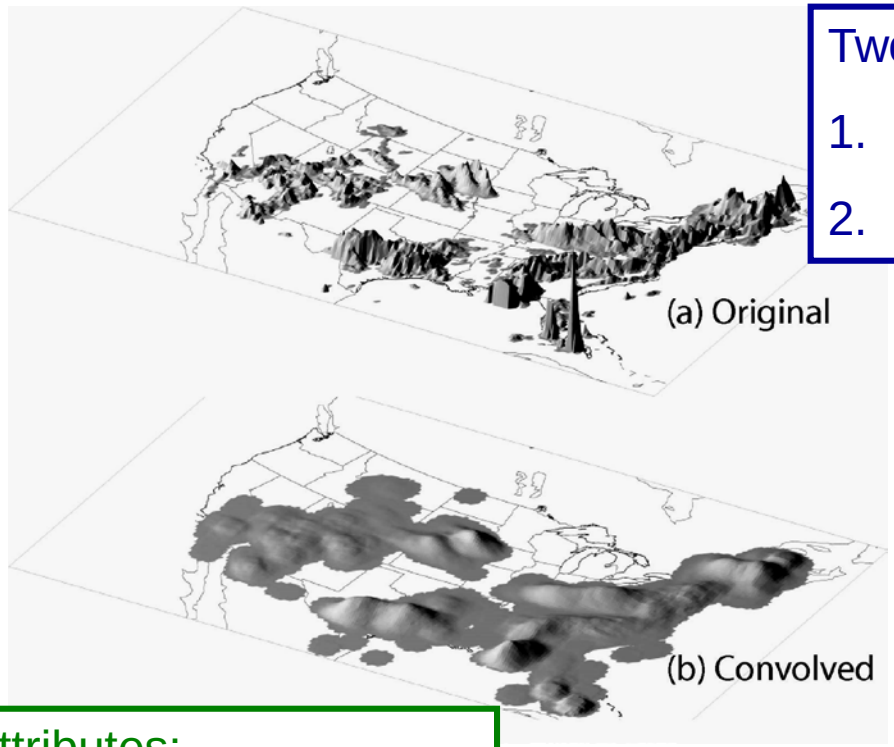
Feature-based evaluation of global (NWP) forecasts

Marion Mittermaier, Barb Brown and others

MODE – Method for Object-based Diagnostic Evaluation

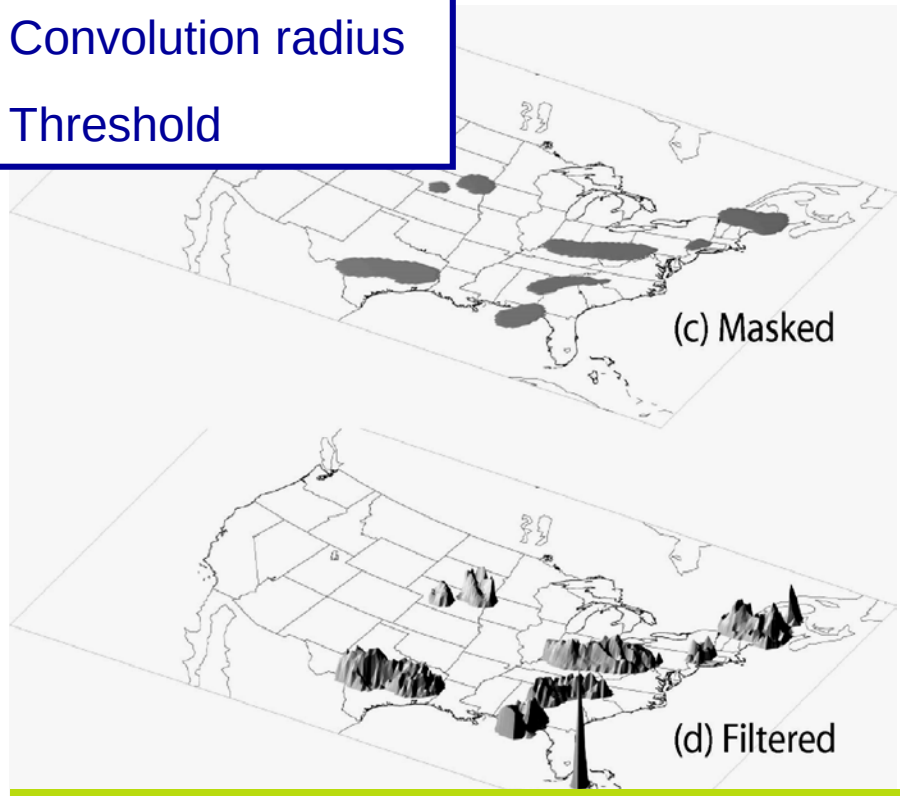
Davis et al., *MWR*, 2006

Highly configurable



Two parameters:

1. Convolution radius
2. Threshold

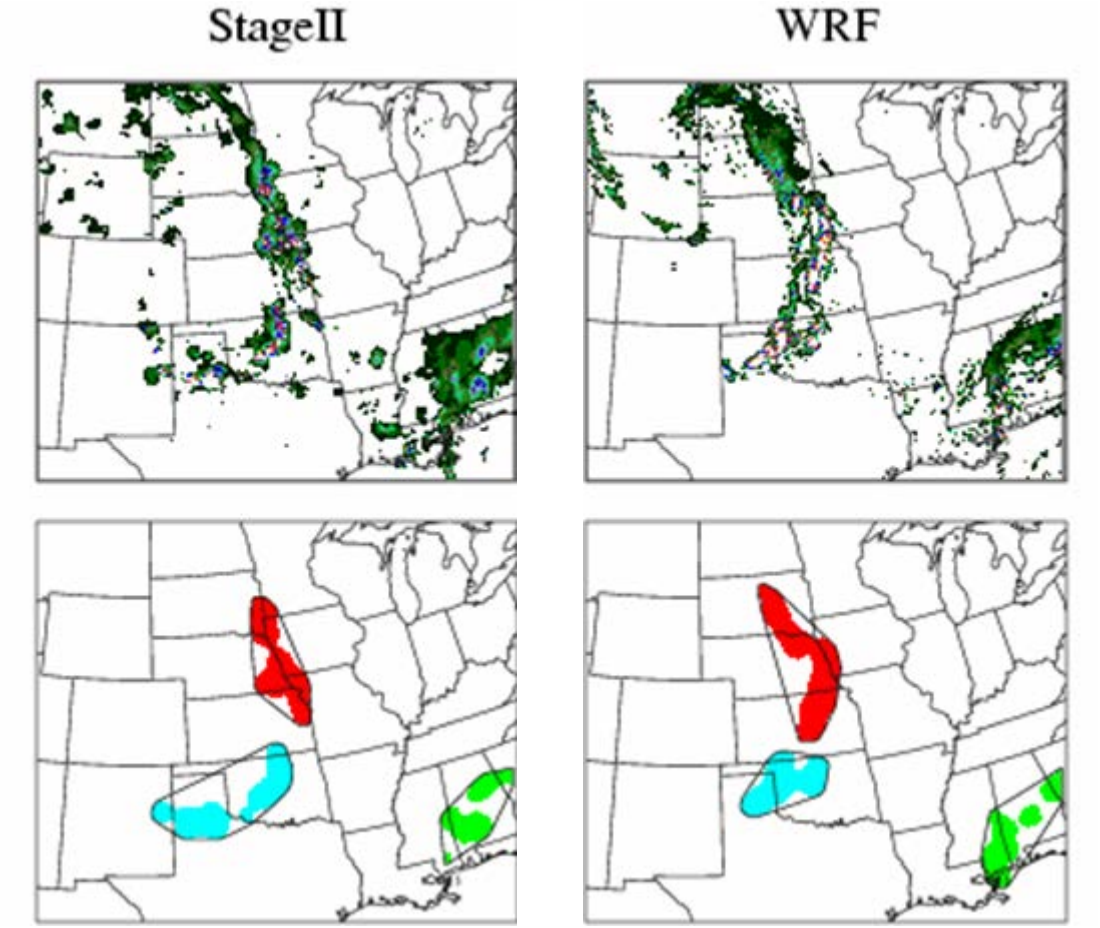


Attributes:

- Centroid difference,
- Angle difference,
- Area ratio etc

Focus is on *spatial* properties, especially the *spatial* biases

MODE object matching/merging



24h forecast of 1h rainfall on 1 June 2005

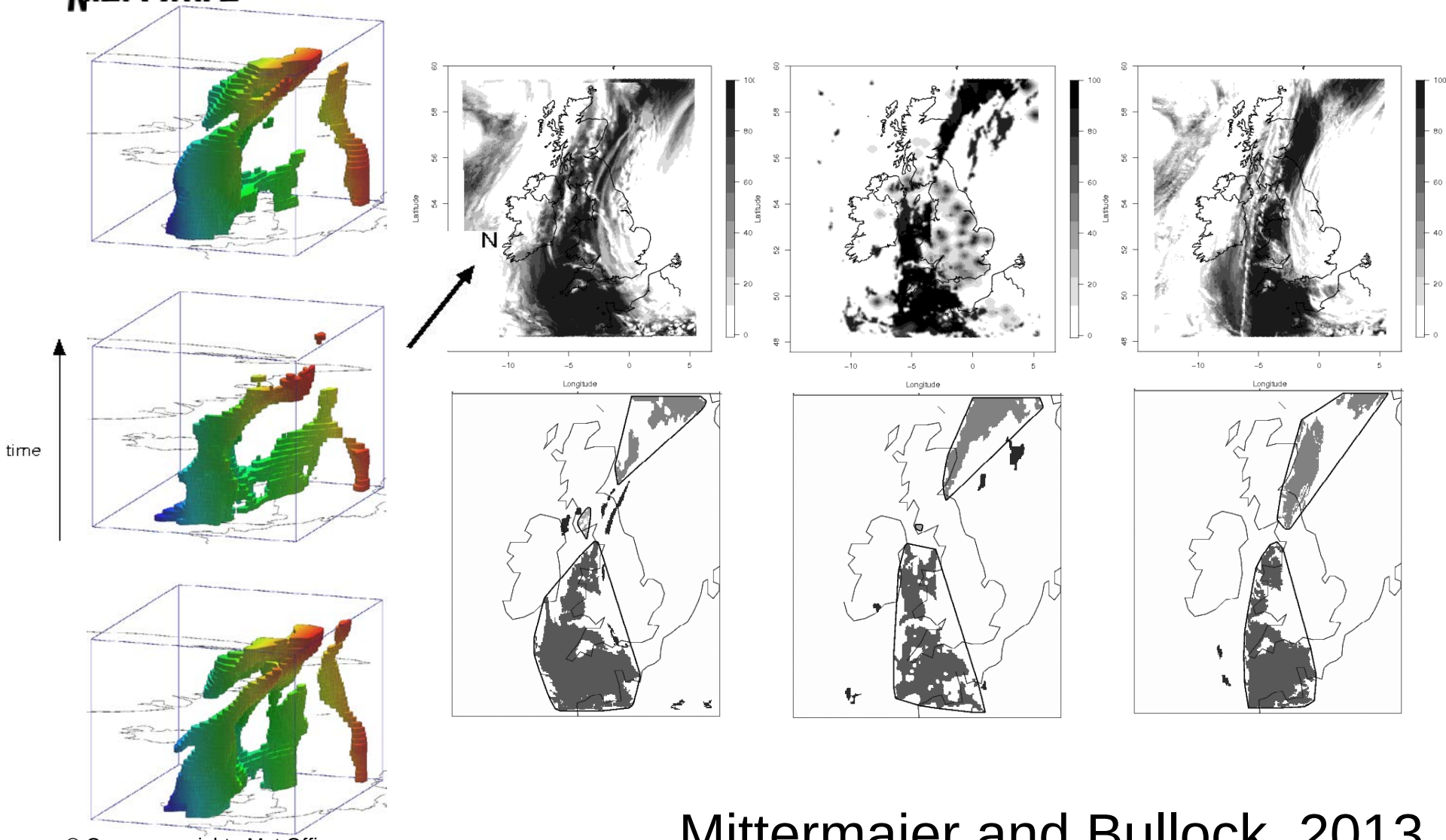
Compare attributes:

- centroid location
- intensity distribution
- area
- orientation
- etc.

When objects not matched:

- false alarms
- missed events
- etc.

MODE and MODE-TD applied to cloud breaks



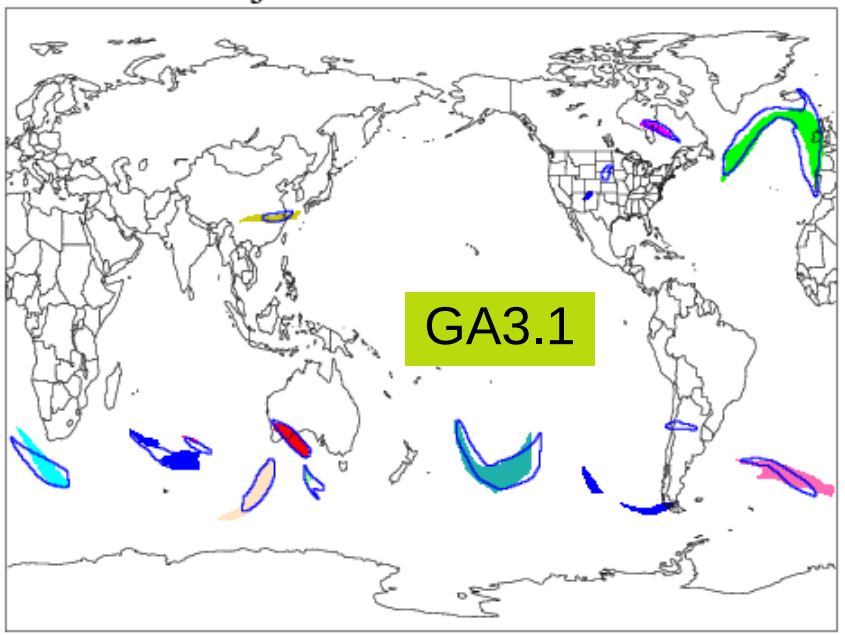
Mittermaier and Bullock, 2013

Temporal evolution

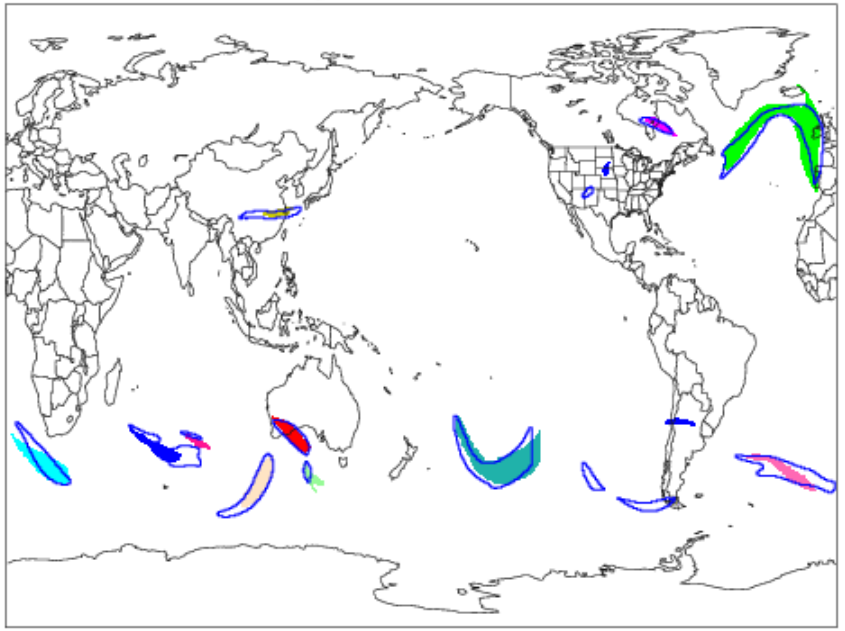
- Older **N320** trial **250 hPa winds > 60 m/s** at forecast lead time of **t+96h** from the 12Z initialisation **compared to EC analyses**

- Differences in the size of forecast and analysed objects is not overshadowed by growth of synoptic forecast error, i.e. still **able to find matches**.

Forecast Objects with Observation Outlines



Observation Objects with Forecast Outlines



Analysis considers:

- *Spatial* biases – extent of features
- Changes in *intensity* – deeper, stronger, higher etc
- Changes in the *number* of analysed and forecast objects – hits, false alarms, misses
- Changes in the *attribute* distributions – are the forecast attribute distributions closer to perfection?

