Tropical Cyclone Modelling at the Met Office

Royal Meteorological Society Meeting

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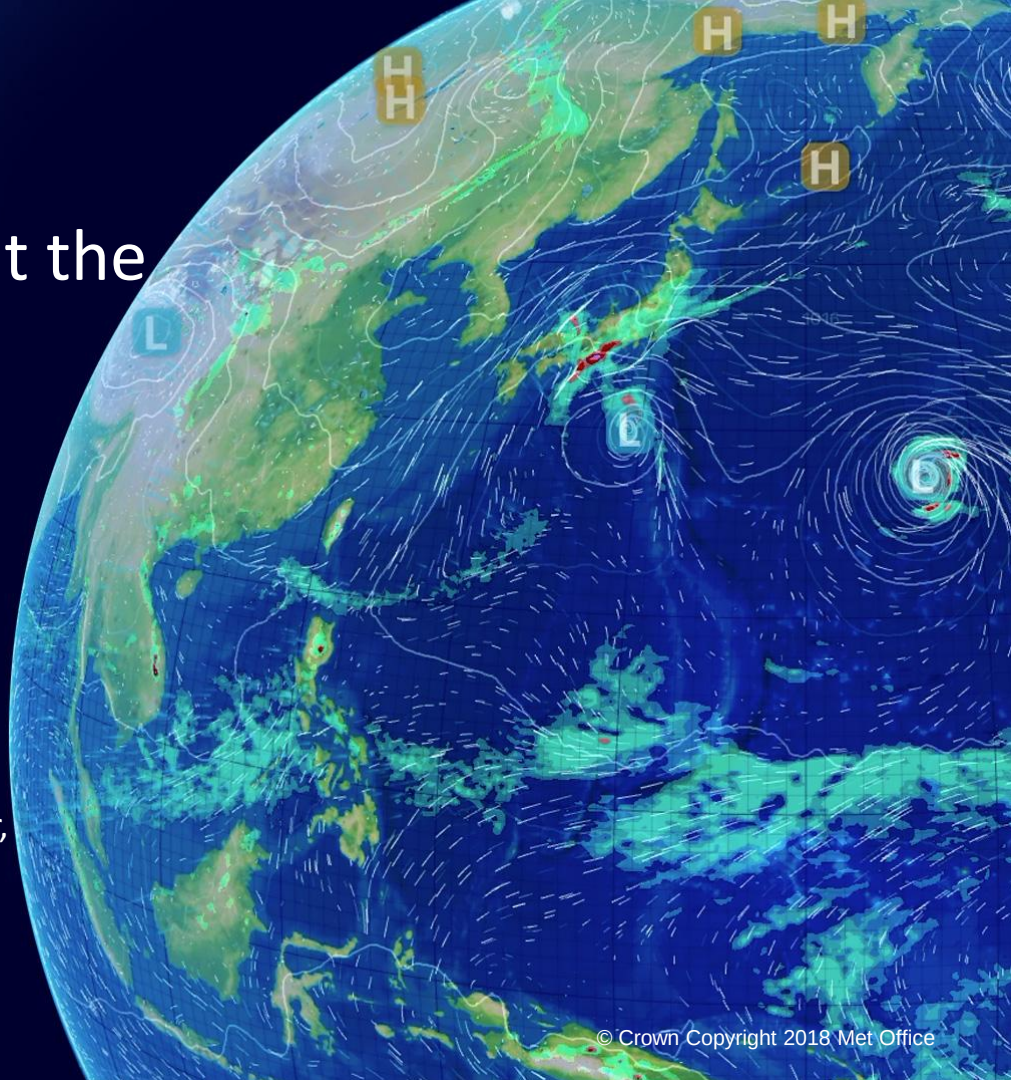
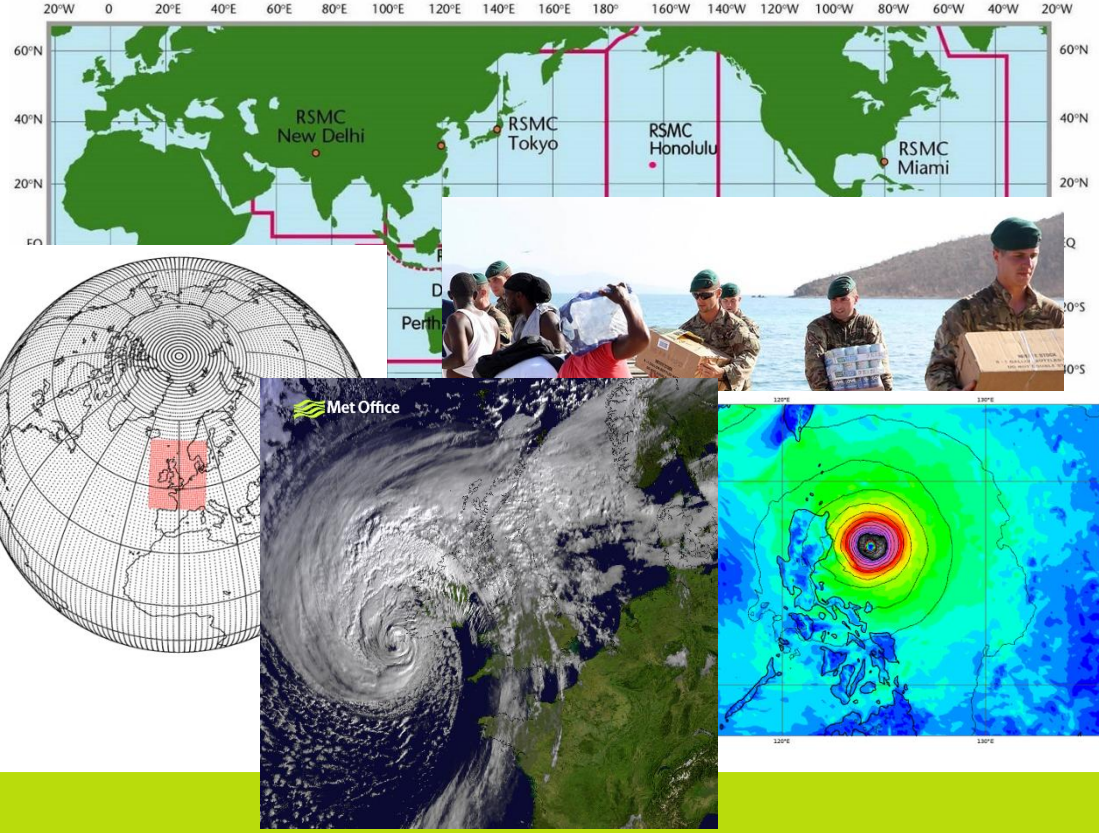
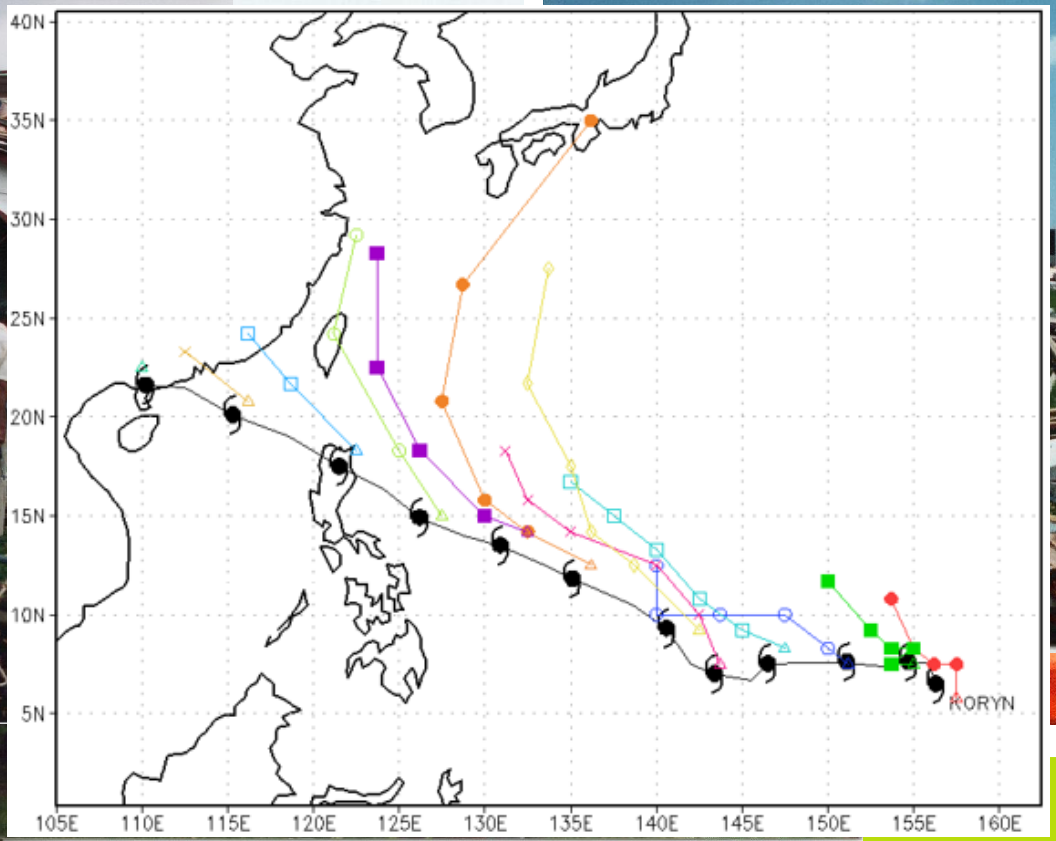


