

EPS and EFI: Understanding and Interpretation

ADAPTED FROM DAVIES, 2012

Short-Range Ensembles

ECMWF EPS has transformed the way we do Medium-Range Forecasting

Uncertainty also in short-range:

- ▶ Rapid Cyclogenesis often poorly forecast deterministically
- ▶ Uncertainty of sub-synoptic systems (eg thunderstorms)
- ▶ Many customers most interested in short-range

Assess ability to estimate uncertainty in local weather

- ▶ QPF
- ▶ Cloud Ceiling, Fog
- ▶ Winds, etc

Initial Conditions Perturbations

- ▶ Perturbations centred around 4D-Var analysis
- ▶ Transforms calculated using same set of observations in 4D-Var (including all satellite obs) within +/- 3 hours of data time
- ▶ Ensembles uses 12 hour cycle (data assimilation uses 6 hour cycle)

Differences with ECMWF Singular Vectors:

- ▶ It focuses on errors growing during the assimilation period, not growing period > Suitable for short-range!
- ▶ Calculated using the same resolution than the forecasts
- ▶ ETKF included moist processes
- ▶ Running in conjunction with stochastic physics to propagate effect

Model error: parameterisations

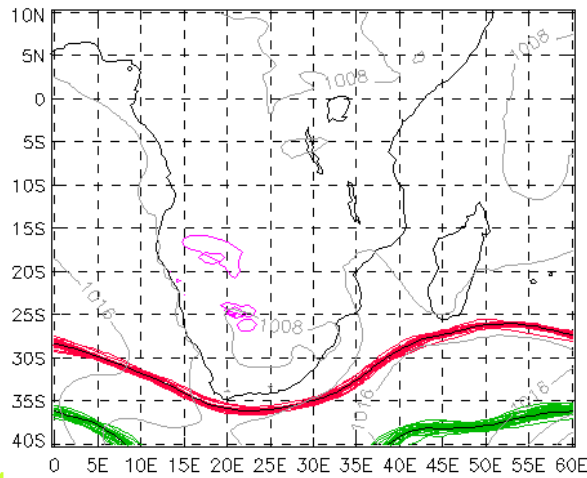
4

- ▶ Random parameters

Parameter	Scheme	min/std/Max
Entrainment rate	CONVECTION	2 / 3 / 5
Cape timescale	CONVECTION	30 / 30 / 120
RH critical	LRG. S. CLOUD	0.6 / 0.8 / 0.9
Cloud to rain (land)	LRG. S. CLOUD	1E-4/8E-4/1E-3
Cloud to rain (sea)	LRG. S. CLOUD	5E-5/2E-4/5E-4
Ice fall	LRG. S. CLOUD	17 / 25.2 / 33
Flux profile param.	BOUNDARY L.	5 / 10 / 20
Neutral mixing length	BOUNDARY L.	0.05 / 0.15 / 0.5
Gravity wave const.	GRAVITY W.D.	1E-4/7E-4/7.5E-4
Froude number	GRAVITY W.D.	2 / 2 / 4

MOGREPS products

MOGREPS-15 Spaghetti chart for 500hPa geopotential height
DT 00Z on 11/11/2013 VT 00Z on 13/11/2013 lead time 48h
(Ensemble Mean PMSL plotted as faint background)

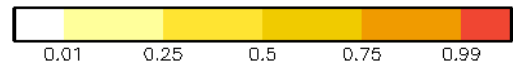
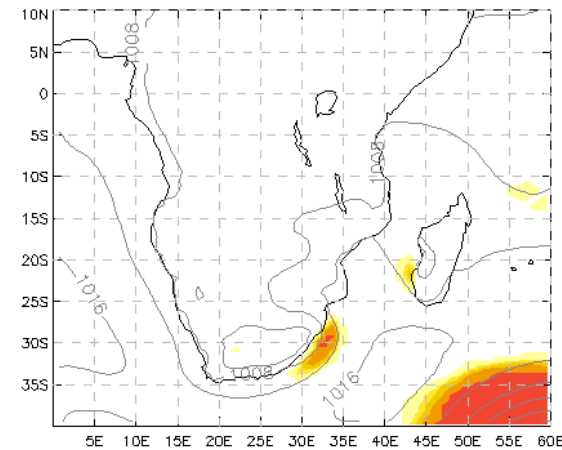


Green = 546 dam, Red = 564 dam, Pink = 582 dam
Black lines represent Control member

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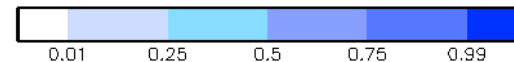
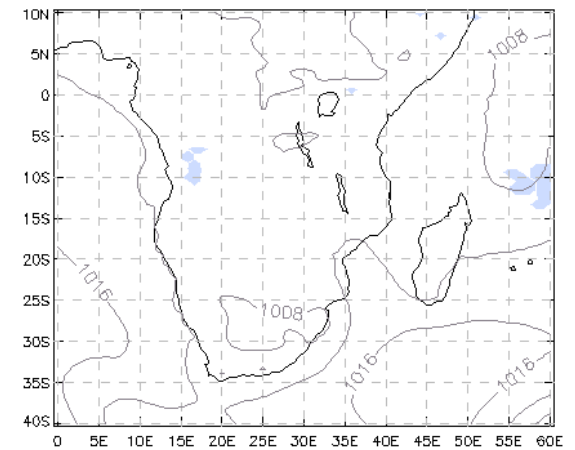
MOGREPS-15 Probability map for 10mWindSpeed > 20.0knots
DT: 00Z Mon 11/11/2013 VT: 12Z Tue 12/11/2013 lead time 36h
(Ensemble Mean PMSL plotted as faint background)



(c) British Crown copyright. Material supplied by the Met Office.



MOGREPS-15 Probability map for 24HourPrecip > 50.0mm
DT: 00Z Mon 11/11/2013 VT: 00Z Wed 13/11/2013 lead time 48h
(Ensemble Mean PMSL plotted as faint background)



