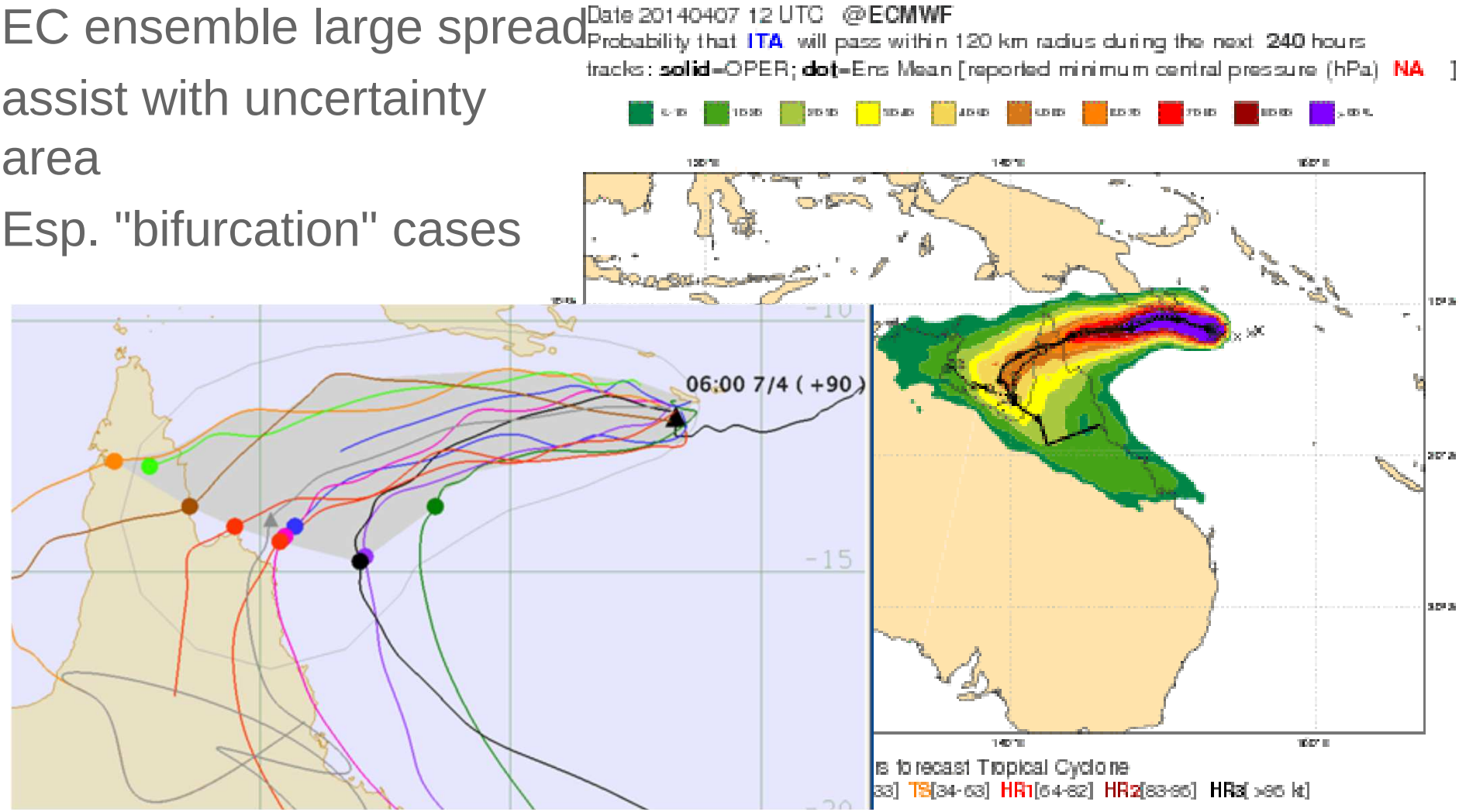
Track Forecasting - ensembles

EC strike probability – TC *Ita*

EC ensemble large spread

assist with uncertainty area

Esp. "bifurcation" cases



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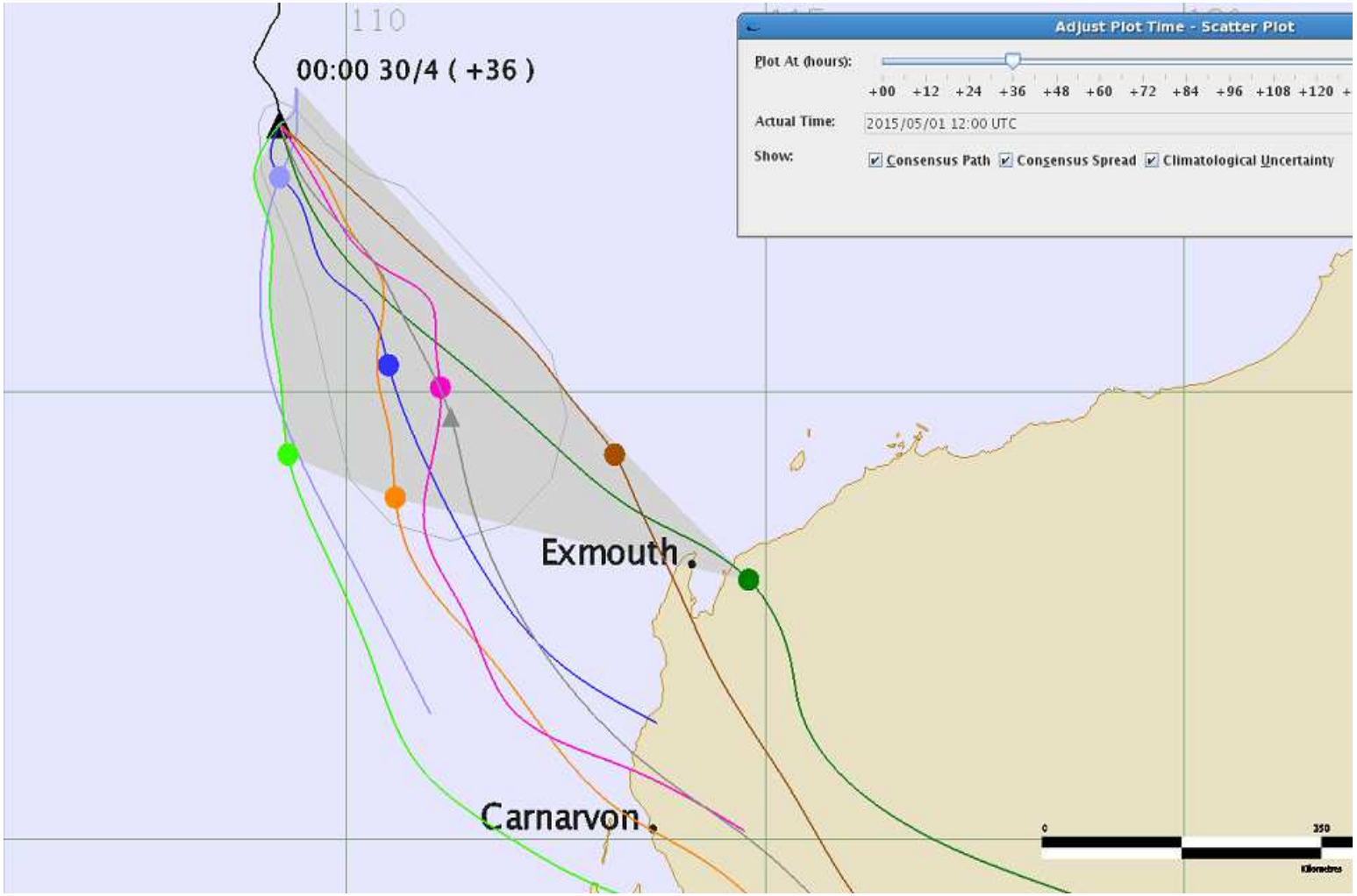
Applying ensembles