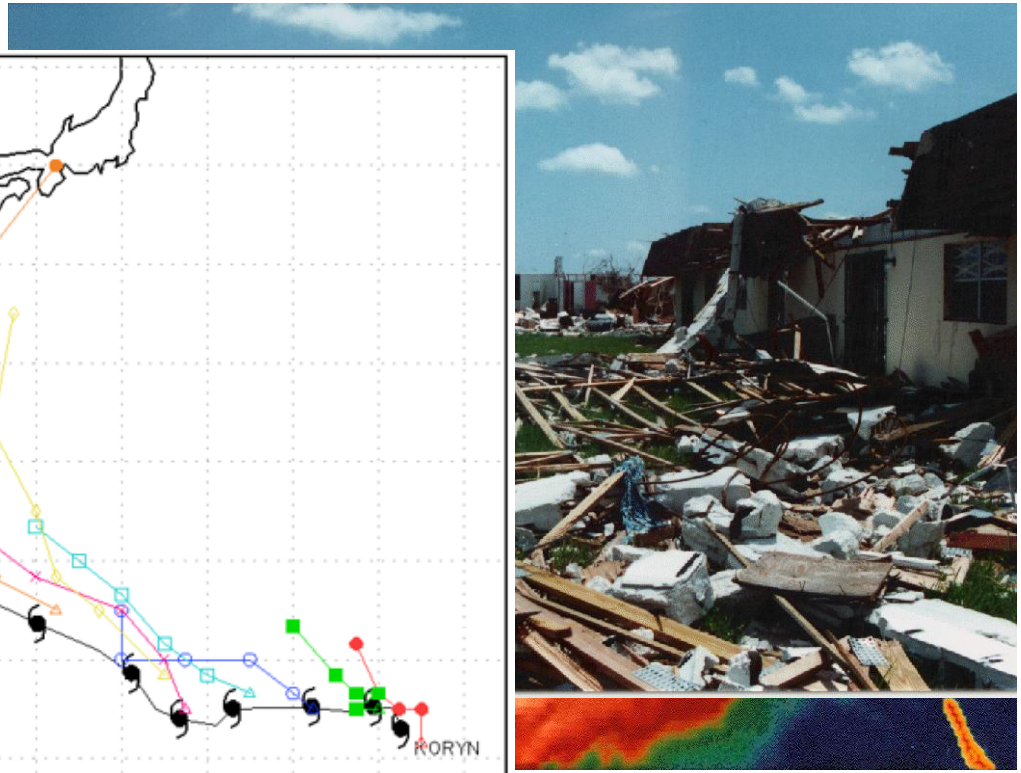
Why is the Met Office interested in tropical cyclones?

- Support for RSMCs
- Global guidance including support for Government and UK interests overseas
- Global Model development
- Unified Model partners and collaborators in tropics
- Extratropical transition