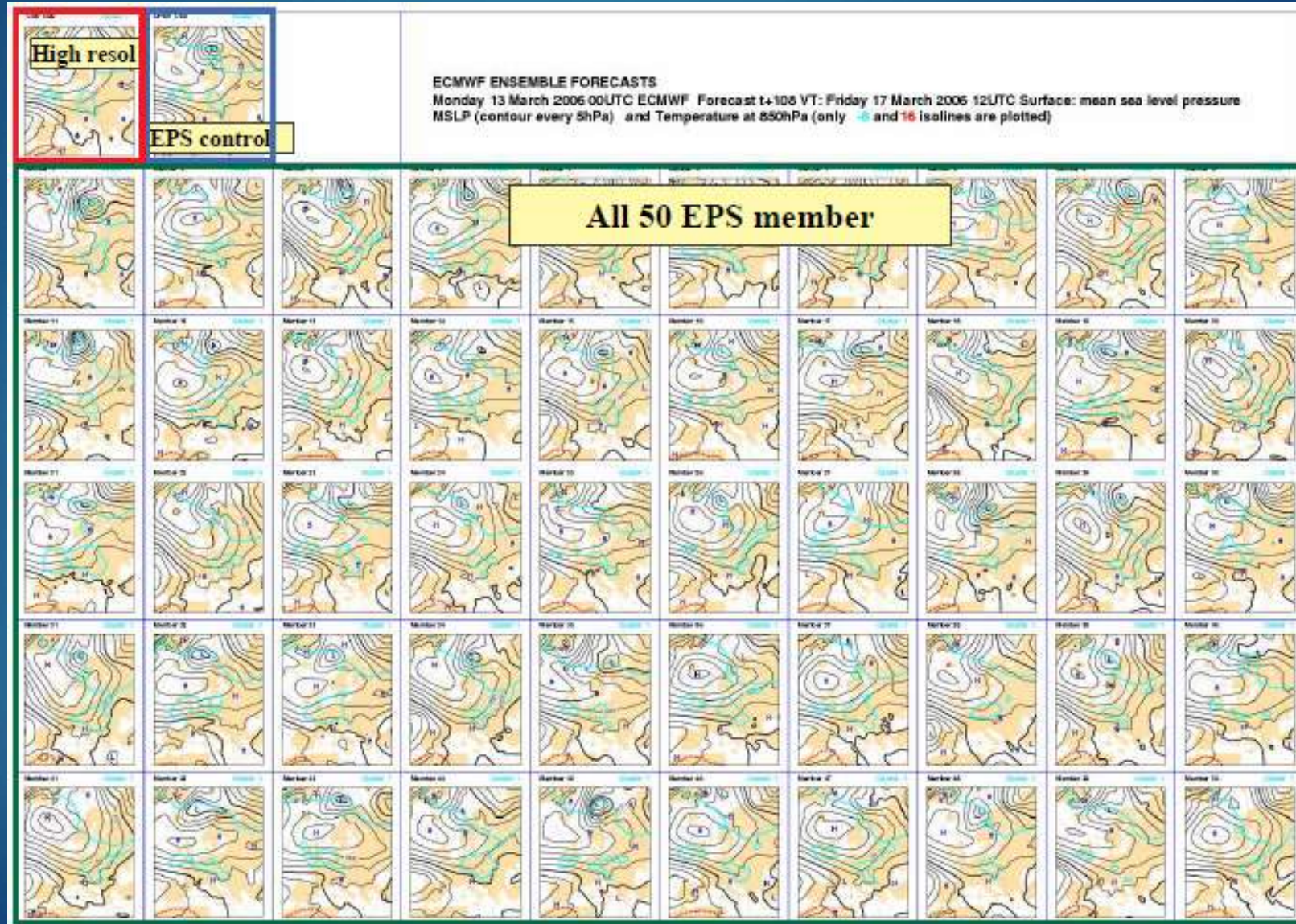
(c) British Crown copyright. Material supplied by the Met Office.



Using Probabilities

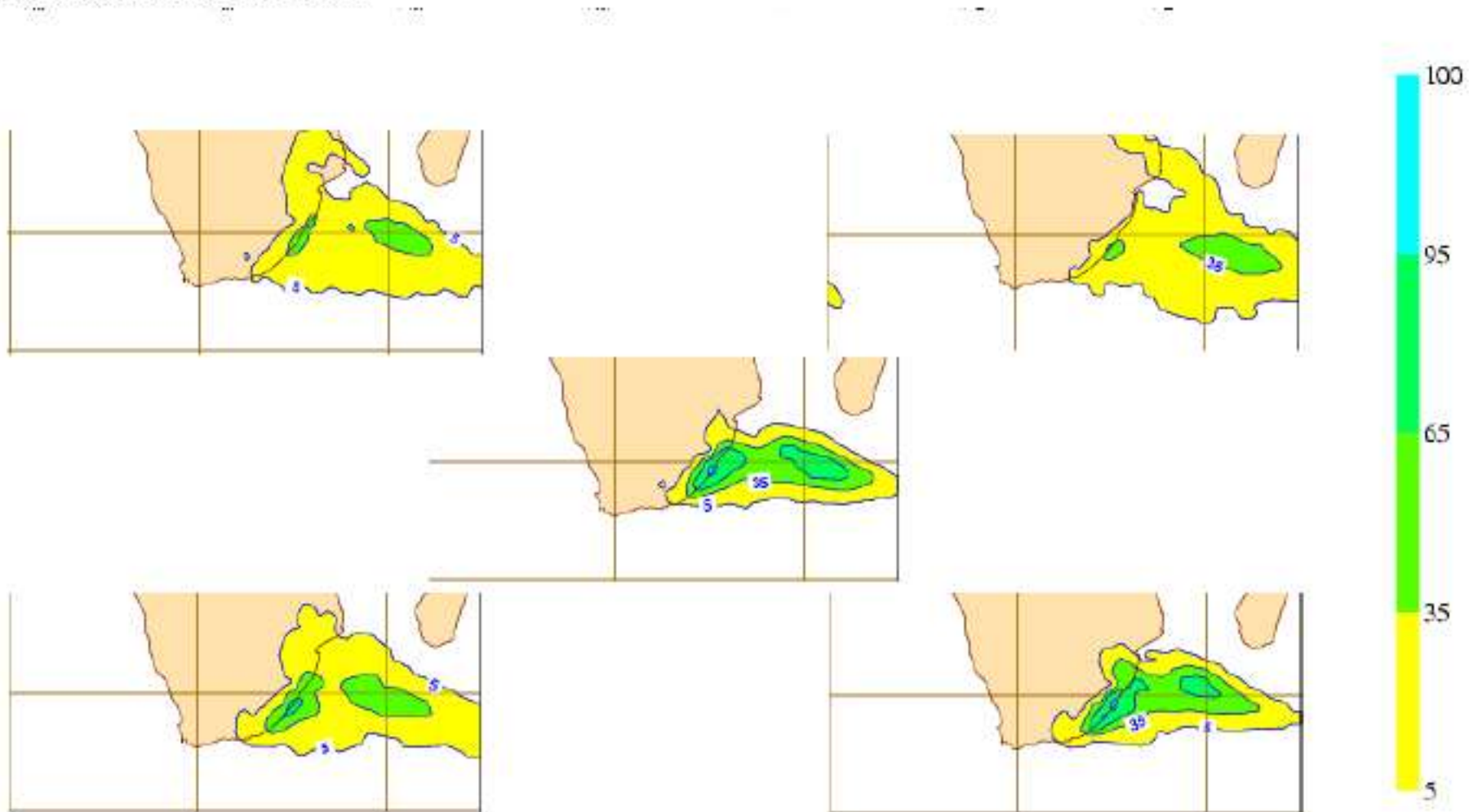
- ▶ Recipients of forecasts & warnings are sensitive to different levels of risk: reflecting cost of mitigation vs expected loss
- ▶ An intelligent response to forecasts & warnings depends on risk analysis, requiring knowledge of impacts probability
- ▶ Use of ensembles to estimate probability at longer lead times is well established in meteorology