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Applying ensembles

Bright&Nutter 2004

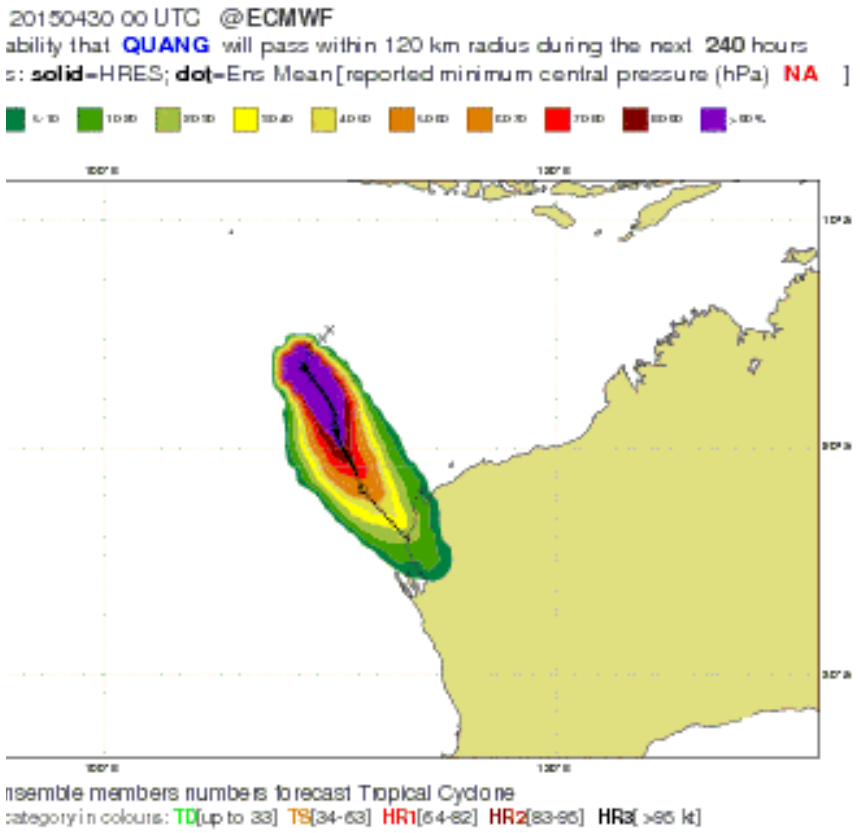
Extracting best ensemble member will not yield the best forecast over time!

attempting to choose or eliminate members may degrade the future value of the ensemble because "bad" members may appear as the best member at a later time.

mmm…

But Quang – can we eliminate some members west or east?

Maybe …



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ADVANCED Track Forecasting - ensembles

Filtering, clustering and super-ensembles

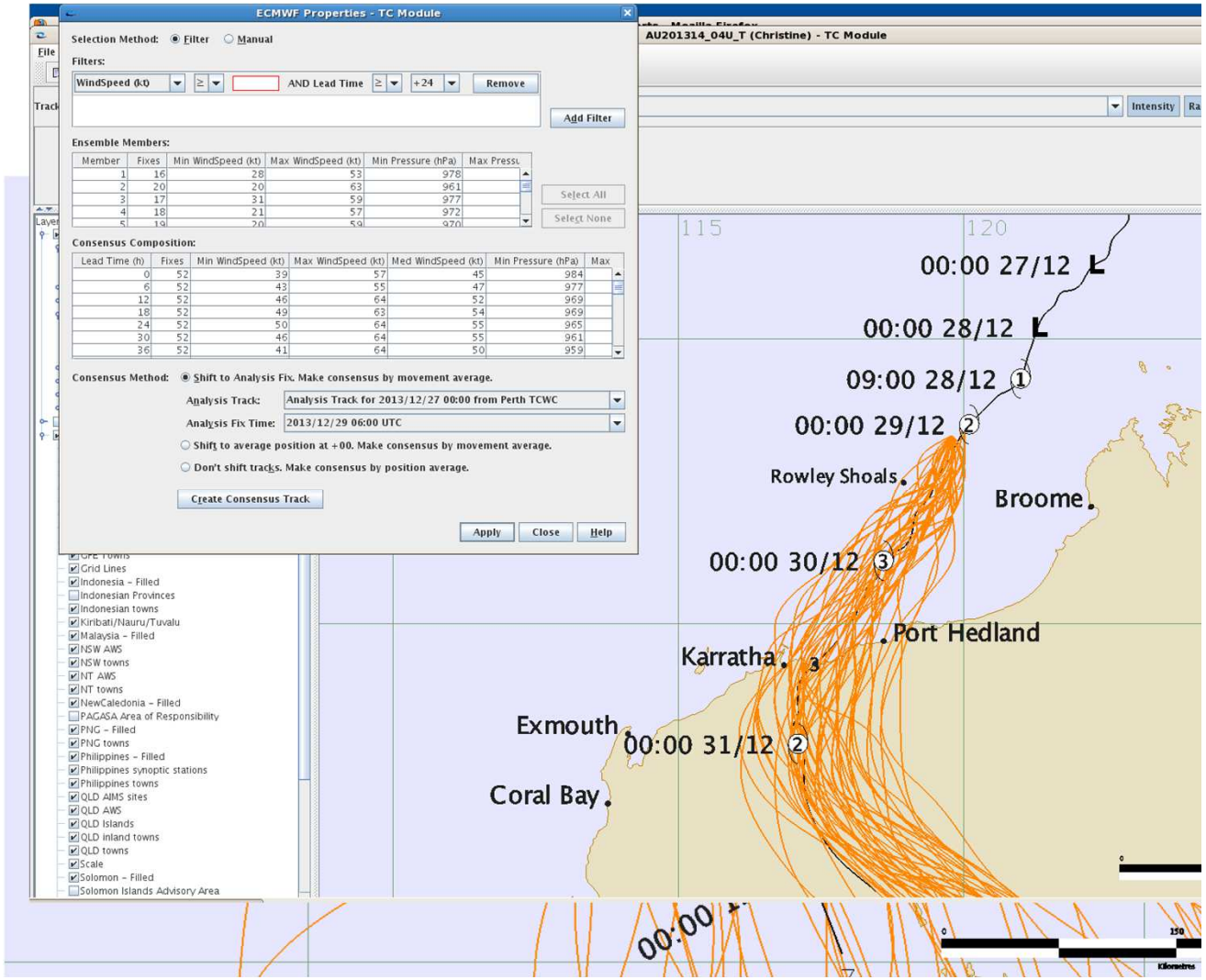
Filter on position/intensity

Cluster techniques

Useful SOMETIMES

Bang for buck?