Hurricane Andrew

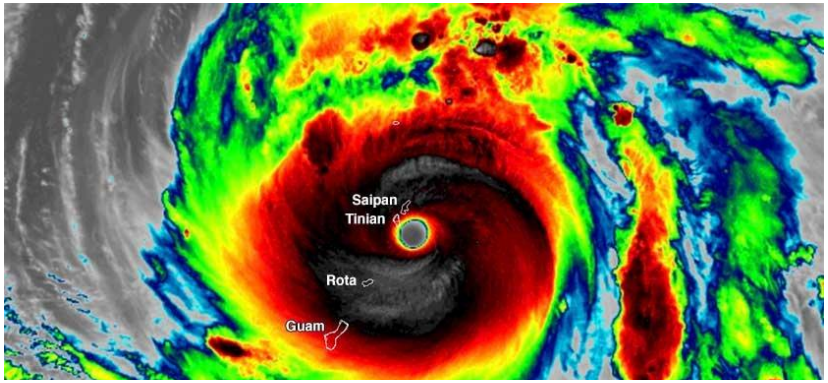


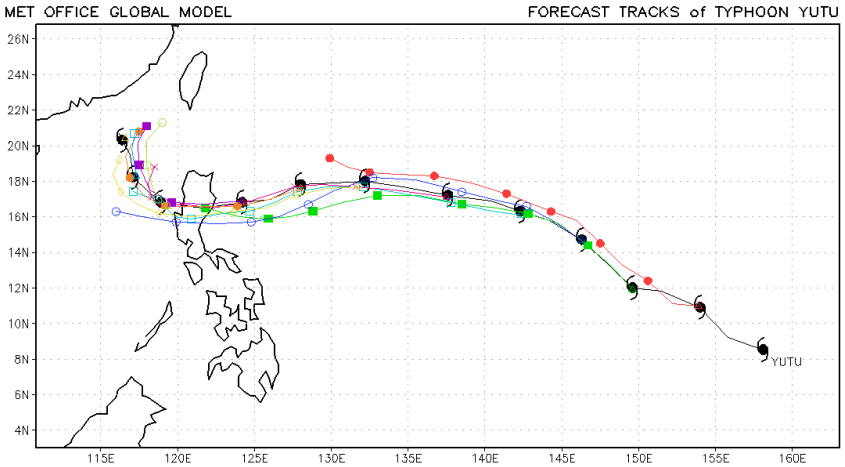


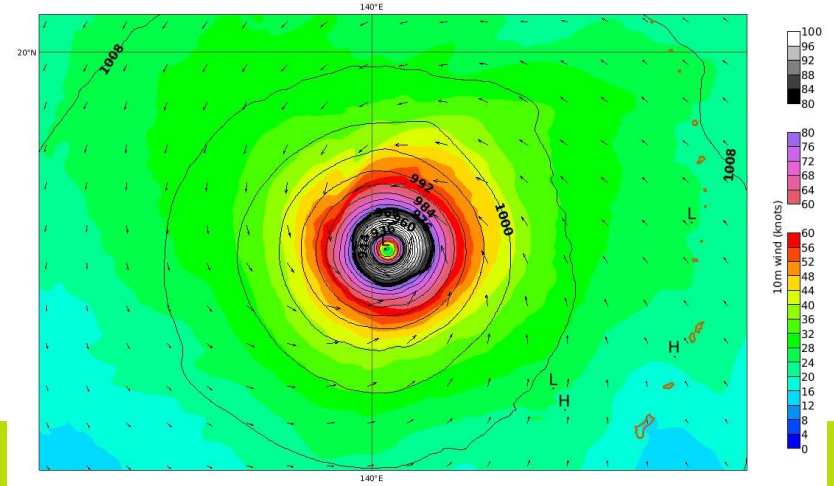
Fast forward to 2018

- Typhoon Yutu
  Category 5, 905 mb, 180 mph

- Global model
  910 mb, 120 mph
  Philippines landfall predicted 7 days in advance



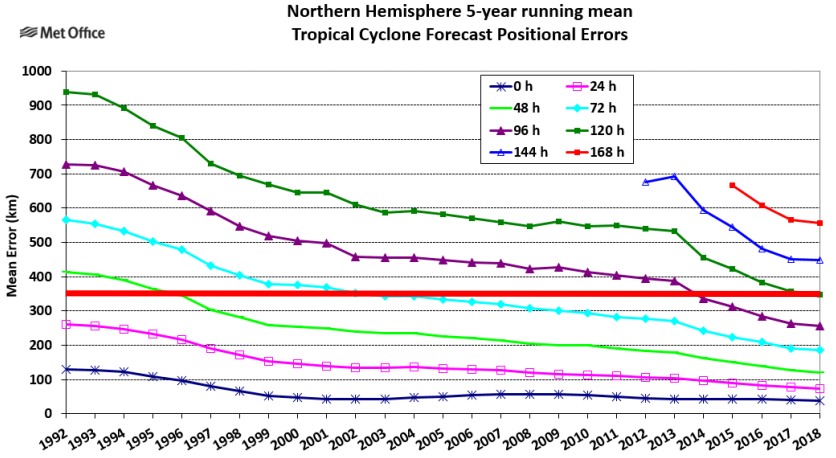


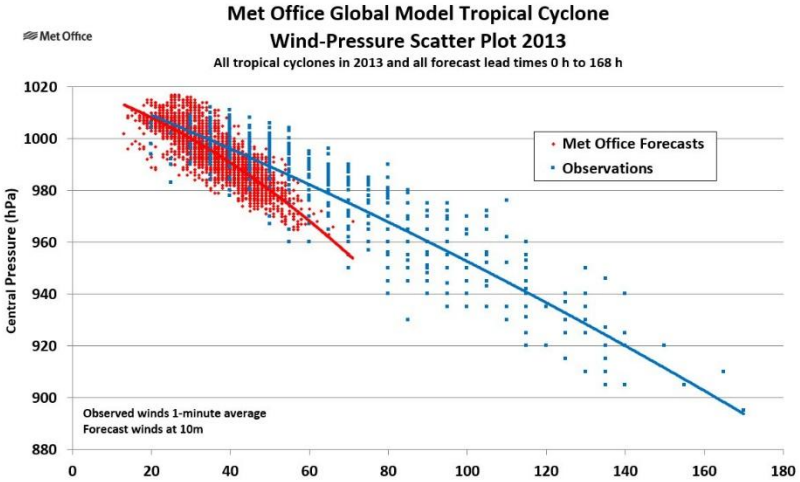


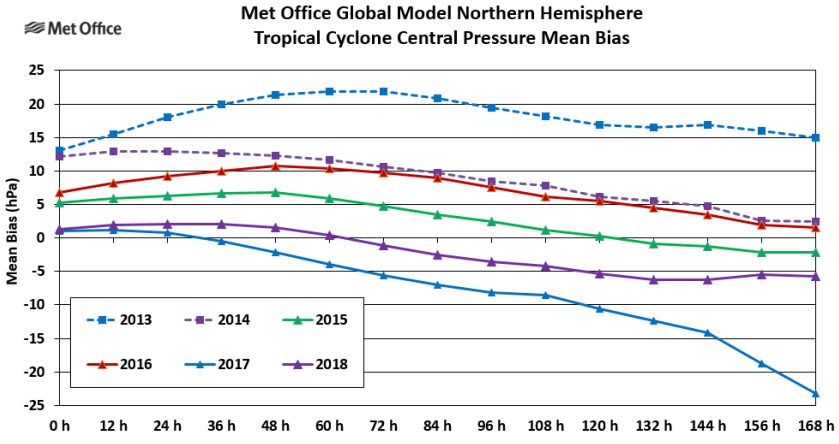
Tropical Cyclone Model Forecast Improvements

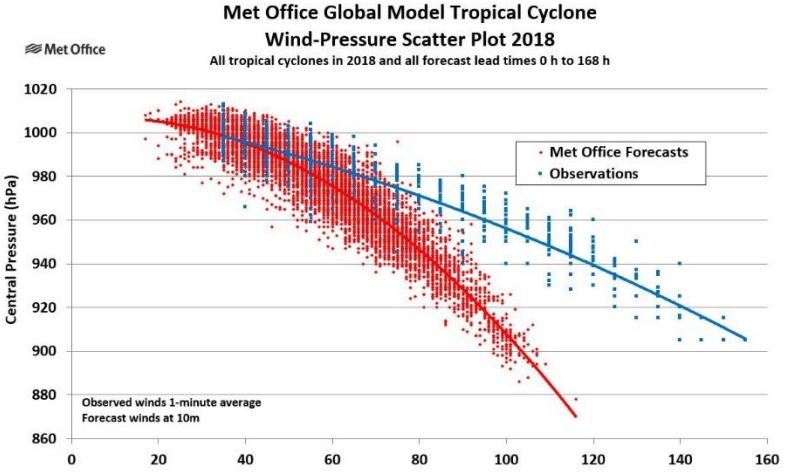
- Resolution
  - 1990: Global 150 km, regional 75 km
  - 2018: Global 10 km, regional 1.5 km
- Model dynamics and physics
  - Major changes 1991, 2002, 2014
  - Frequent incremental changes
- Observations
  - Vast increases in satellite data
  - Initialization
- Data assimilation methods
  - 3D-Var, 4D-Var, 4D-EnsVar