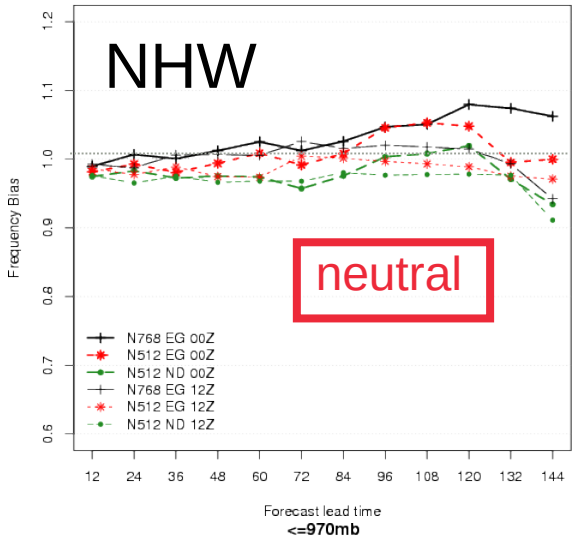
EC analyses

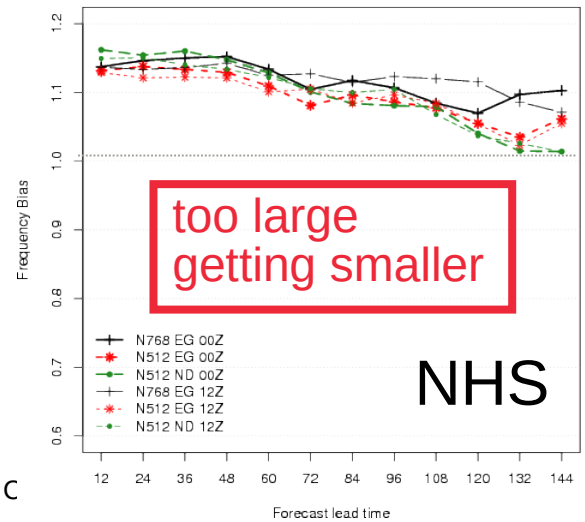
Object-based *spatial* frequency bias

Met Office

Lows

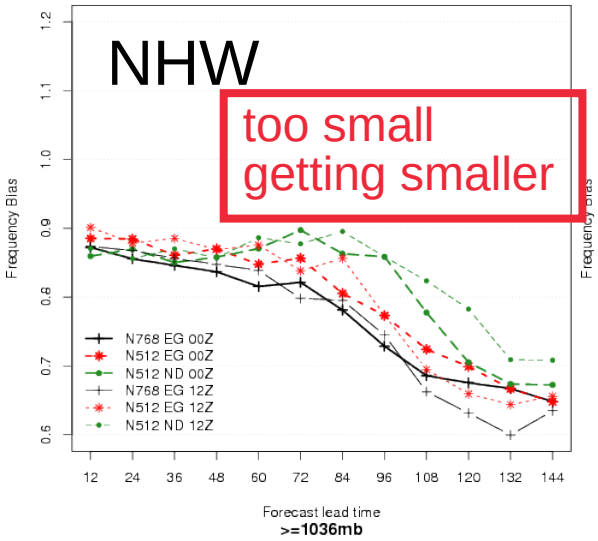
<=970mb

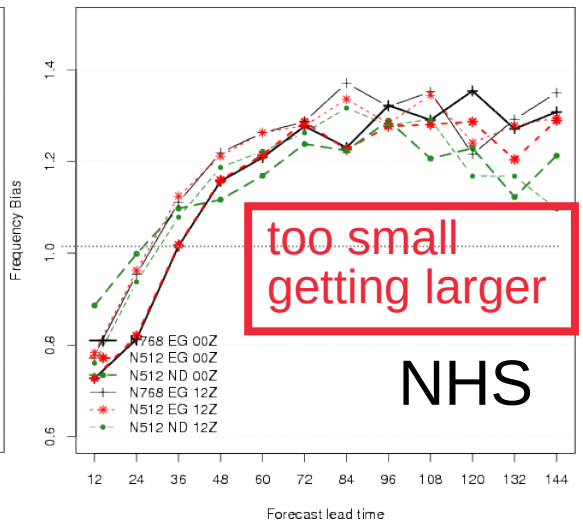




Highs

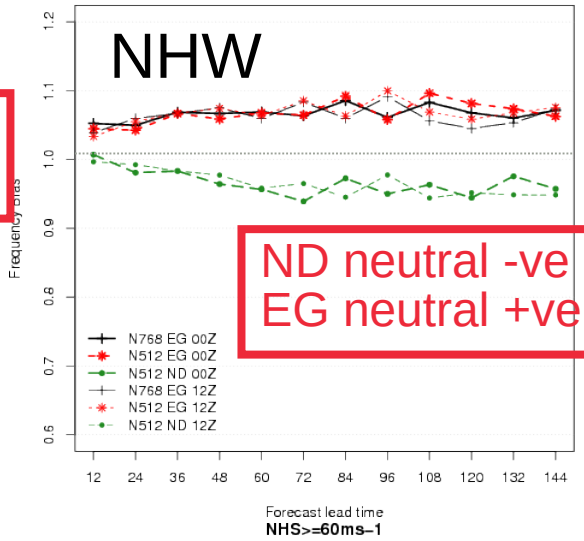
>=1036mb

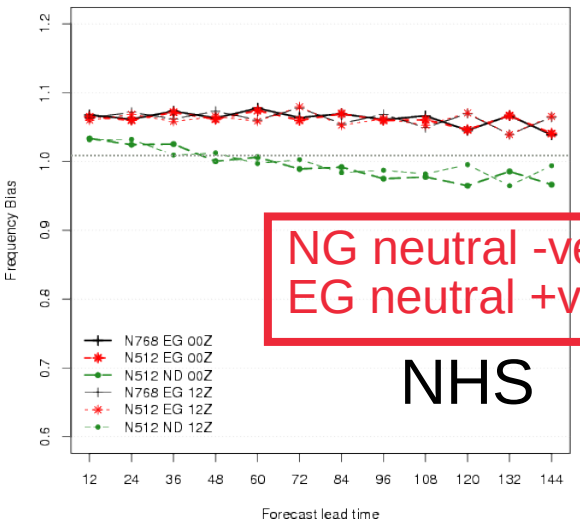




Jets

NHW>=60ms−1





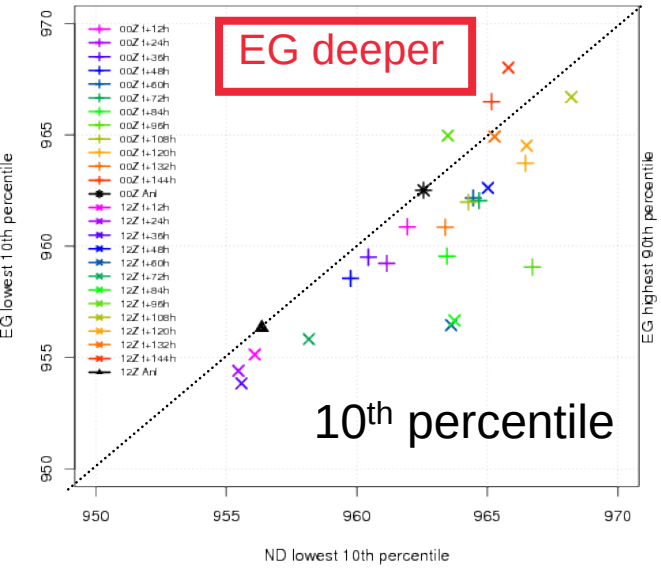
EC analyses
N768 EG v N512 ND

Object intensities

Met Office

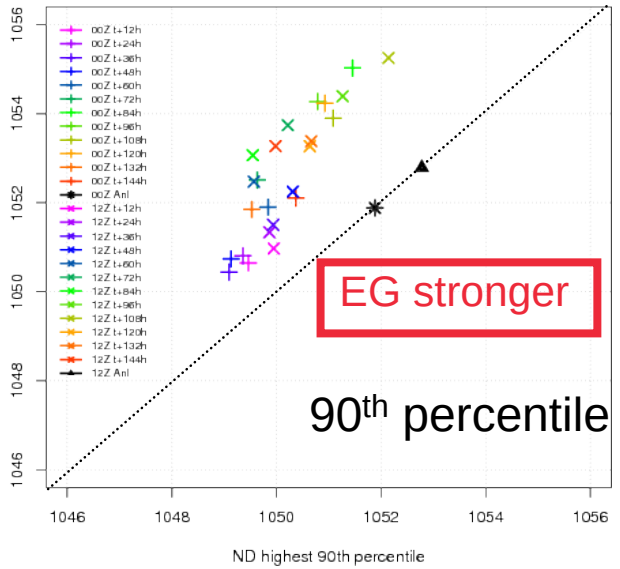