Super-ensembles coming…availability



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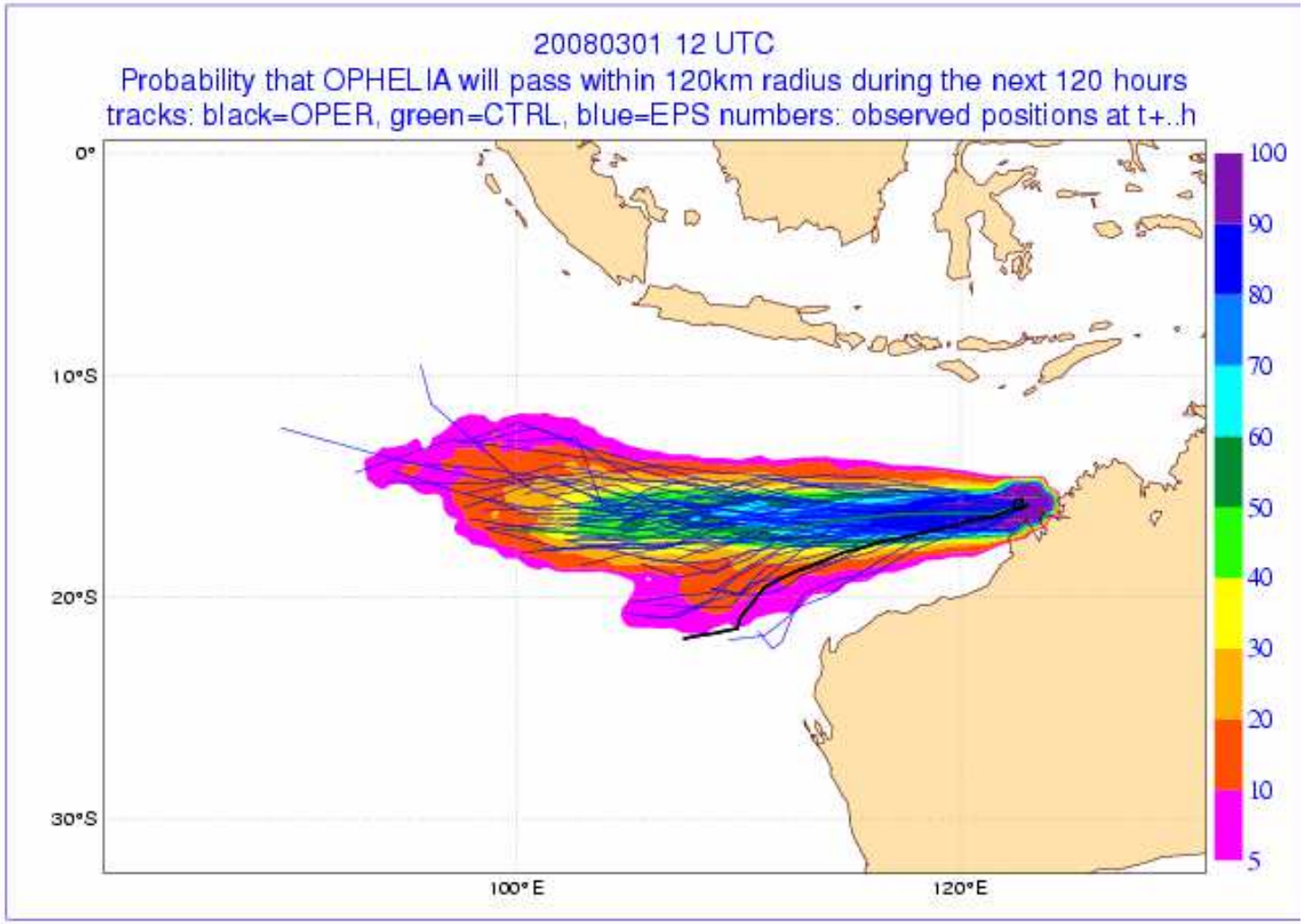
ADVANCED: Deterministic Vs Ensemble mean Black line - determistic

Why is the black line different from the highest probability?



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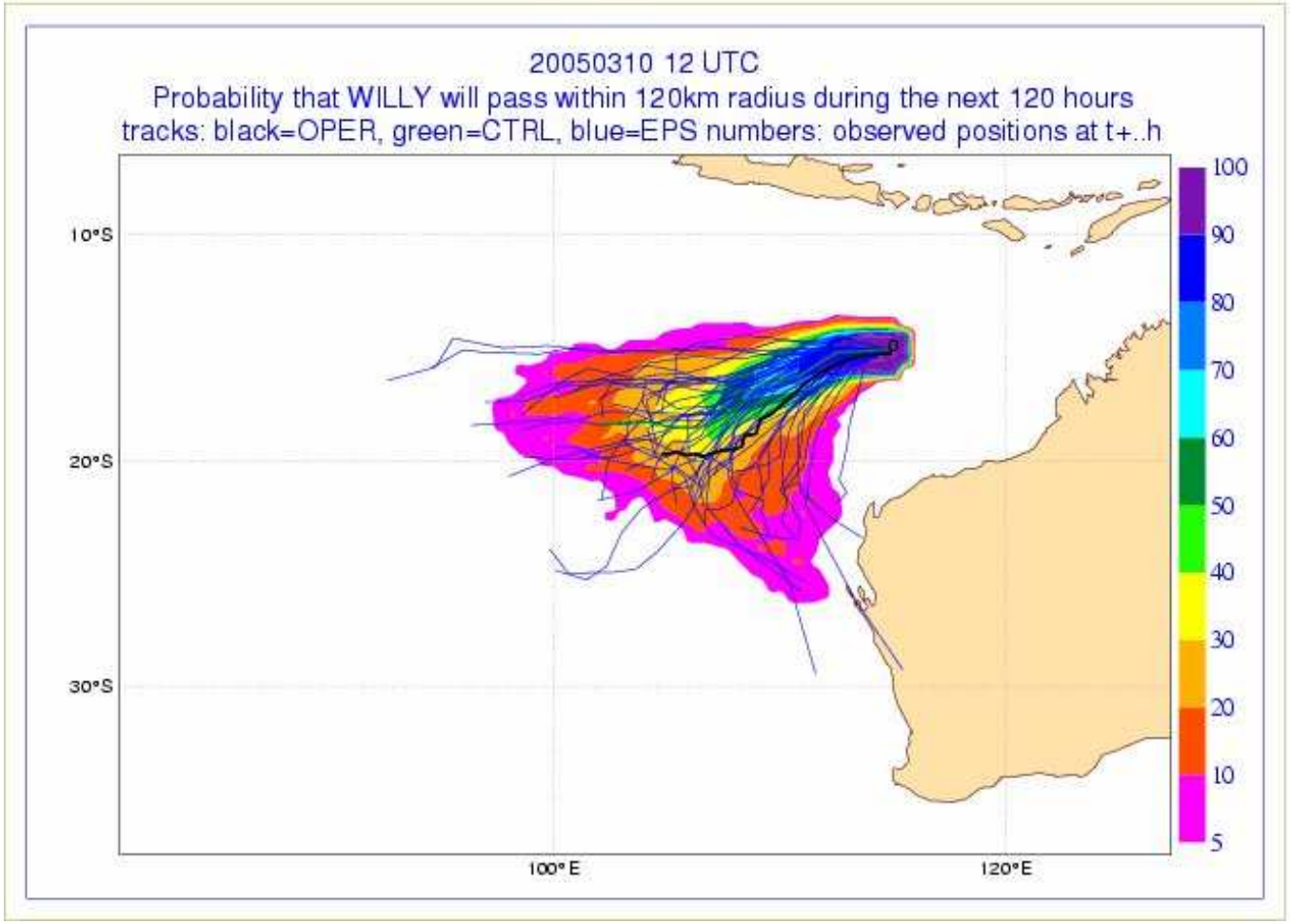
ADVANCED Track Forecasting