Met Office Global Model Performance









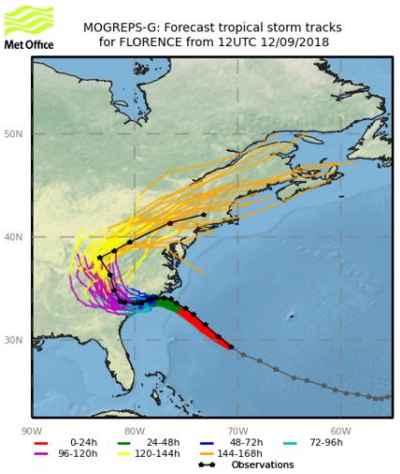
Global Ensembles

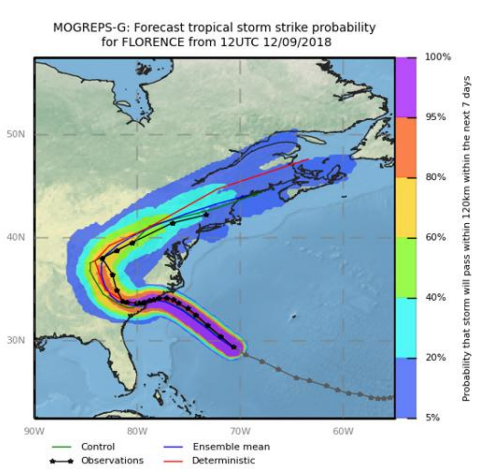
- Ensembles useful for expressing uncertainty in forecasts of tropical cyclone track and intensity

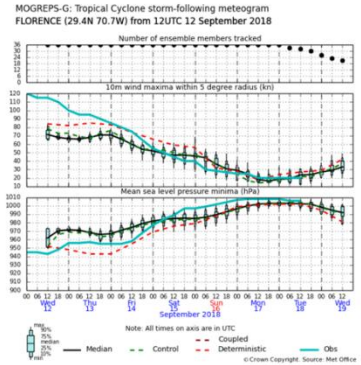
- Tropical cyclone ensemble products are created at the Met Office from the following models:

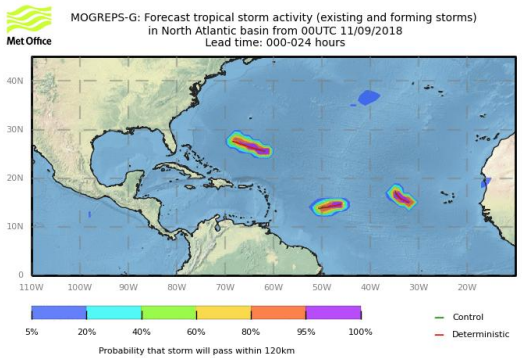
MOGREPS-G	36 members	20 km
ECMWF ENS	51 members	18 km
NCEP GEFS	21 members	34 km
Multi-model ensemble (MOGREPS-G, ECMWF, NCEP)	108 members	
MOGREPS convection permitting ensemble	18 members	4.4 km

- Products include:
  - Ensemble member tracks
  - Strike probabilities
  - Storm following meteograms
  - Animated tropical cyclone activity plots





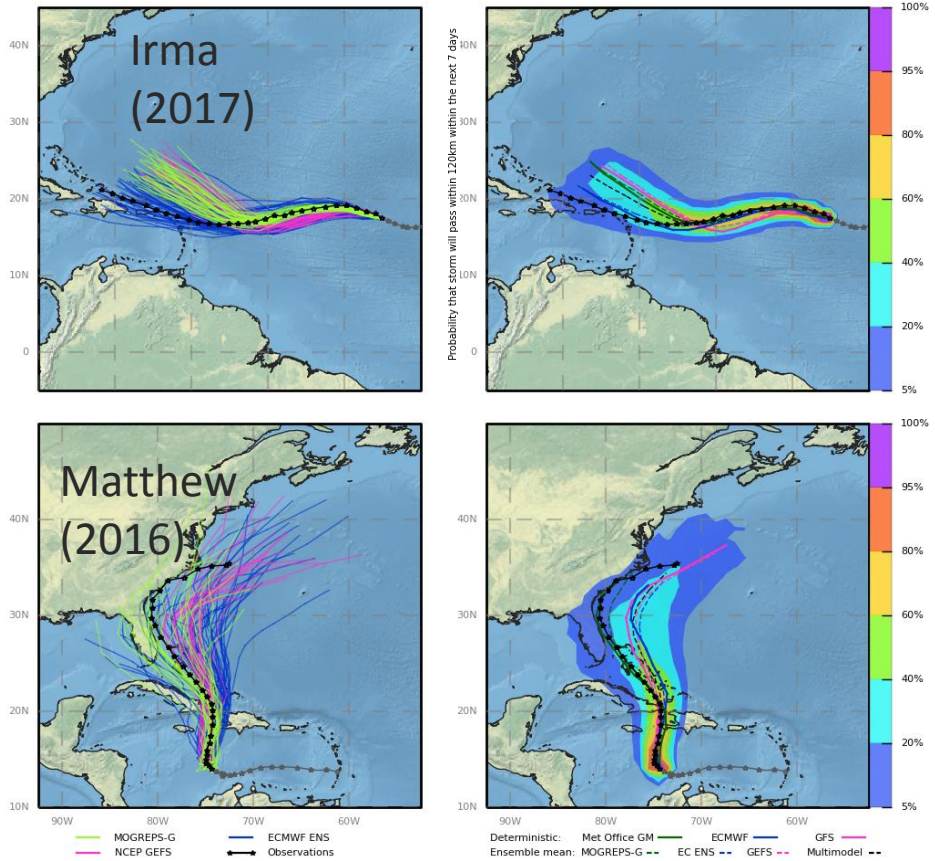


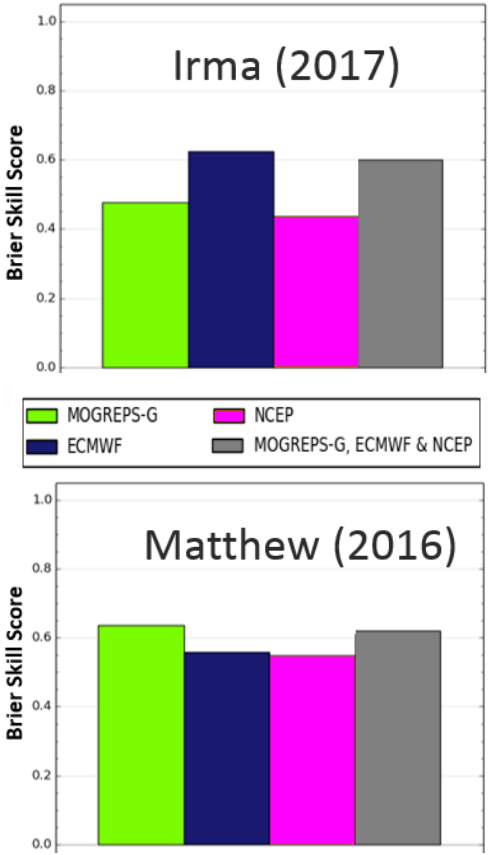


Multi-model ensemble: Products and Verification

- Two examples of storm-based verification that illustrate the benefit of multi-model ensembles