Stamp maps and clusters



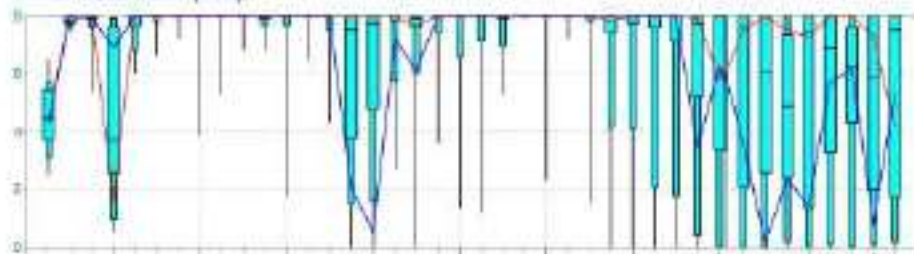
Probability maps

Monday 2 October 2008 00UTC @ECMWF Forecast probability t+036-060 VT: Tuesday 3 October 2008 12UTC - Wednesday 4 October 2008 12UTC
Surface: Total precipitation probability > 20.0 mm

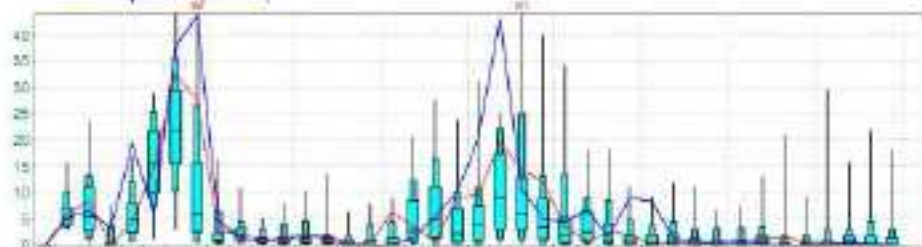


Pretoria
 EPS Meteorogram
 Pretoria (1292m) 25.84°S 28.32°E
 Deterministic Forecast and EPS Distribution Friday 7 November 2008 00 UTC

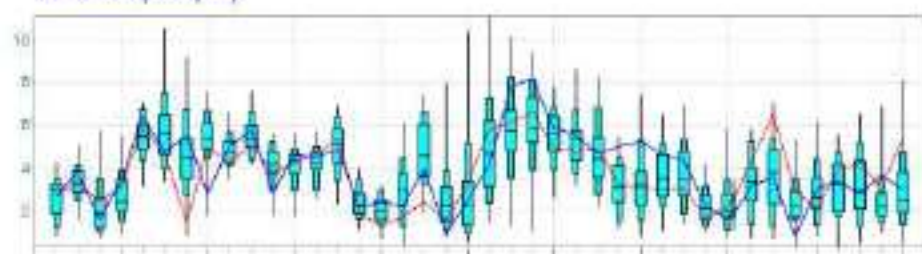
Total Cloud Cover (okta)



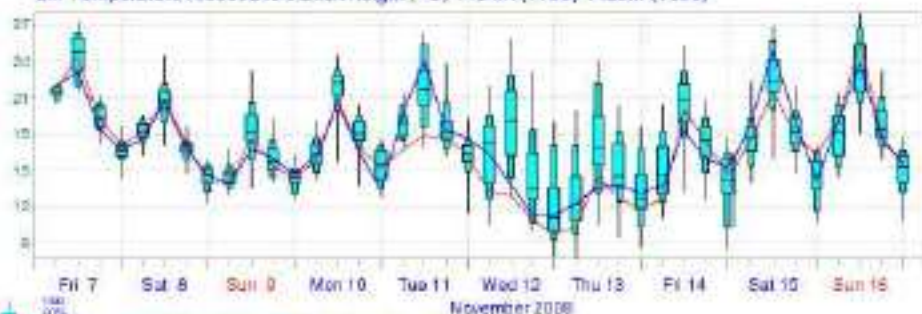
Total Precipitation (mm/6h)




10m Wind Speed (m/s)



2m Temperature reduced to station height (°C) 1454m (T799) 1420m (T399)




 EPS Control(50 hrs) High Resolution Deterministic(25 km)

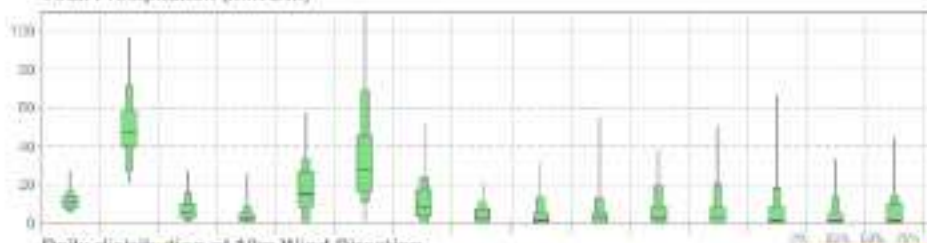
2012-11-28

EPS Meteorogram
 Pretoria (1292m) 25.61°S 28.5°E
 Extended Range Forecast based on EPS Distribution Friday 7 November 2008 00 UTC

Daily mean of Total Cloud Cover (okta)



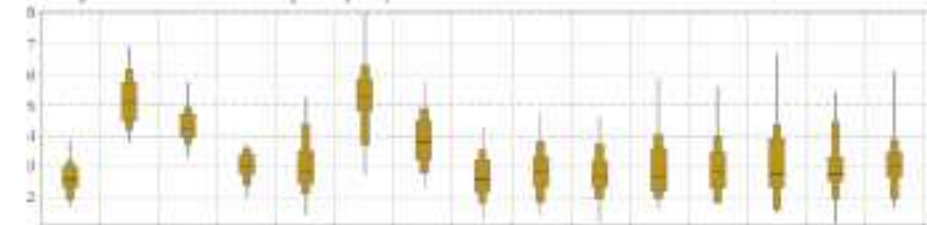
Total Precipitation (mm/24h)



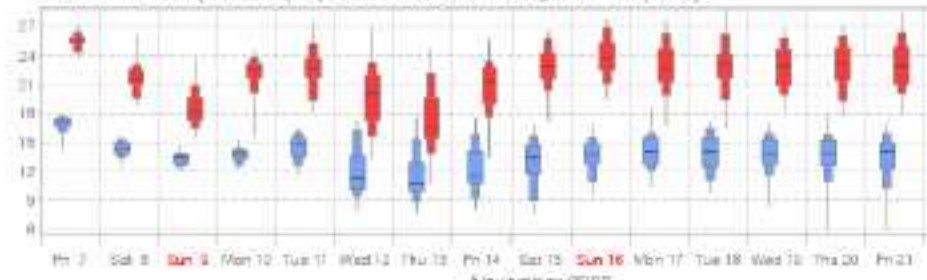
Daily distribution of 10m Wind Direction



Daily mean of 10m Wind Speed (m/s)



2m minimax temperature (°C) reduced to station height 1315m (T255)