Bifurcation TC Willy



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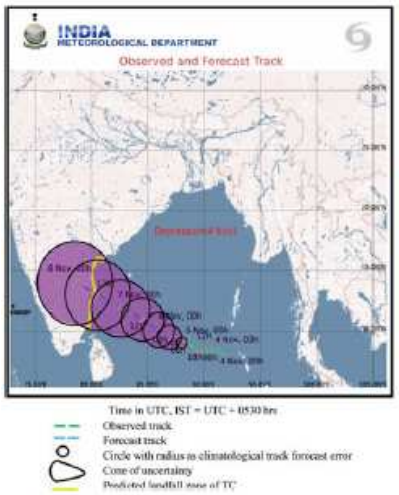
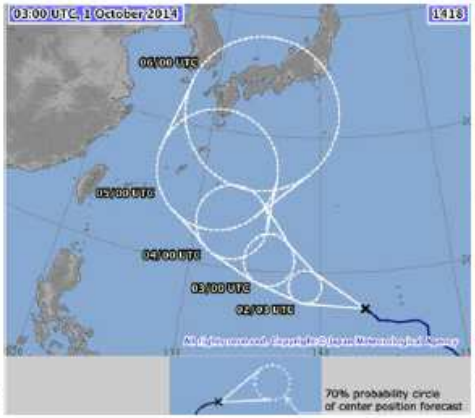
Track map examples

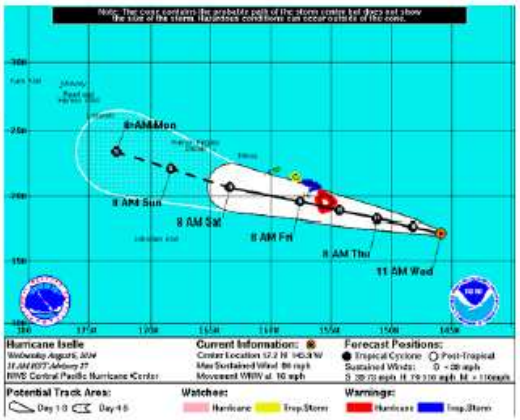
NIO



WNP

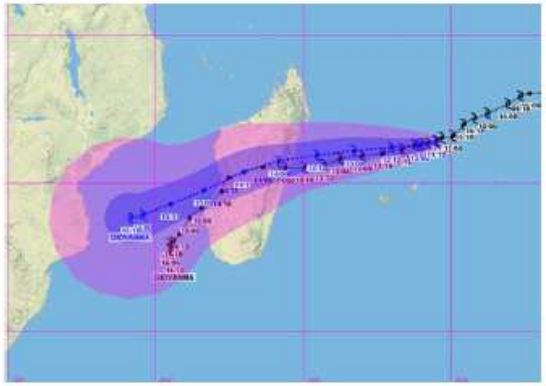


CNP

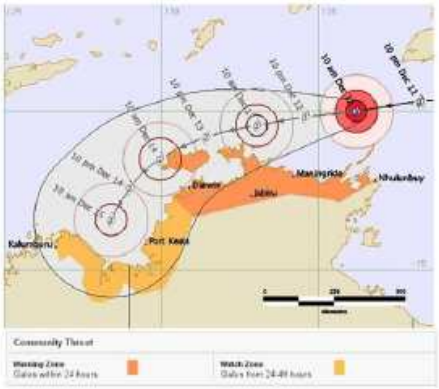


ESP/ATL

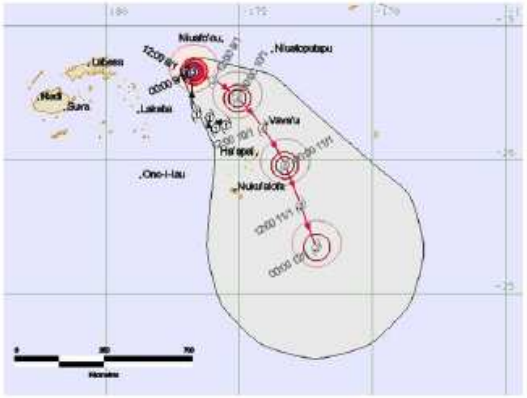
SIO



AUS



SPC



Courtesy: Elliott&Yamaguchi, IWTC VIII http://www.wmo.int/pages/prog/arep/wwrp/new/documents/Topic1_AdvancesinForecastingMotion.pdf

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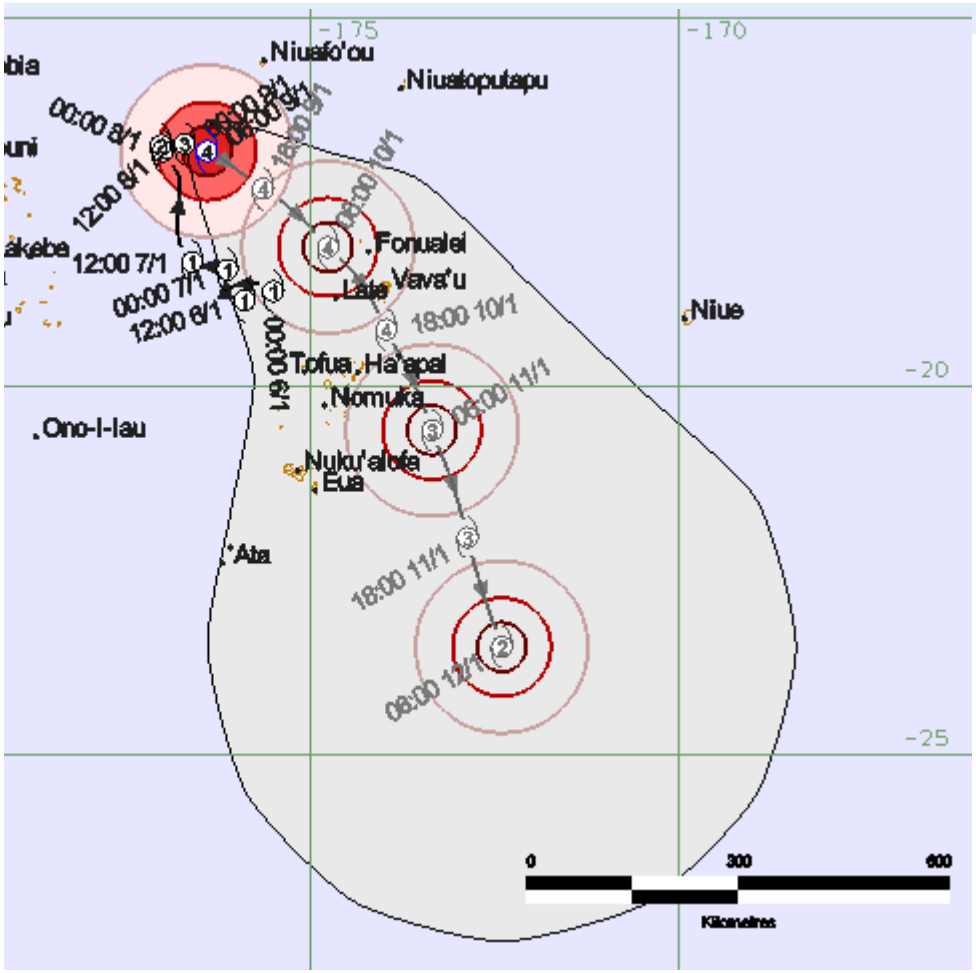
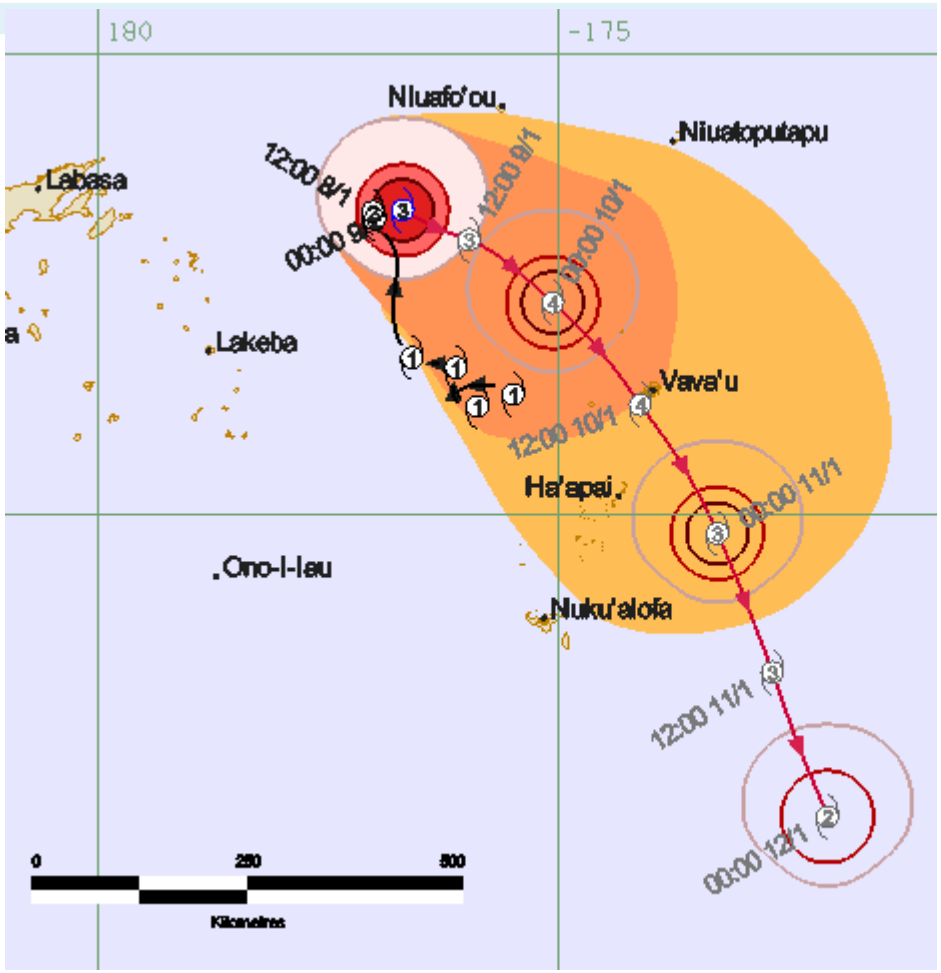
Fiji Track map examples: uncertainty and threat areas