- Best performing model differed, but multi-model ensemble had comparative skill in both cases



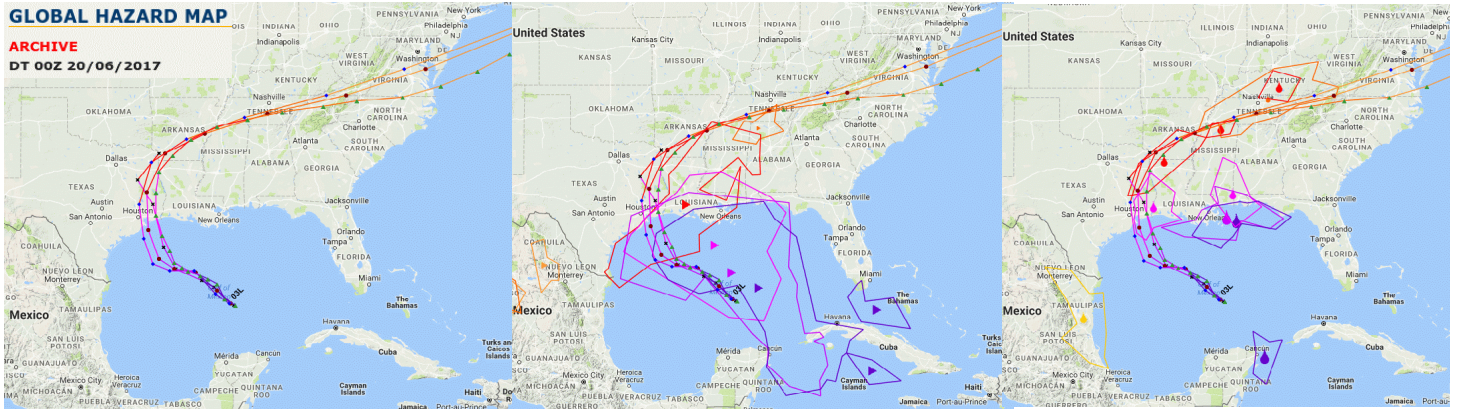


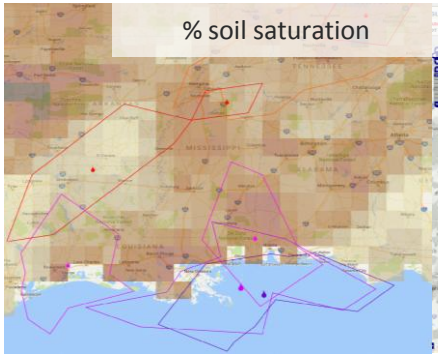
Global Hazard Map:

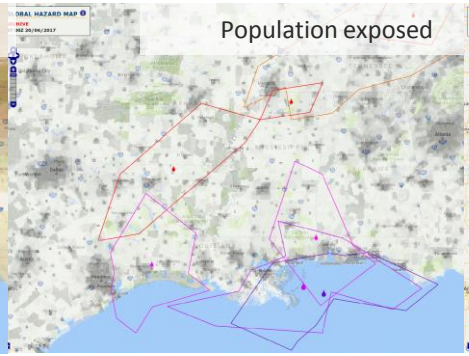
Visualising multi-hazards and potential for impact

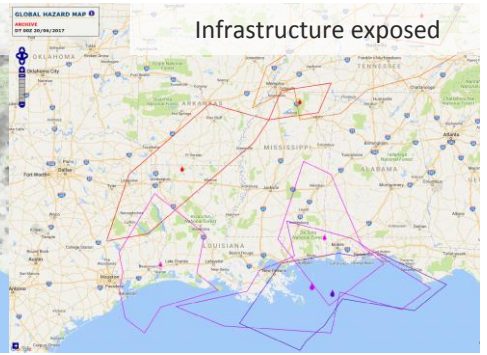
- Hazards associated with TCs can be far removed from the landfall location, as illustrated for Tropical Storm Cindy
- Met Office Global Hazard Map highlights areas of high-impact weather in addition to displaying forecast tracks.
- It also gives the option to overlay vulnerability, exposure and antecedent condition information, which can highlight potential impacts

On display at tea break



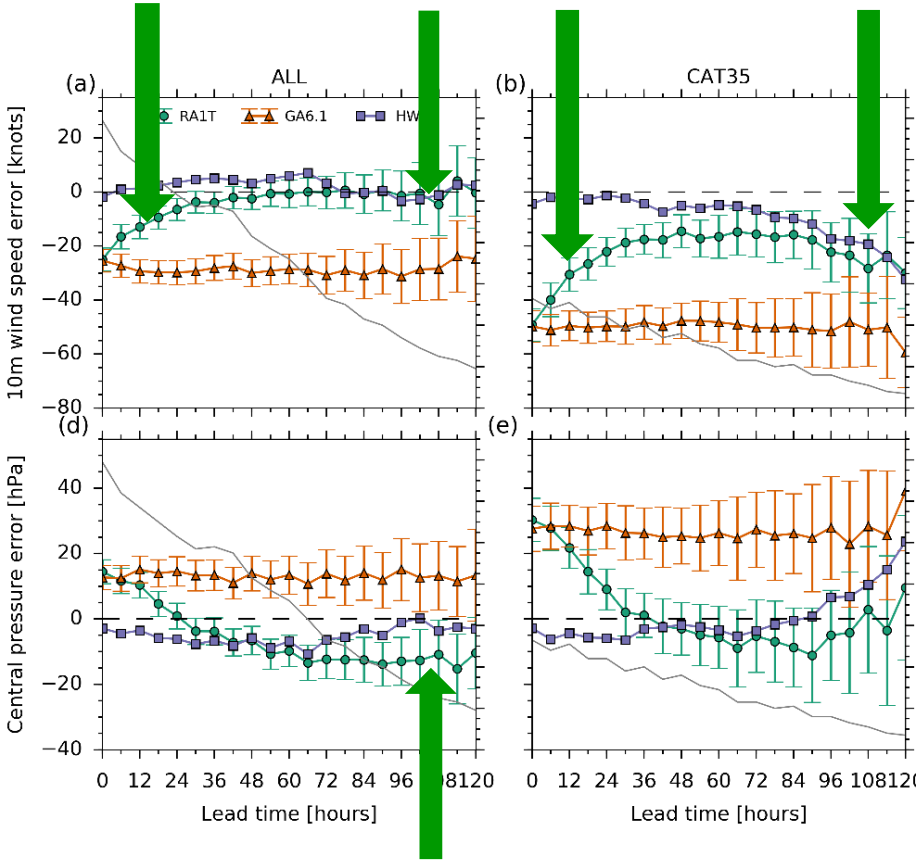






Convection Permitting Deterministic Regional Model

- Regional Modelling of TCs as part of Newton Fund work (later talk by Andy Hartley/Sam Hardy)
- Aim to provide better forecasts of TC intensity, structure and precipitation
- Currently spun up from the Global Model
- Wind speed bias close to zero once spun-up
  - Wind speeds under-estimated in intense TCs
  - Central pressure too deep