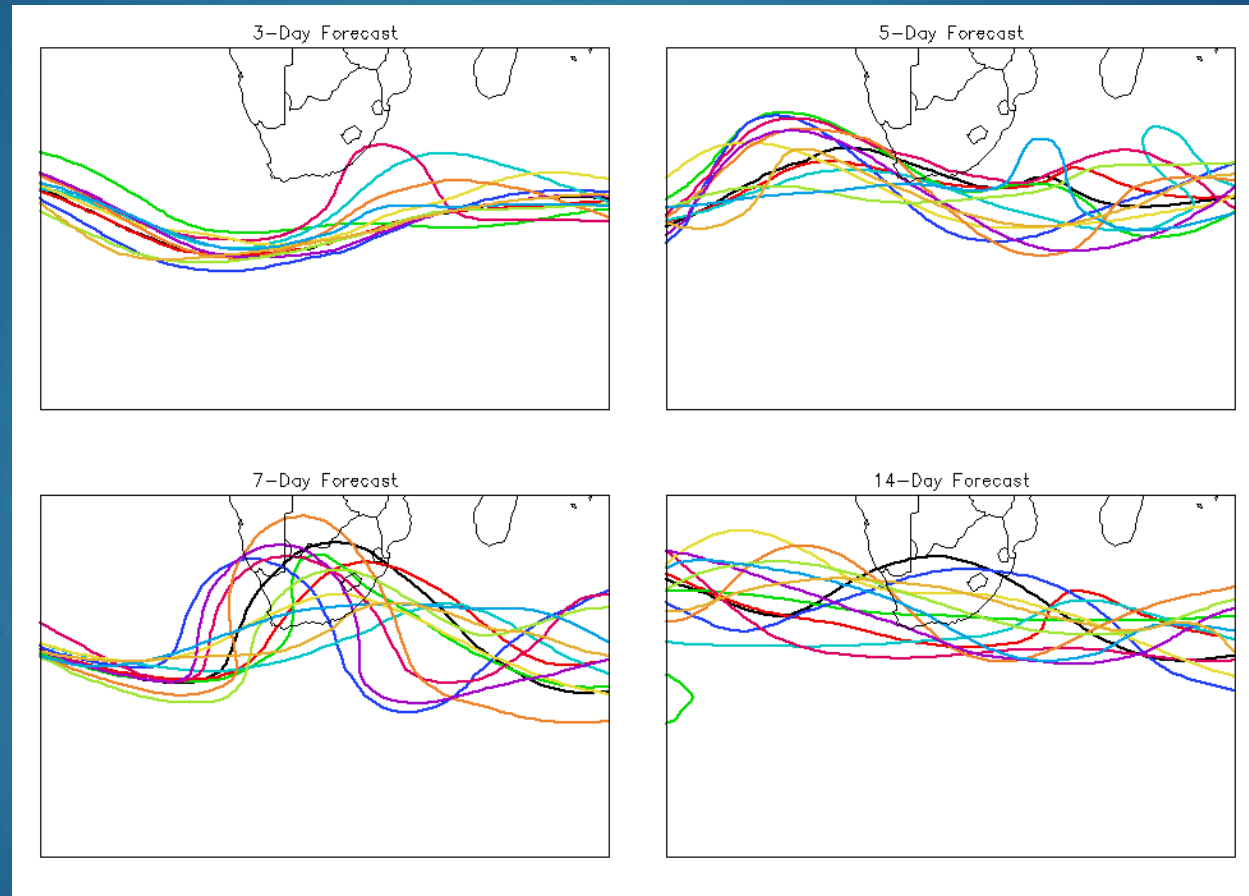


Fri 7 Sat 8 Sun 9 Mon 10 Tue 11 Wed 12 Thu 13 Fri 14 Sat 15 Sun 16 Mon 17 Tue 18 Wed 19 Thu 20 Fri 21
 November 2008

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Spaghetti diagram example

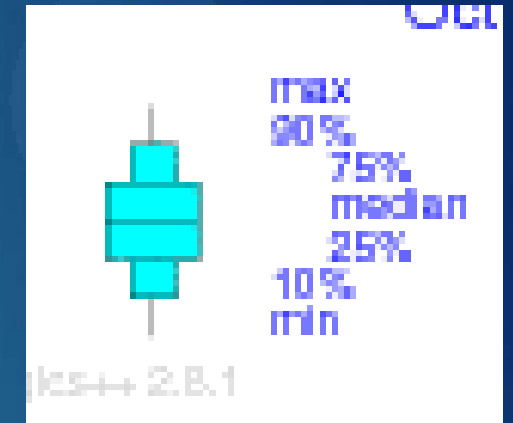
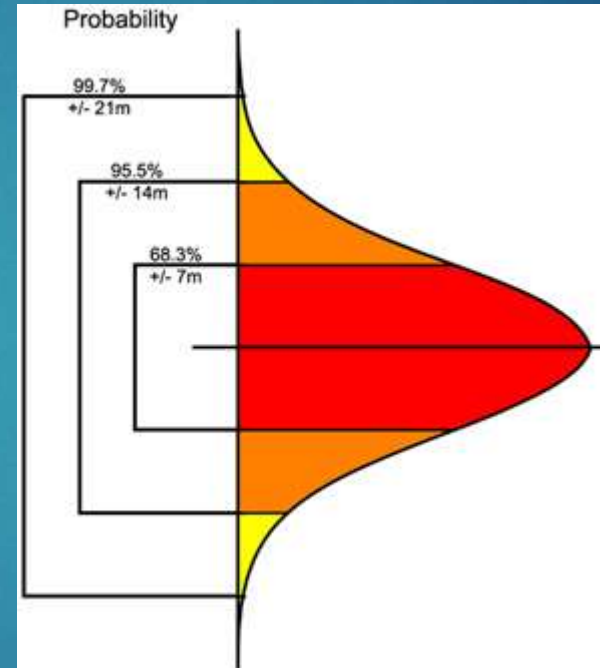
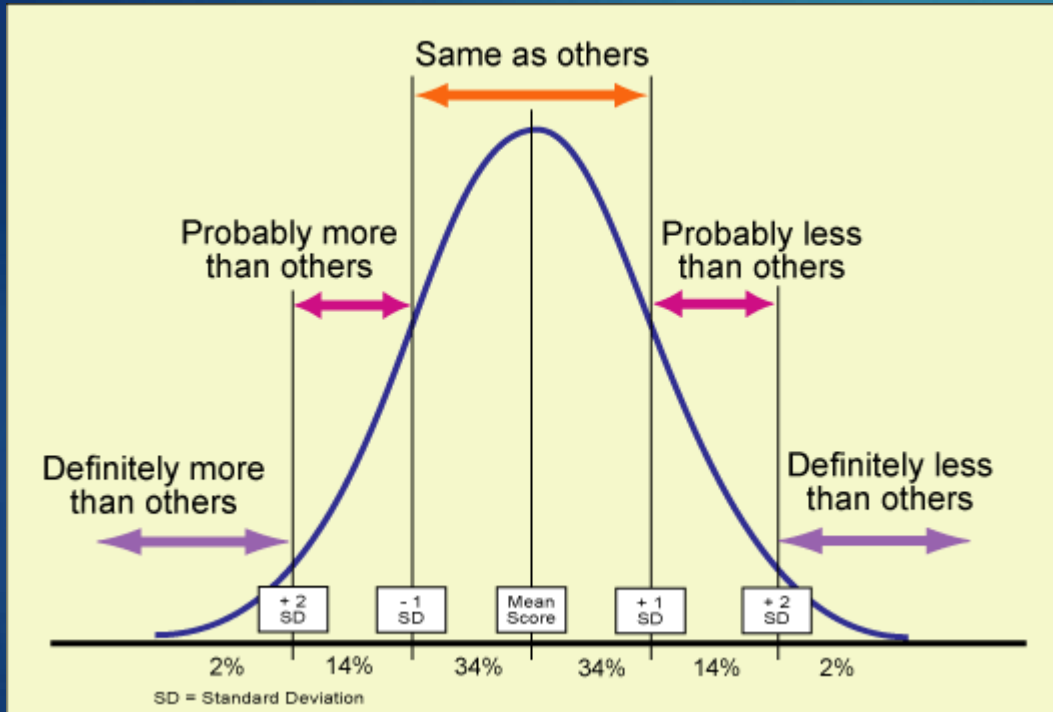
11