Courtesy: Fiji Met Service

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Summary

Forecasting - it is all getting easier!

Questions?

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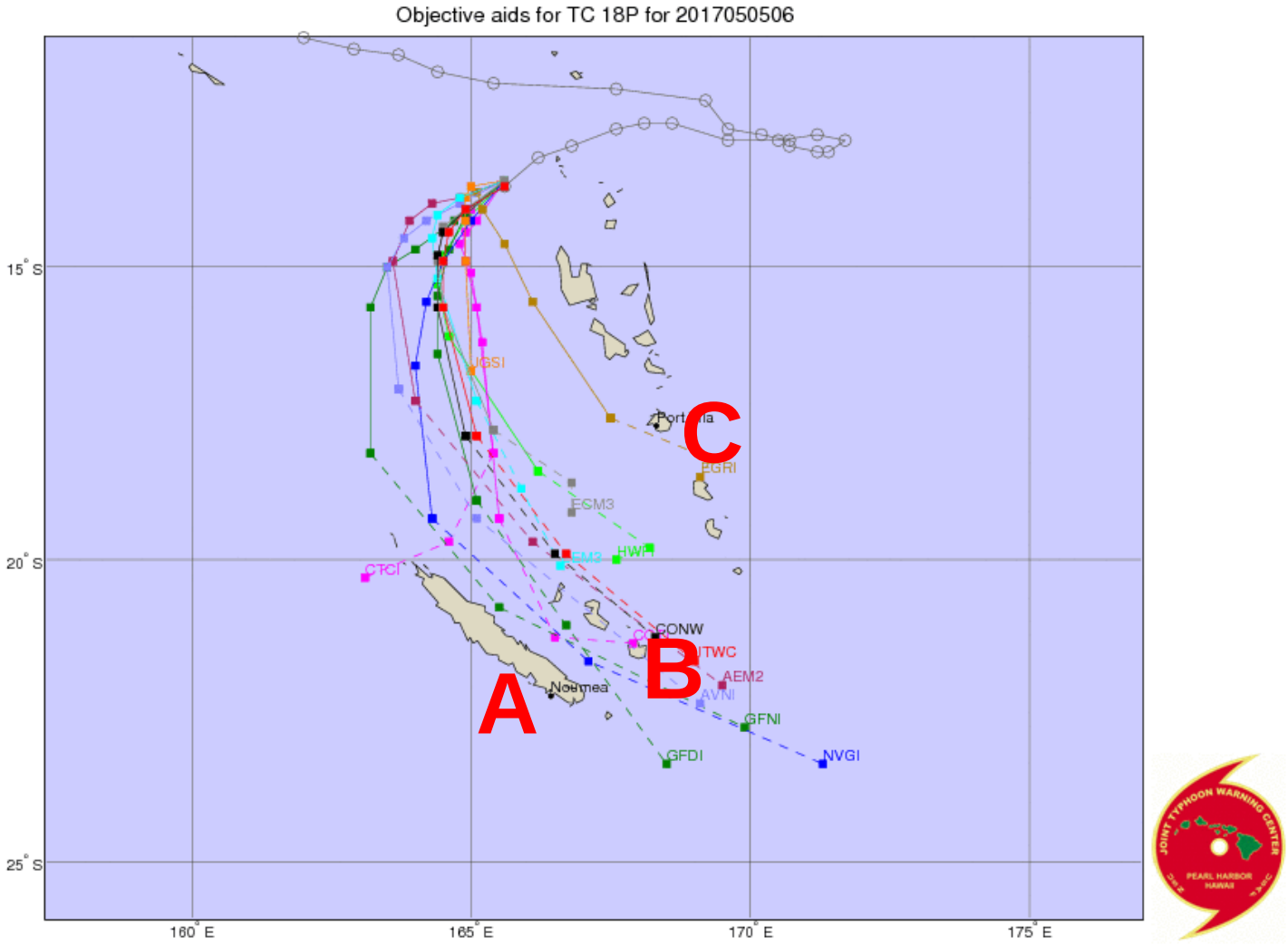
Exercises
What is the probability of impact at locations A, B and C?