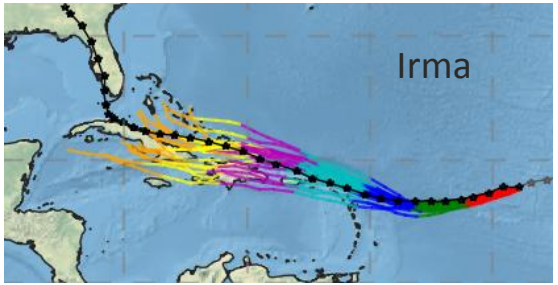
Convection Permitting Regional Model Ensemble:

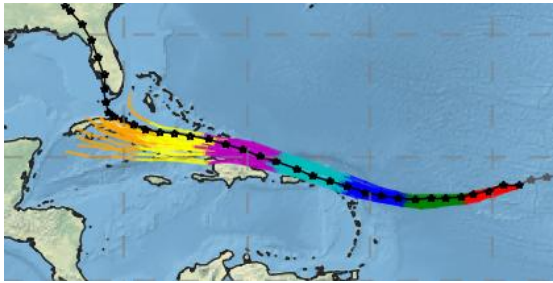
Atlantic hurricanes 2017

- MOGREPS-CP set up for Atlantic hurricanes 2017
- 18 members 4.4 km nested in MOGREPS-G
- Relocatable within ~1 hour
- Much improved central pressures, including intensification rates.
- Improved speed of movement, less spread

MOGREPS-G

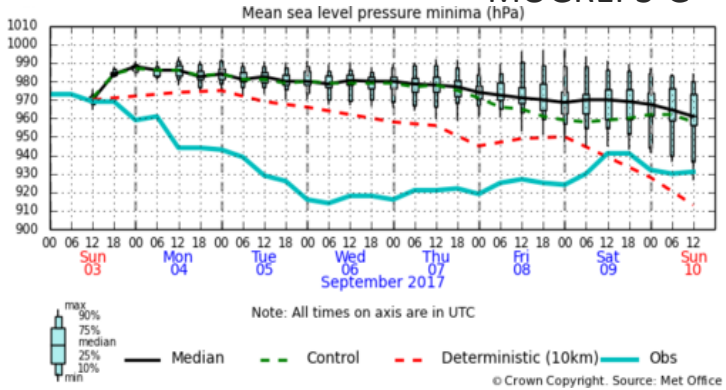
MOGREPS-CP



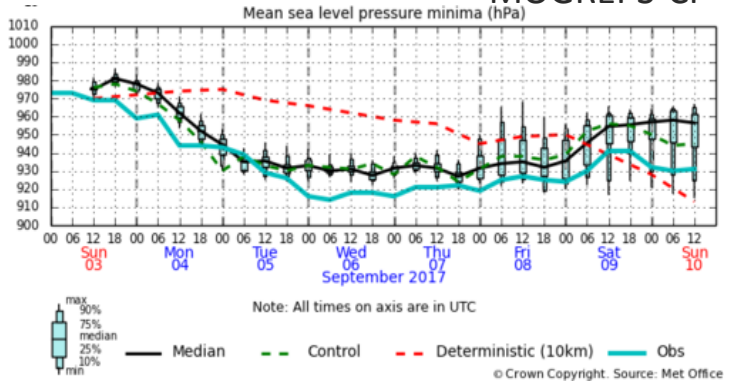


Irma

MOGREPS-G



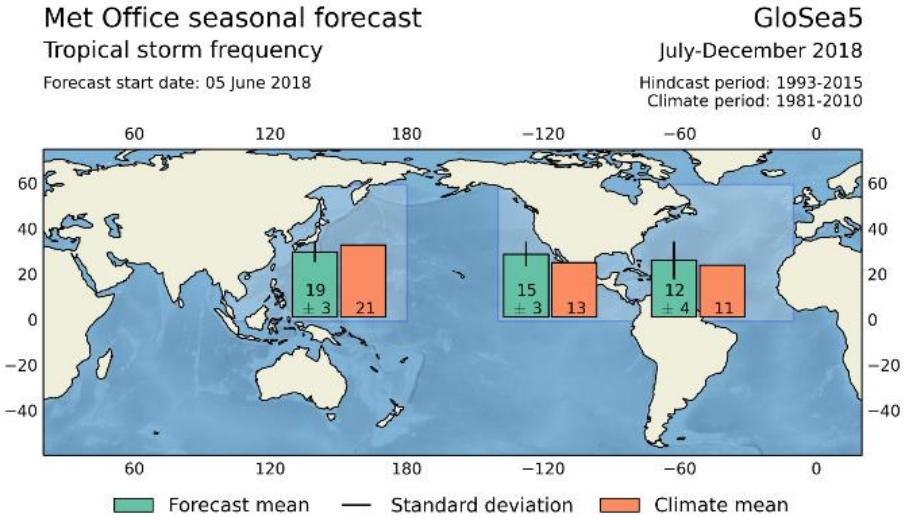
MOGREPS-CP

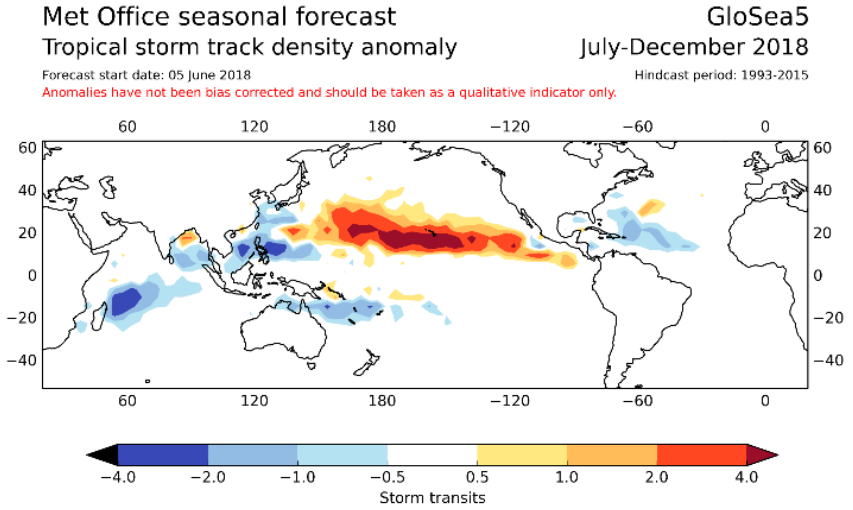


High resolution modelling demo in the tea break

Seasonal forecasting

- Met Office seasonal forecast model (GloSea) runs weekly
- Provides 6-month probabilistic forecast
- Calibrated against hindcasts to predict tropical cyclone activity forecasts