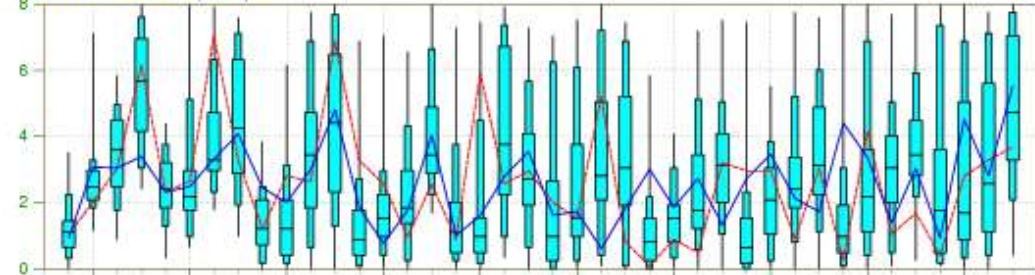
- Drop in forecast confidence with increasing lead-time

EPS-meteogrammes

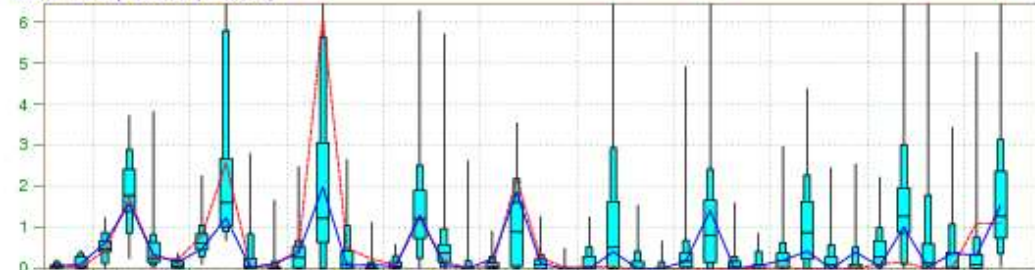
12



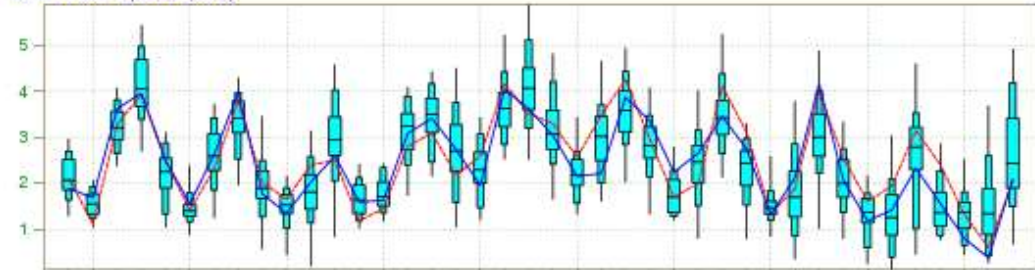
Total Cloud Cover (okta)



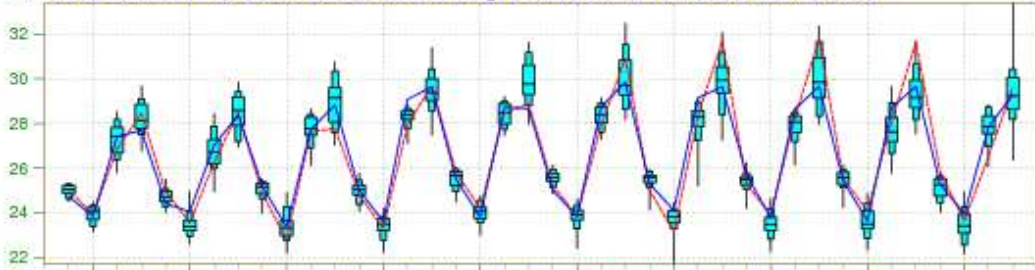
Total Precipitation (mm/6h)



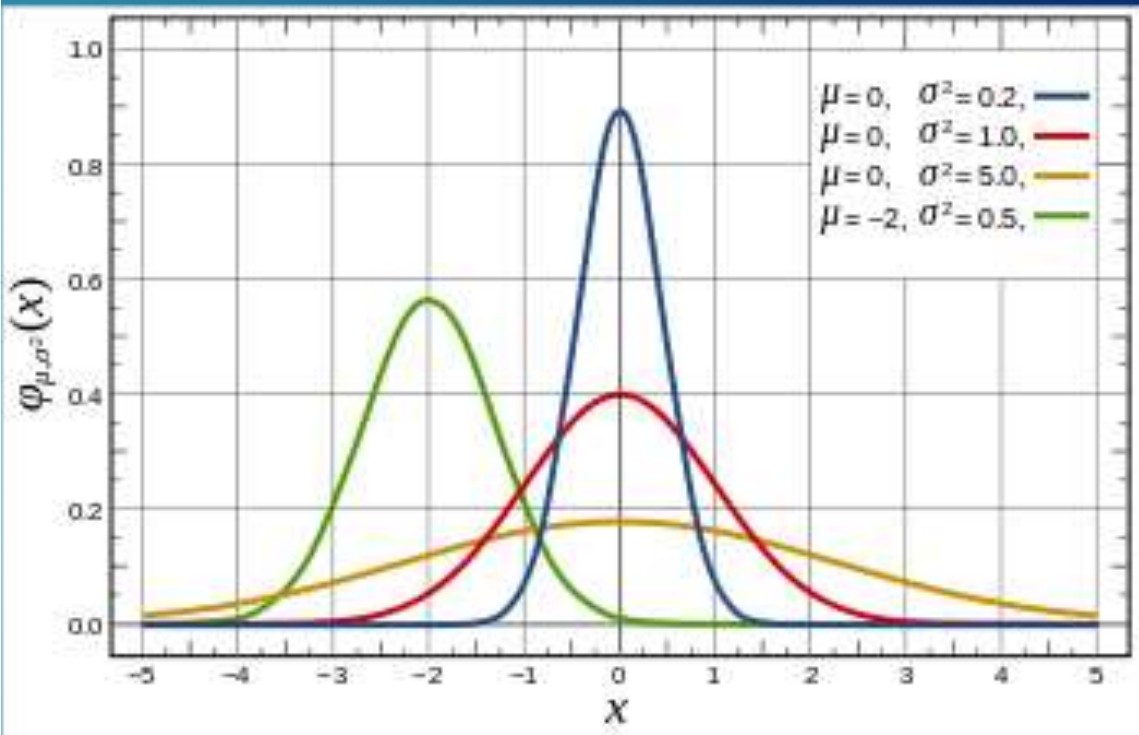
10m Wind Speed (m/s)



2m Temperature (°C) reduced to the station height from 85 m (T1279) and 66 m (T639)