Exercises: EC ensemble

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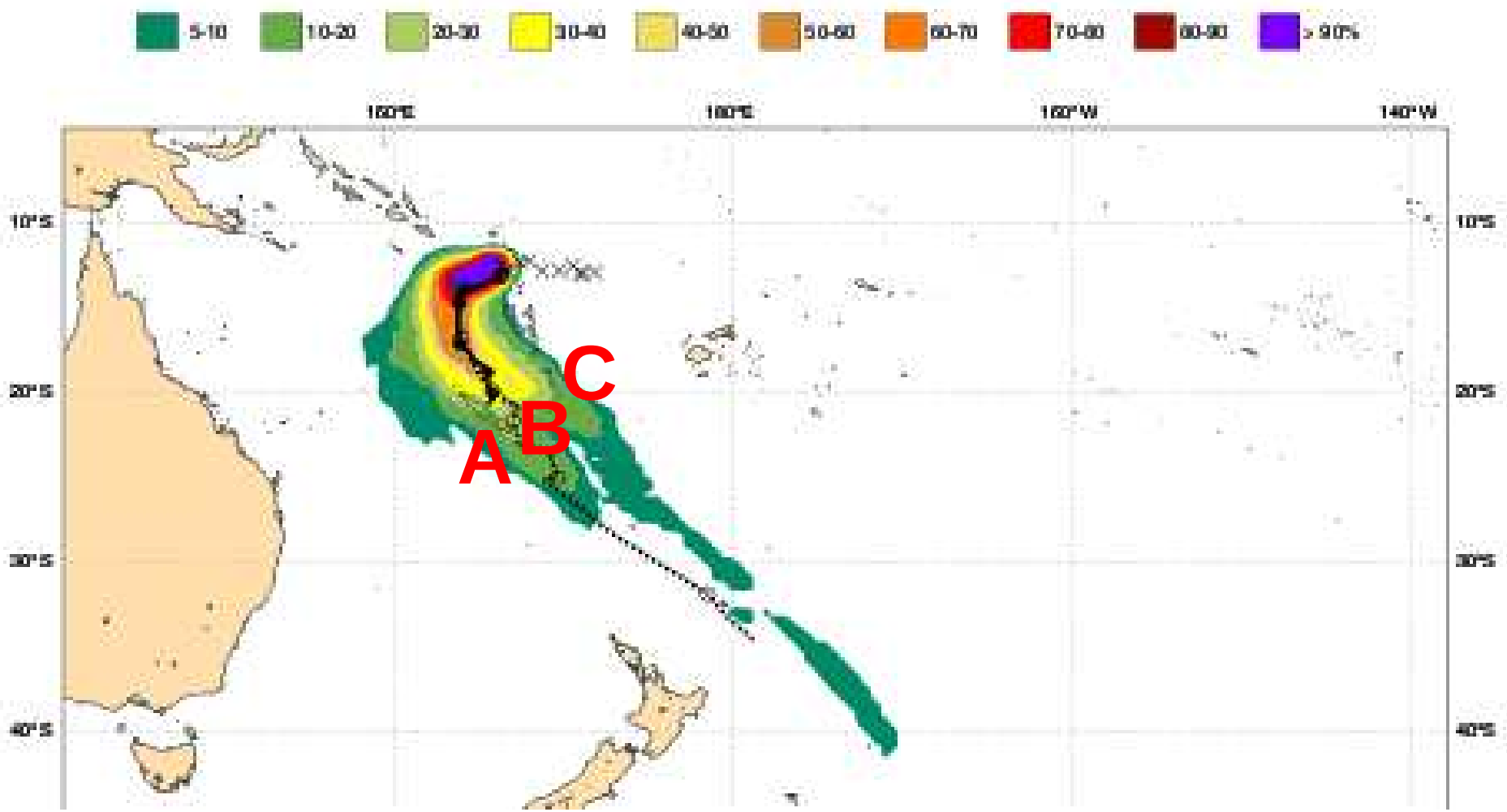
What is the probability of impact at locations A, B and C?



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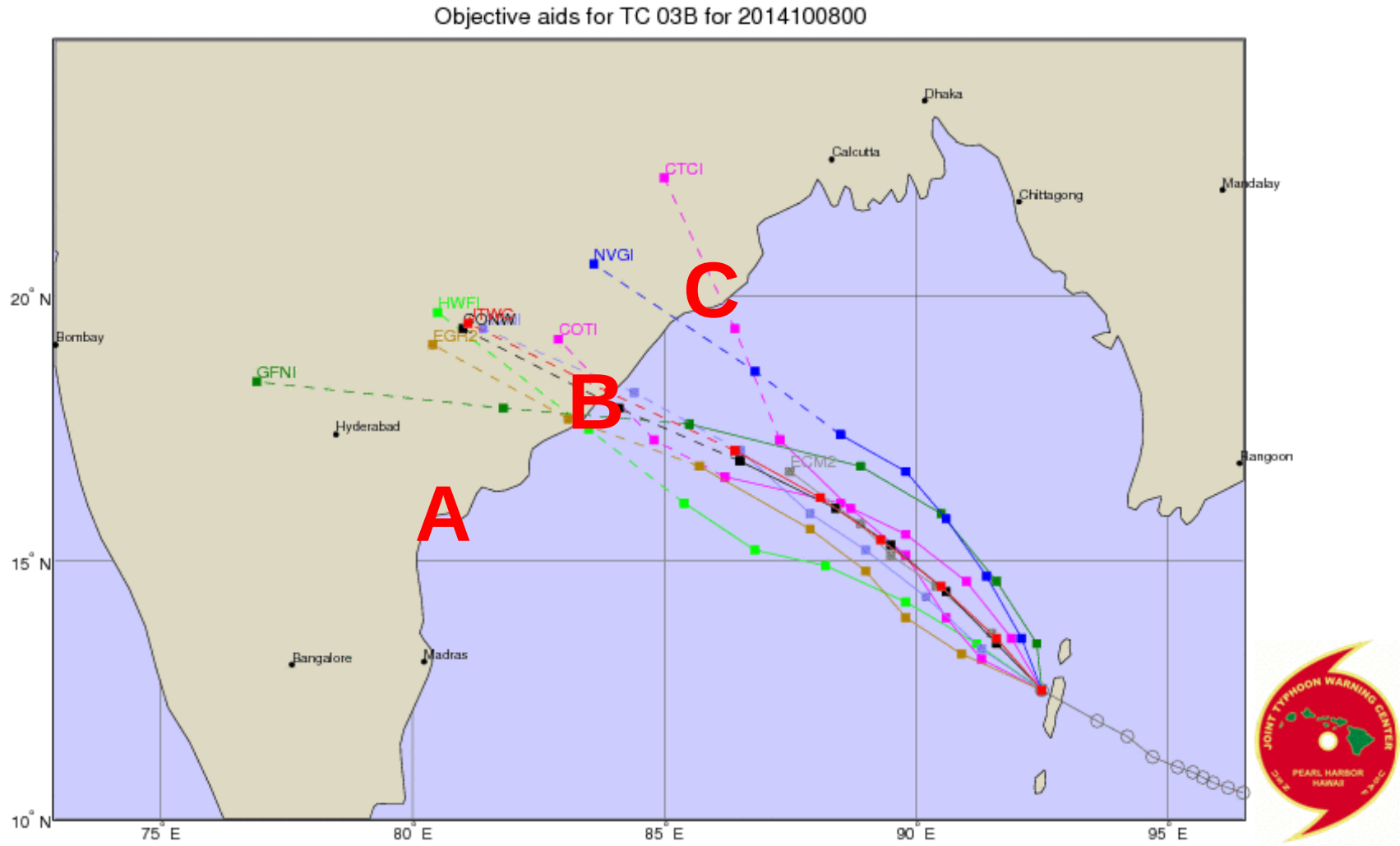
Exercises
What is the probability of impact at locations A, B and C?