Lows

NHW <=990mb



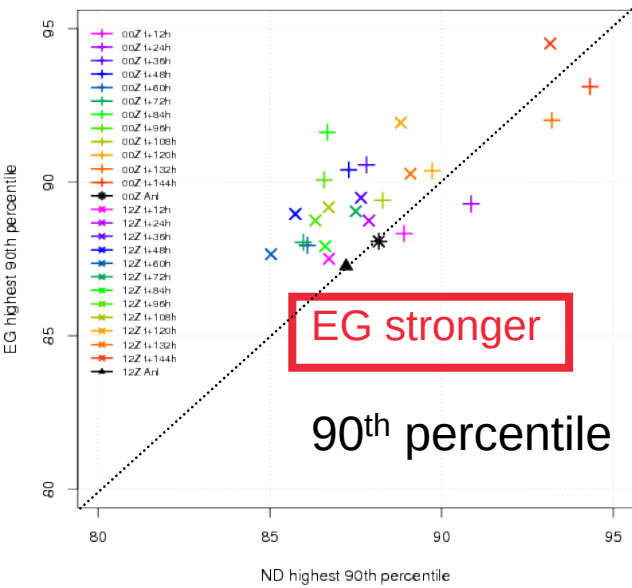
Highs

NHW >=1036mb



Jets

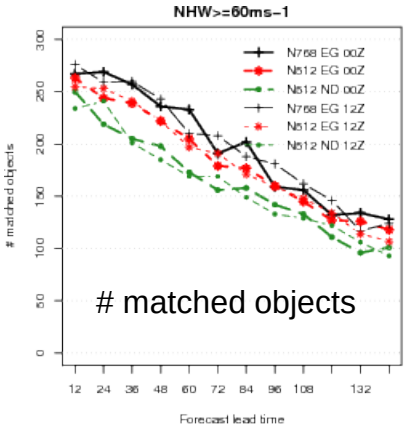
NHW >=60ms-1

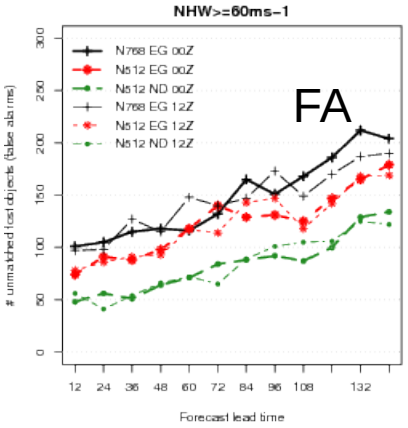


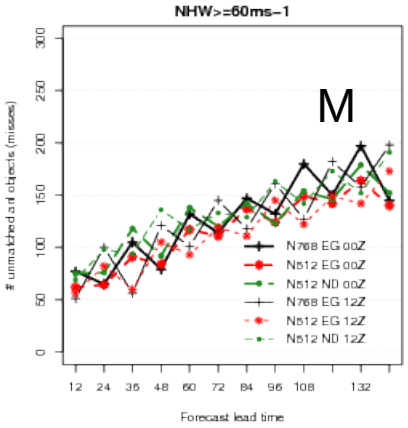
- Do not look at absolute min/max values in objects. Use the 10th or 90th percentile as a more reliable estimate of how the intensity distribution has shifted/changed.
- Lows are deeper, highs and jets are stronger → sharper gradients and a more active energetic model.