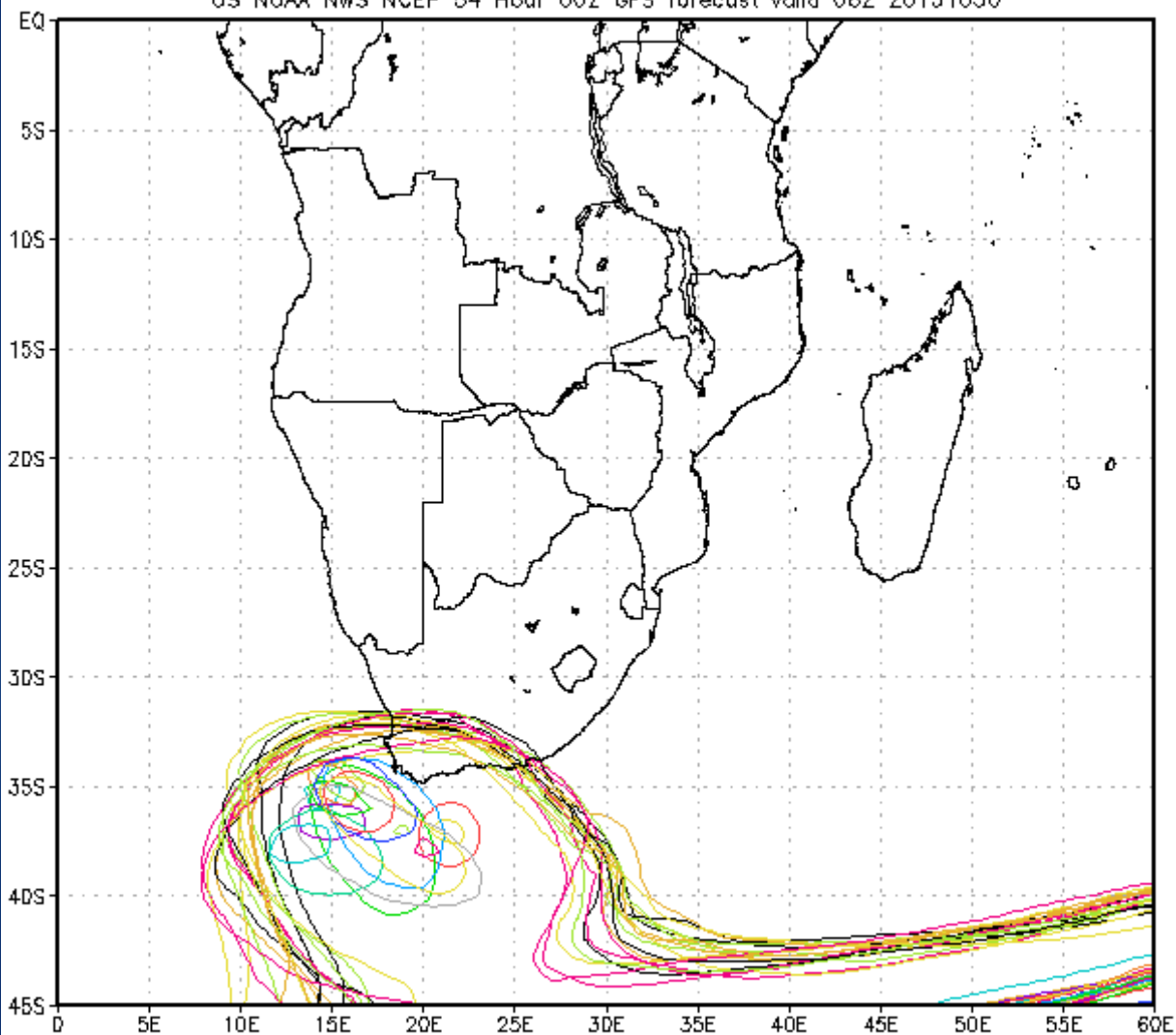


Mon 28 Tue 29 Wed 30 Thu 31 Fri 1 Sat 2 Sun 3 Mon 4 Tue 5 Wed 6 Thu 7
October 2013 November 2013



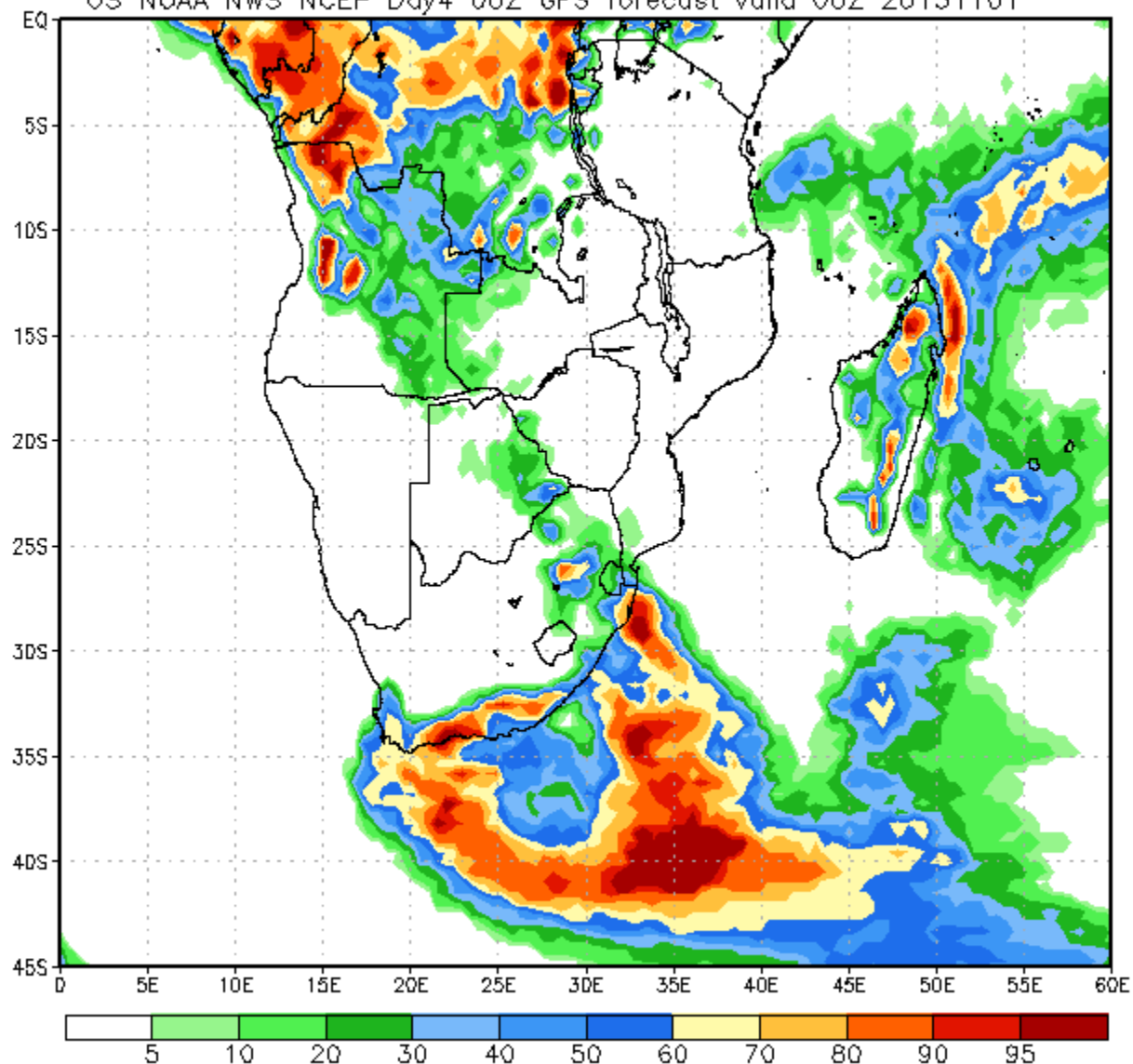
Spaghetti plot of 500mb Hgts 5550m 5650m isolines