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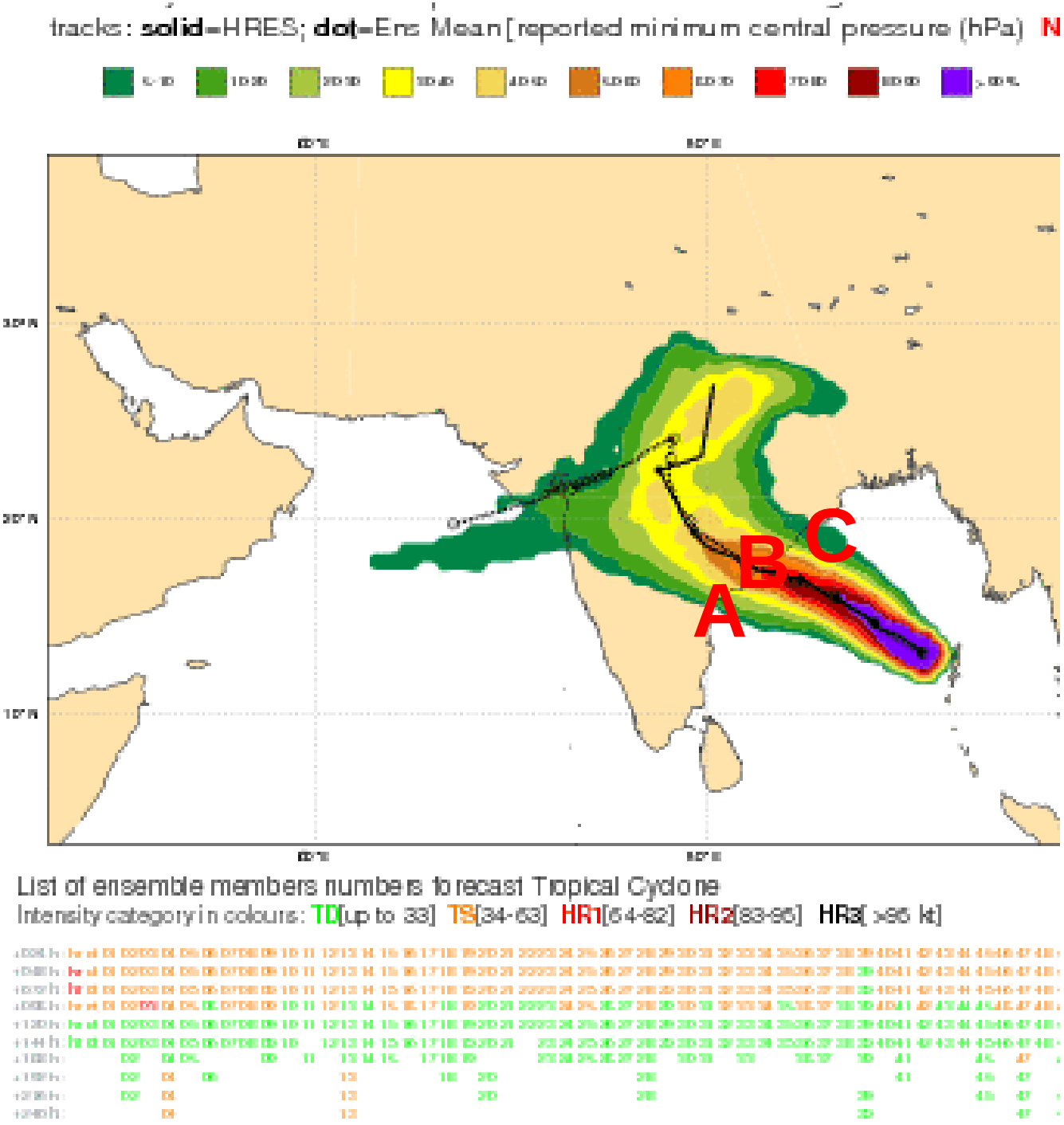
What is the probability of impact at locations A, B and C?



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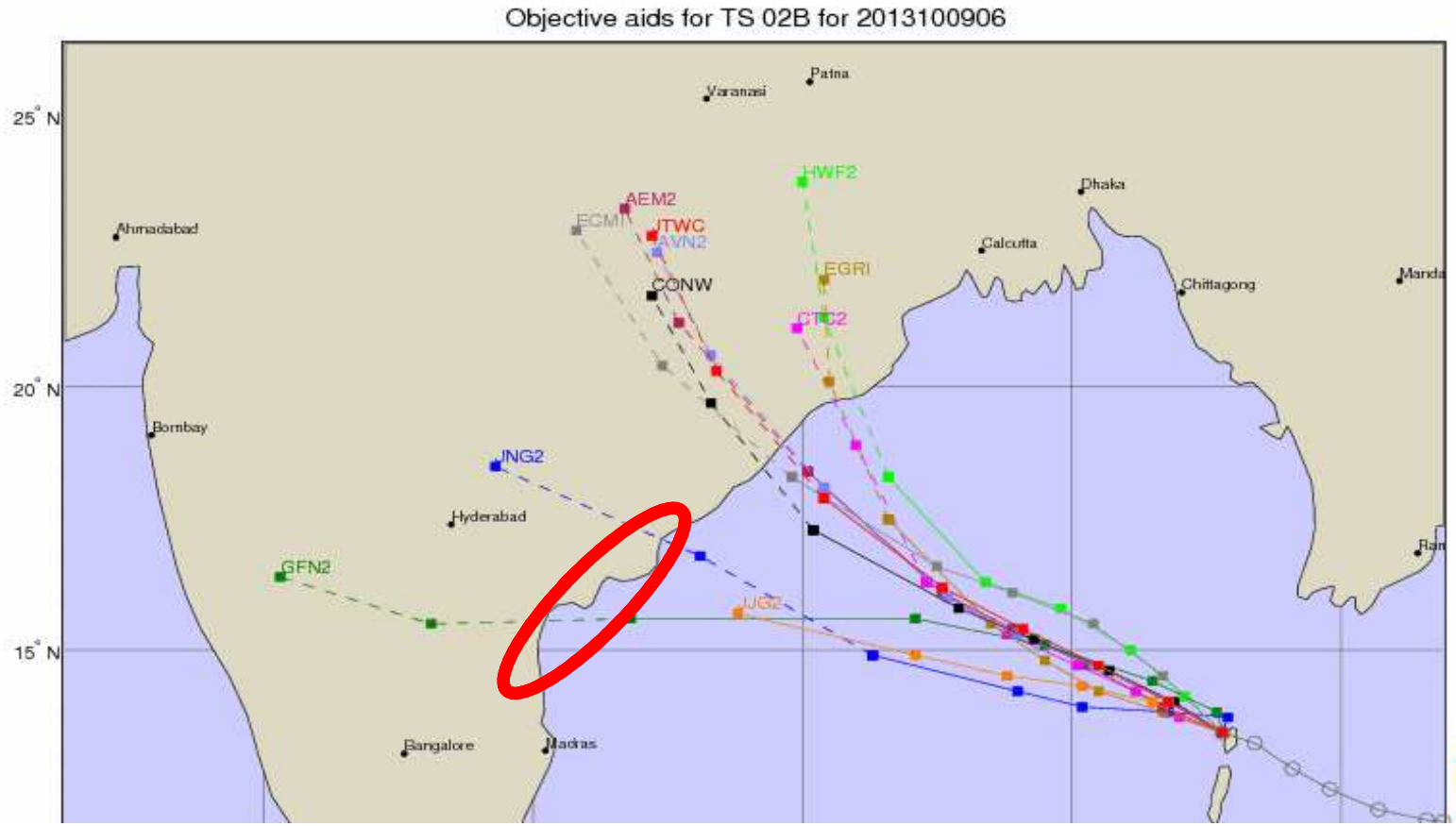
Exercises

How would you go about determining the risk to southern Andhra Pradesh?