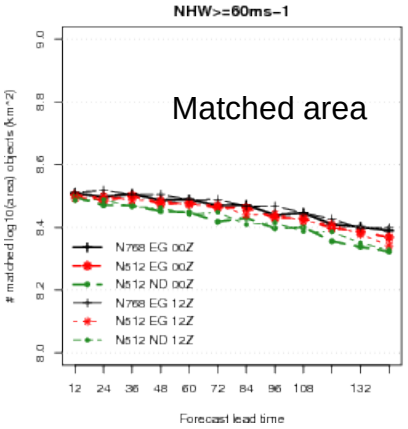
Number of objects

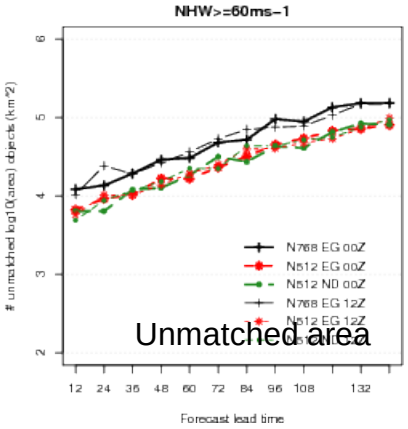
Jets











- **Jets**
  - → EG **more matched** objects
  - → Substantial increase in false alarms with comparable misses
  - → Modest increase in matched areas, but substantial increase in unmatched area

Climate applications (Barb Brown *et al.*)

Application to global climate model output

Current climate simulations by Community Earth System Model (CESM) large ensembles http://www2.cesm.ucar.edu/