US NOAA NWS NCEP 54 Hour 00Z GFS forecast valid 06Z 20131030

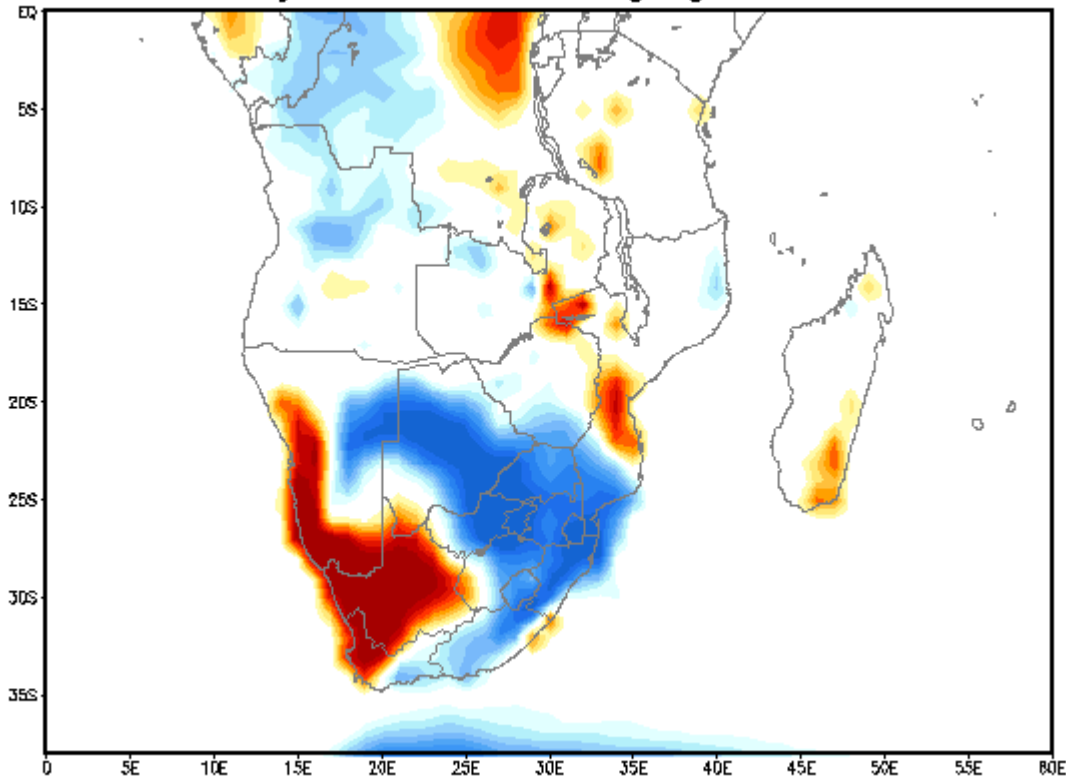


Probability of 24hr total precipitation exceeding 5 mm

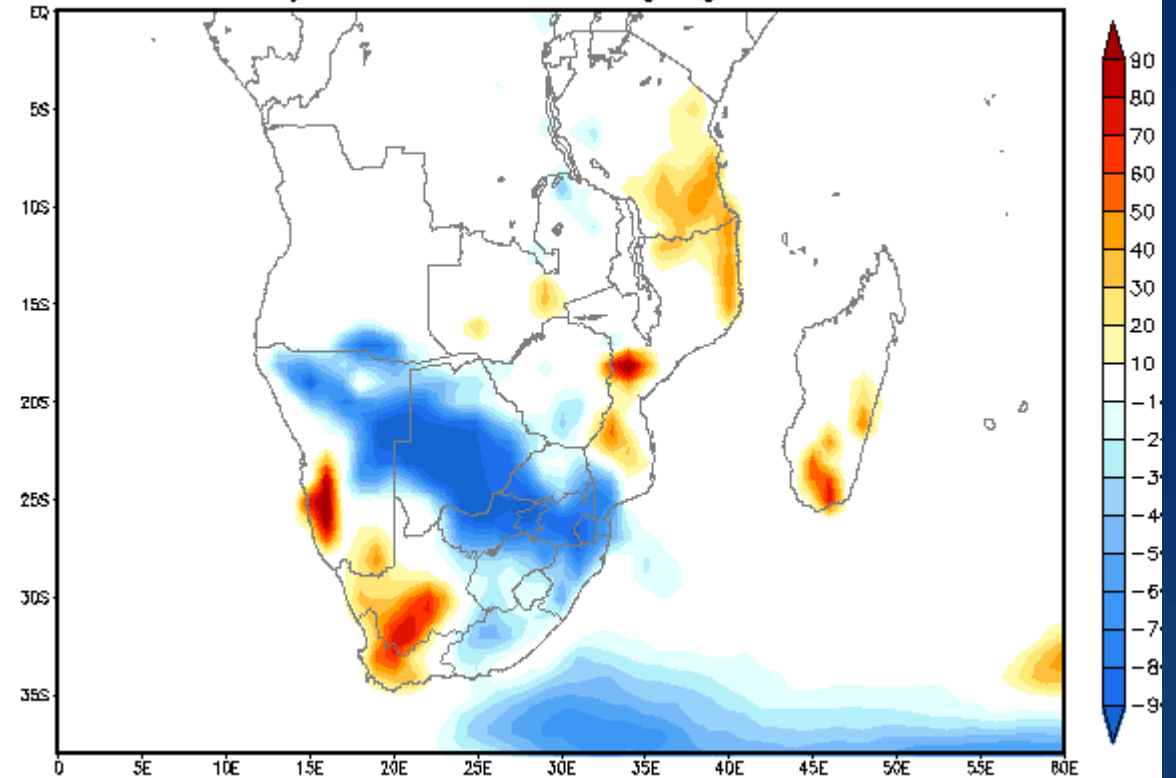
US NOAA NWS NCEP Day4 00Z GFS forecast valid 00Z 20131101