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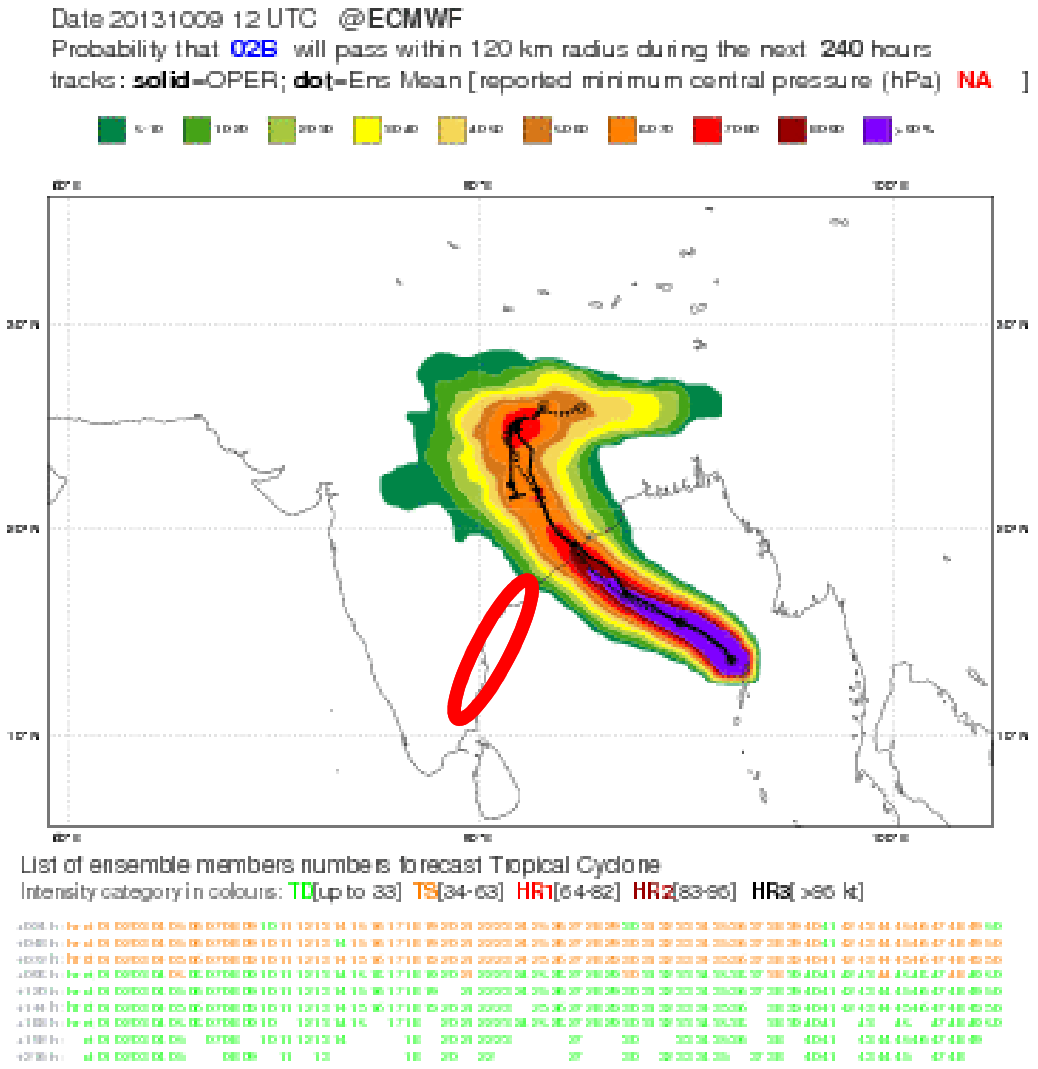
Exercises
How to use this spread?

Is there a risk to southern Andhra Pradesh?



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Exercises
Real-time: steering pattern in the Pacific

For …
Determine the steering pattern based on the 700 and 500hPa winds/heights from HWRF and GFS

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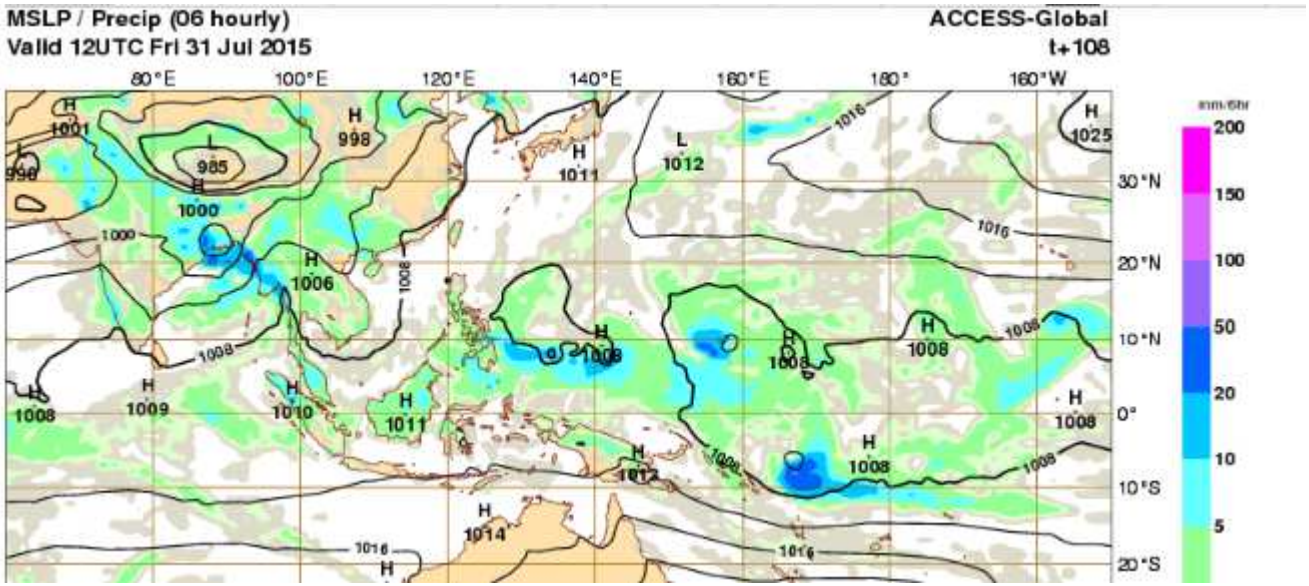
Model upgrades : ACCESS

http://www.bom.gov.au/australia/charts/viewer/

ACCESS-G upgrade to APS-2 for 2015/16 season resolution 25km from 40km
- Possible concern that model may 'overheat' development.

ACCESS-TC variable domain at 12km resolution

New supercomputer will herald opportunities for upgrades in 2016 & 2017



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Applying ensembles: should we bother being selective?

US Dewpoint example: different colours represent different ensemble members closest to the analysis (most accurate)

Little spatial correlation between members

No one member dominates a large region

Red: 1-5 Yellow 6-10 Blue 11-15