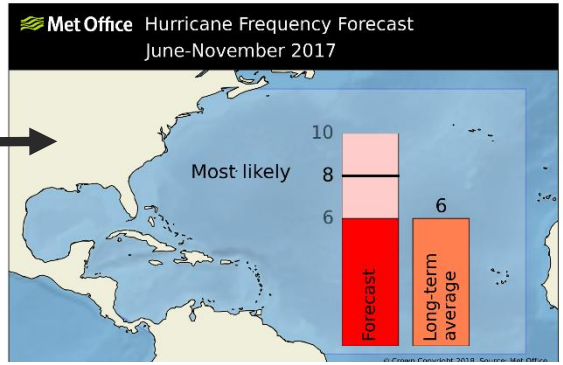


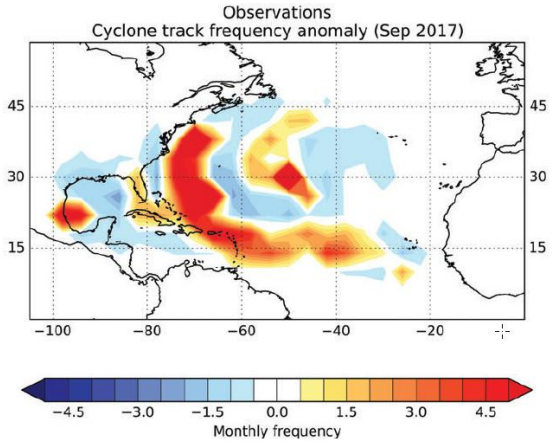


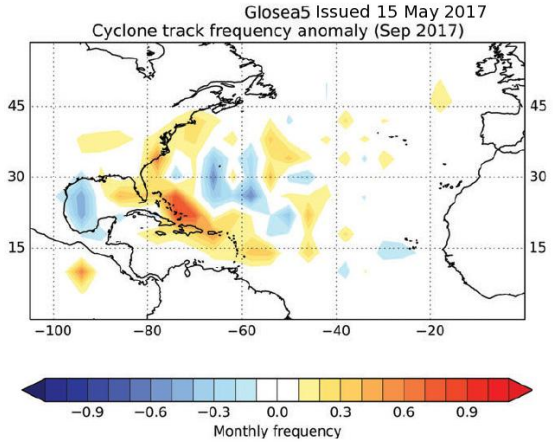
Seasonal Forecasting

North Atlantic - 2017

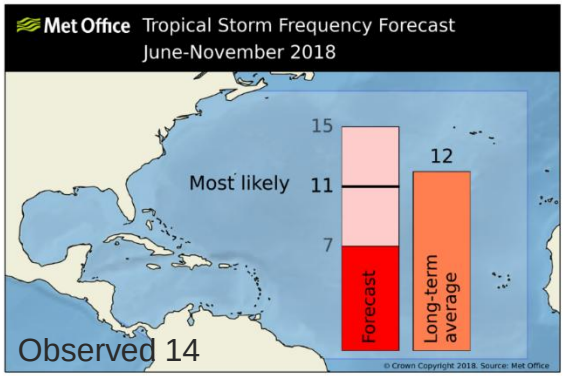
- Successful forecast for active season in 2017
- Predicted increase in TC track frequency to north and east of Caribbean

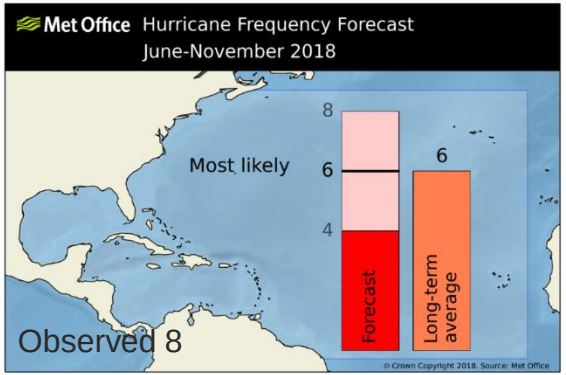






North Atlantic - 2018





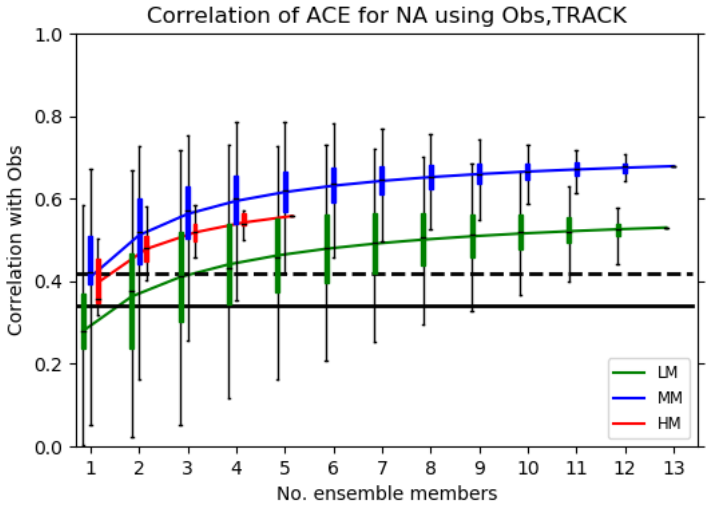
Climate Modelling and Tropical Cyclones

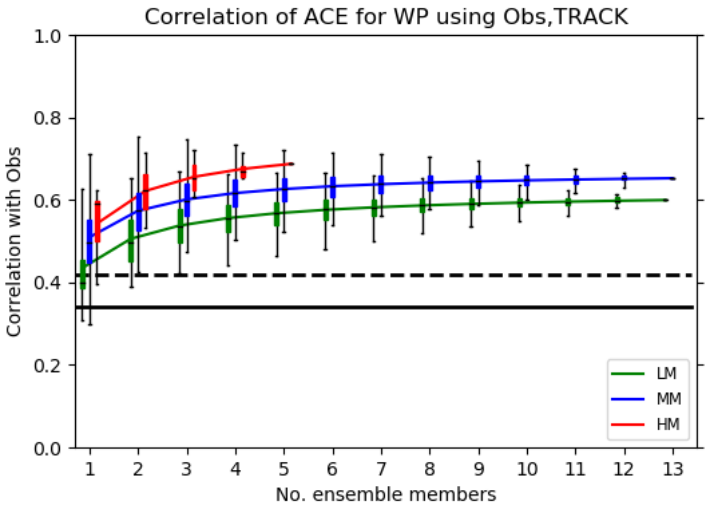
Interested in

- The impact of horizontal resolution on the skilfulness of tropical cyclone interannual variability
- How many ensemble members are needed to separate the ‘signal’ from the weather ‘noise’
- What drives tropical cyclone variability and how this might be changing now and in the future – e.g. stronger storms with more rainfall associated with them.