Focus on total DJF precipitation

Observations: CRU TS-3.21

Use MODE to characterize climatologies of precipitation objects

- Compare distributions for various attributes
- No object matching

Domains: Global, **S-America**, N-America

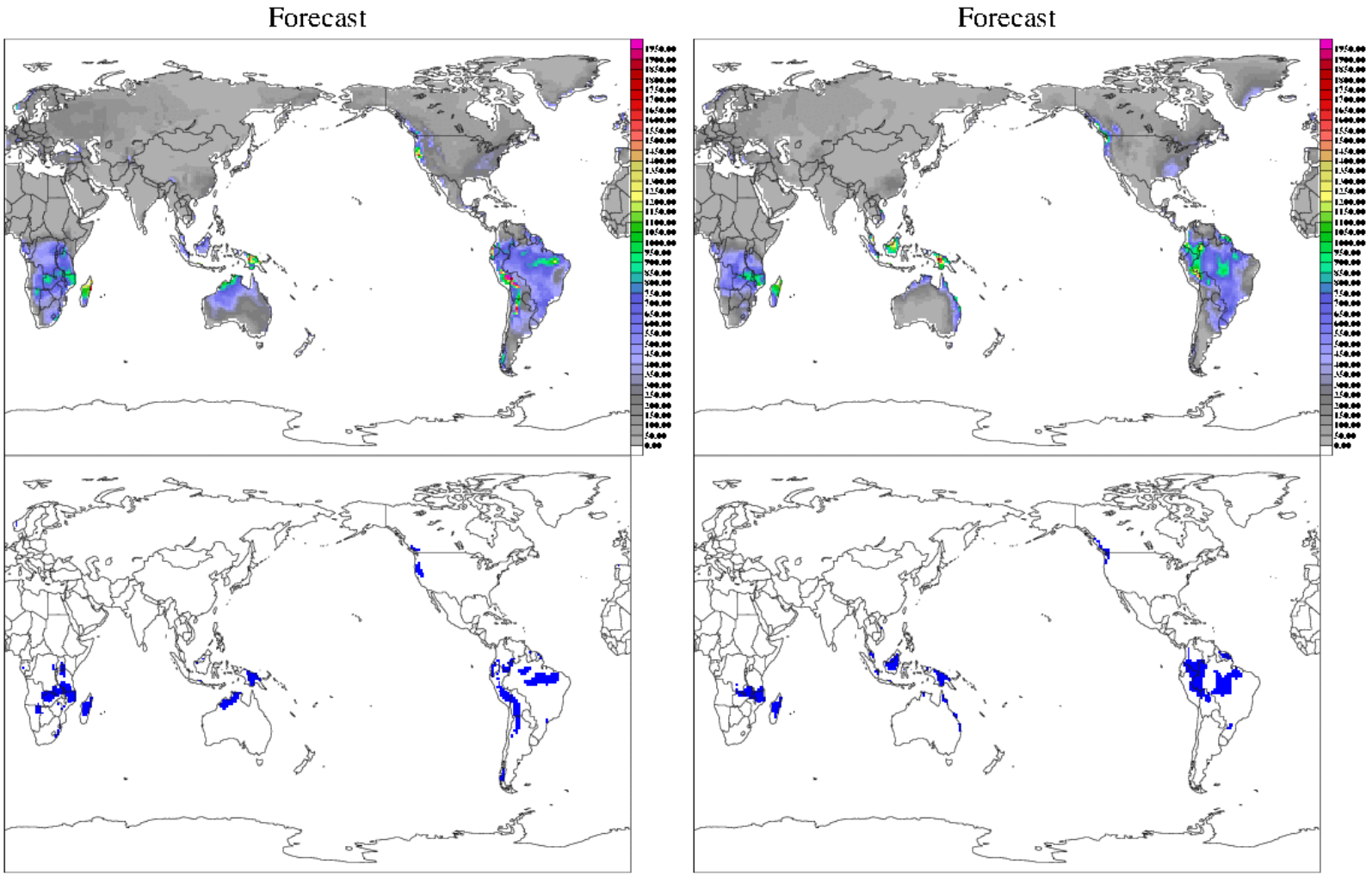
Thresholds: 500, **700**, 900 mm

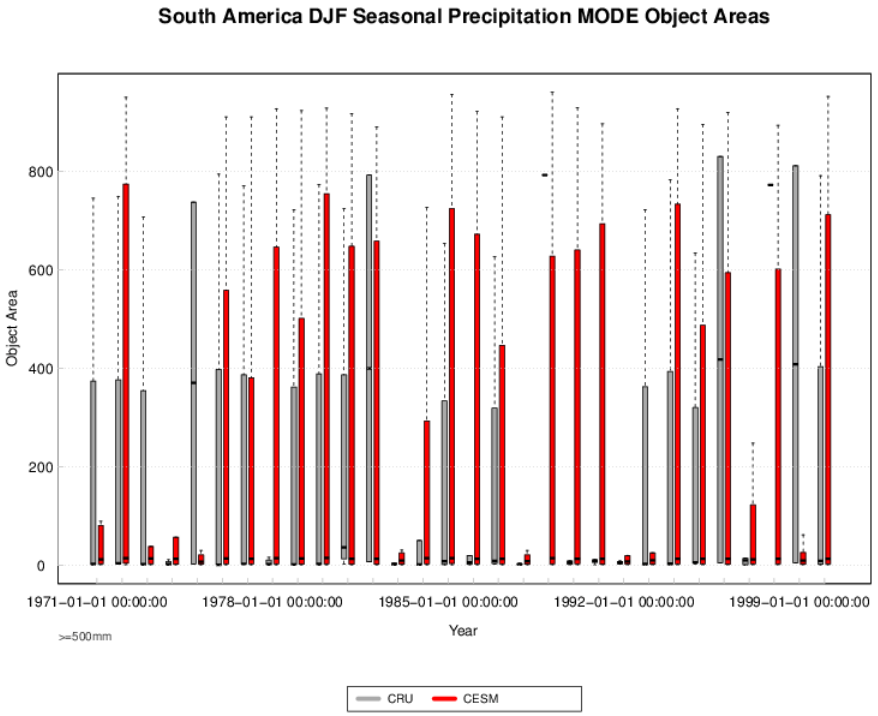
Overall and conditional analysis (ENSO phase)

