NWP for Tropical Cyclone forecasting

- NWP upgrades
- Track forecasting
  - Consensus
  - Ensembles

Rewa, 1993/94
Models : ECMWF

- [https://software.ecmwf.int/wiki/display/FCST/Implementation+o+f+IFS+cycle+43r3](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**

- [https://software.ecmwf.int/wiki/display/FCST/Implementation+of+IFS+cycle+43r3](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% (bootstrap)
Model upgrades:

GFS

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

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)

TC Tracks

有效日期: 2017年5月6日 05 UTC
Model: HWRF

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
Model upgrades: HWRF


Blanca 2015
3km run

2km run, more symmetric and smaller sized storm

Courtesy: V. Tallapragada, NCEP
ACCESS NWP

ACCESS-G Global (~25km)
ACCESS-TC variable domain 12km resolution for TCModule tracking
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
Verification: Track JTWC 2016 in WPAC (update) [typical for all basins]
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
The BoM Consensus approach
Non-SELECTIVE (NCON) – robust most of time

TC Christine:
Model position check
TC *Christine*: spread in shifted models
Tier 1 models consistent
cf climatology (grey)
cf previous forecast (dashed)
TC Christine: Uncertainty and gales shape watch/warning areas
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. …?
The BoM Consensus approach
SELECTIVE (SCON)
Will *Quang* hit Exmouth??

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

UK last three runs for consistency
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?
The BoM Consensus approach
SELECTIVE (SCON)

When to be selective: High spread, can explain model behaviour
pre-\textit{Olwyn}:
bias to EC and UK
Uncertainty bulge for other scenarios
Track Forecasting –
The BoM Consensus approach
SELECTIVE (SCON)

Ex-TC Lam: high spread in models – EC Vs GFS/UK!
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
Track Forecasting – BEWARE
Don't ever be complacent

Sometimes nature doesn't go by the NWP rules
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
Track Forecasting - ensembles

EC strike probability – TC *Ita*

EC ensemble large spread assist with uncertainty area
Esp. "bifurcation" cases
Applying ensembles
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 …
ADVANCED Track Forecasting - ensembles

Filtering, clustering and super-ensembles

Filter on position/intensity
Cluster techniques
Useful SOMETIMES
Bang for buck?
Super-ensembles coming...availability
ADVANCED: Deterministic Vs Ensemble mean
Black line - deterministic

Why is the black line different from the highest probability?
ADVANCED Track Forecasting

Bifurcation TC Willy

20050310 12 UTC
Probability that WILLY will pass within 120km radius during the next 120 hours
tracks: black=OPER, green=CTRL, blue=EPS numbers: observed positions at t+.h
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
Fiji Track map examples: uncertainty and threat areas

Courtesy: Fiji Met Service
Summary

Forecasting - it is all getting easier!

Questions?
Exercises

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

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

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

How would you go about determining the risk to southern Andhra Pradesh?
Exercises
How to use this spread?

Is there a risk to southern Andhra Pradesh?
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
Model upgrades: ACCESS

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

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