Figure: Combinations of n ensemble members (x-axis) v. correlation with observed interannual variability (y-axis) for different model resolutions for 1979-2014. Solid and dashed are 95% and 99% confidence limits.

130 km – typical climate
60 km – seasonal model
25 km – high-resolution



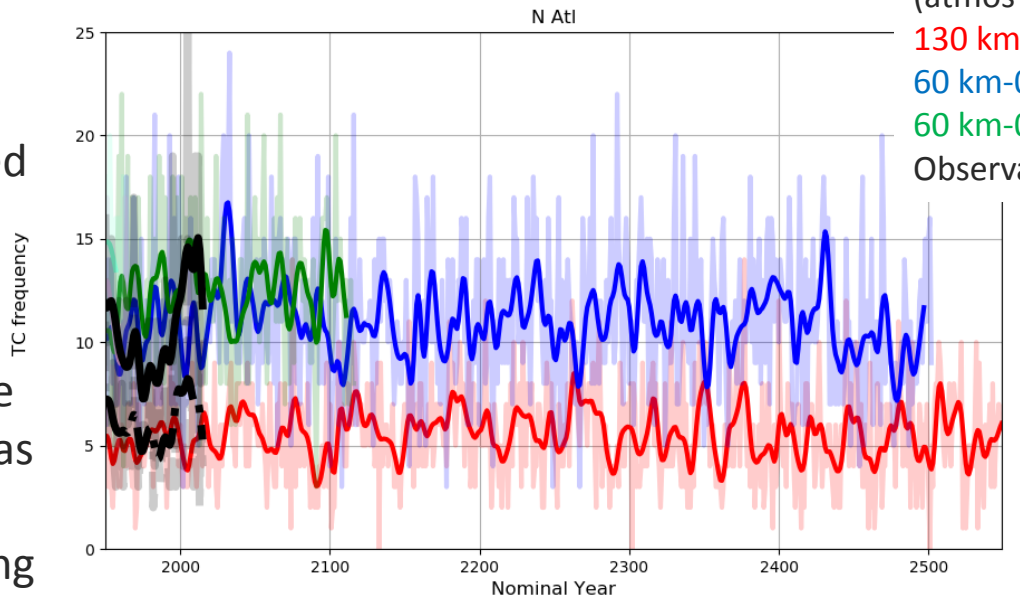


Climate Modelling and Tropical Cyclones

- Free-running coupled model simulations (atmosphere-ocean-sea-ice-land) with constant forcing

- The modelled interannual variability begins to look very much like that recent observed period (black).

- This may suggest that recent decadal variability may be due to internal climate variability as much as to externally-driven warming – more understanding is needed

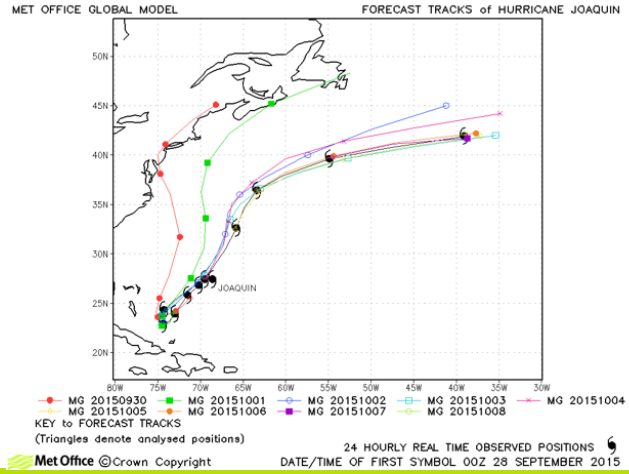


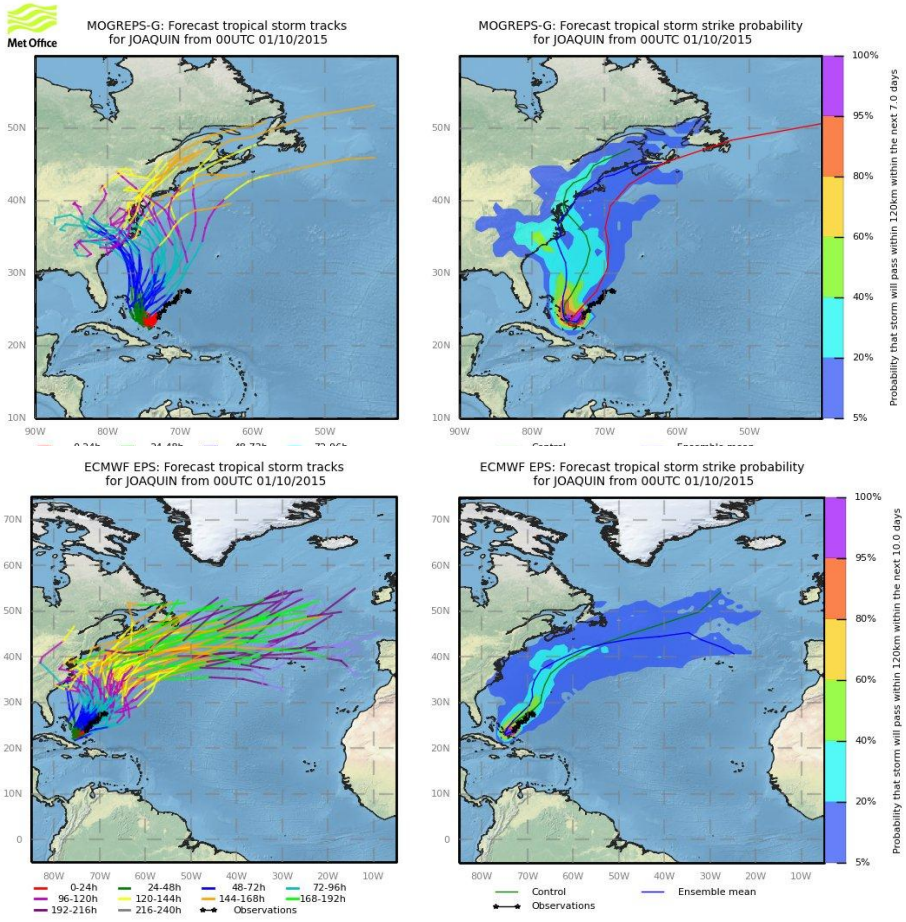
Model resolutions (atmos-ocean)
130 km-1˚
60 km-0.25˚
60 km-0.083˚
Observations

Variability on climate time scale discussed more in later presentation

The Challenges Ahead

- Predicting rapid changes in intensity
- Intensity often controlled by small scale features. e.g. eyewall replacement cycles
- Expression of uncertainty in track forecasts





Met Office

Over to Linus to talk on ECMWF perspectives