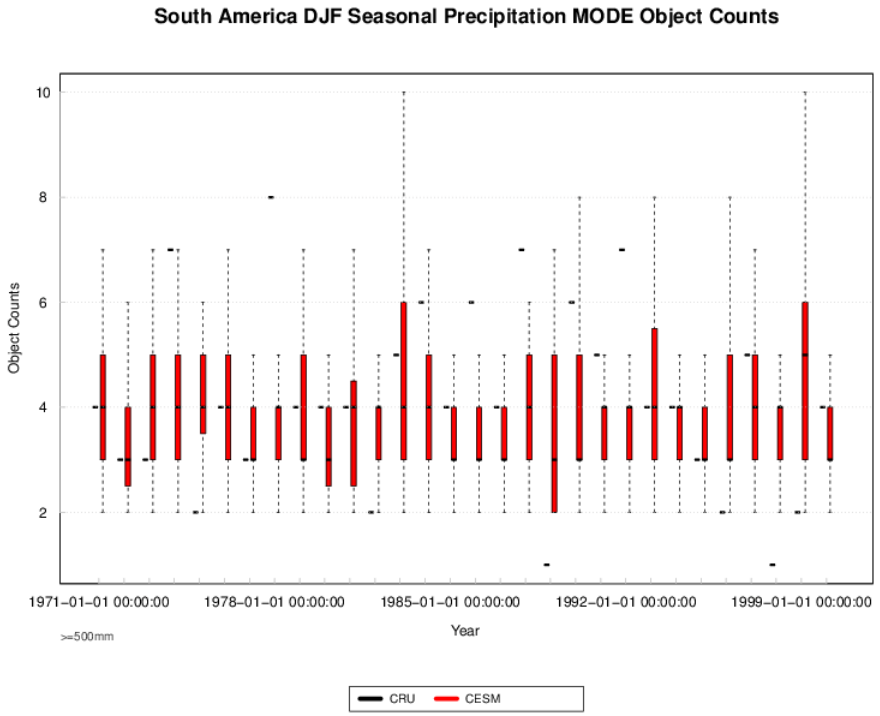
NCAR

Comparison of forecast and observed precipitation objects

Object threshold: 700 mm





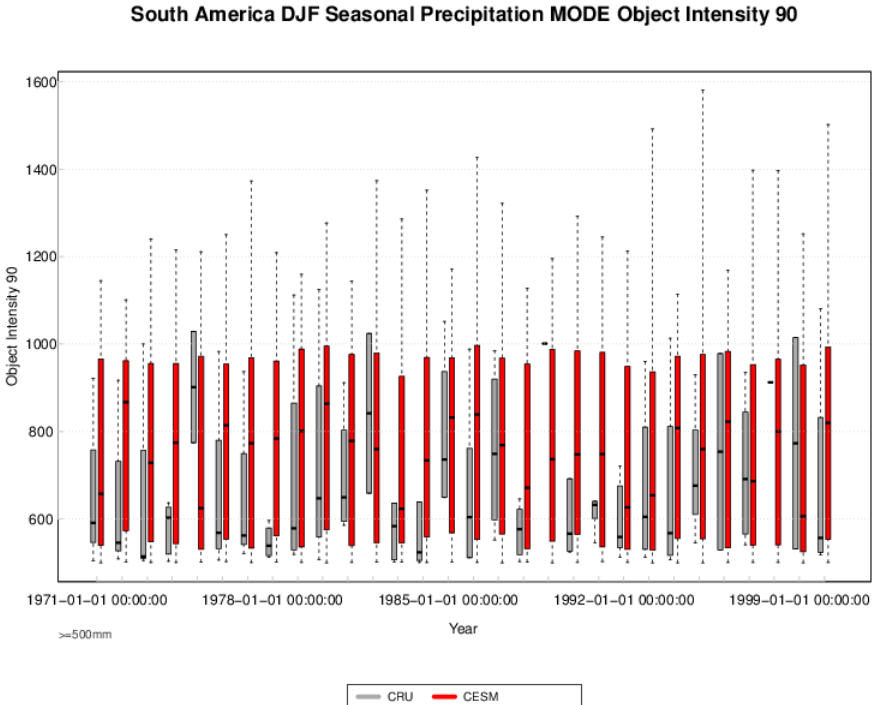


S. America Objs of ppn>500mm

Area: CESM objects generally bigger

Counts: Mixed results, but generally counts are smaller for CESM

Intensity: Generally larger in CESM

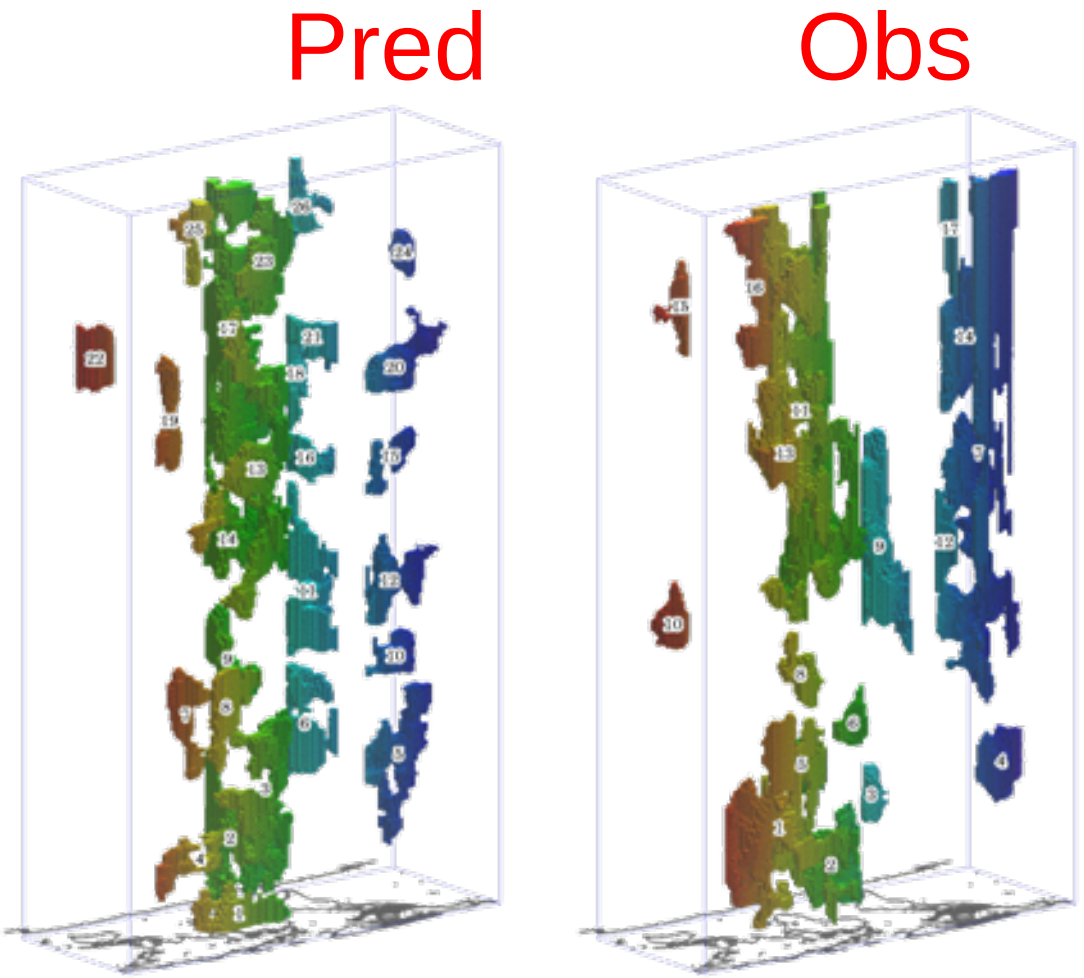


MODE: Time Domain (MODE-TD)

Characterize phenomena in space and time

Evaluate: time-integrated "volume", velocity in space, lifetime, growth/decay rates, spatial complexity, …

September 2015 MET5.1 released



MODE-TD applied to drought index

In summary

- Feature-based methods provide a potentially powerful way of evaluation of particular events/regimes/features in **global** forecasts at **NWP** and **climate** scales especially for evaluation current climate.
- The remaining challenge is to find adequate **gridded data sets** for studies like this.
- It would be interesting to work with others as to how the output from such methods can be **processed further in a statistical sense**.

Questions?

Mittermaier M.P., R. North, A. Semple and R. Bullock, 2015: Feature-based evaluation of global NWP forecasts. *Accepted in Monthly Weather Review.*