Probability of Tx 24-H change greater than 2°C



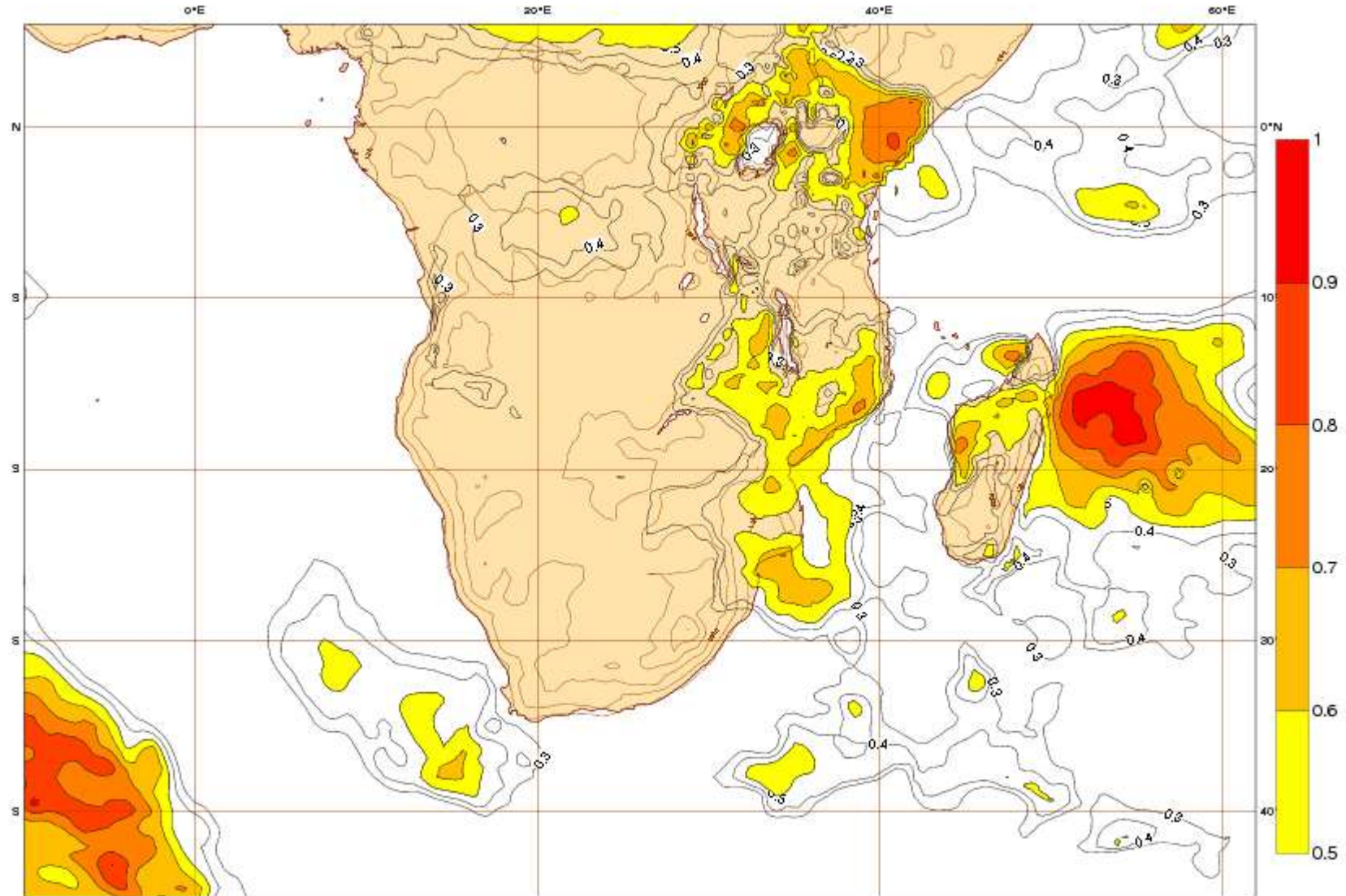
Probability of Tn 24-H change greater than 2°C



Extreme Forecast Index

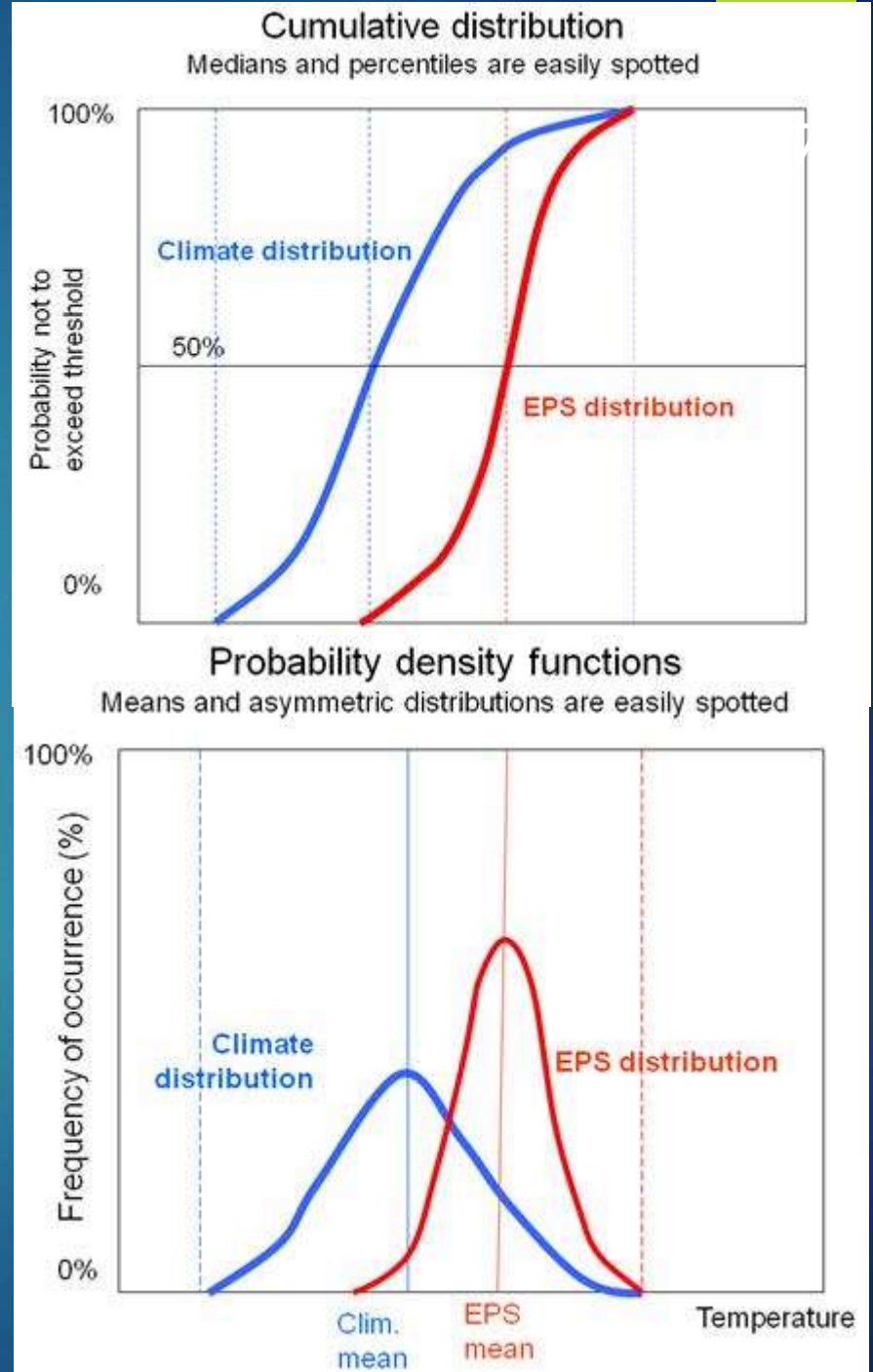
16

Monday 28 October 2013 12 UTC ©ECMWF Extreme forecast index 1-050-084 VT: Thursday 31 October 2013 00 UTC - Friday 1 November 2013 00 UTC
Surface: 2 metre temperature index



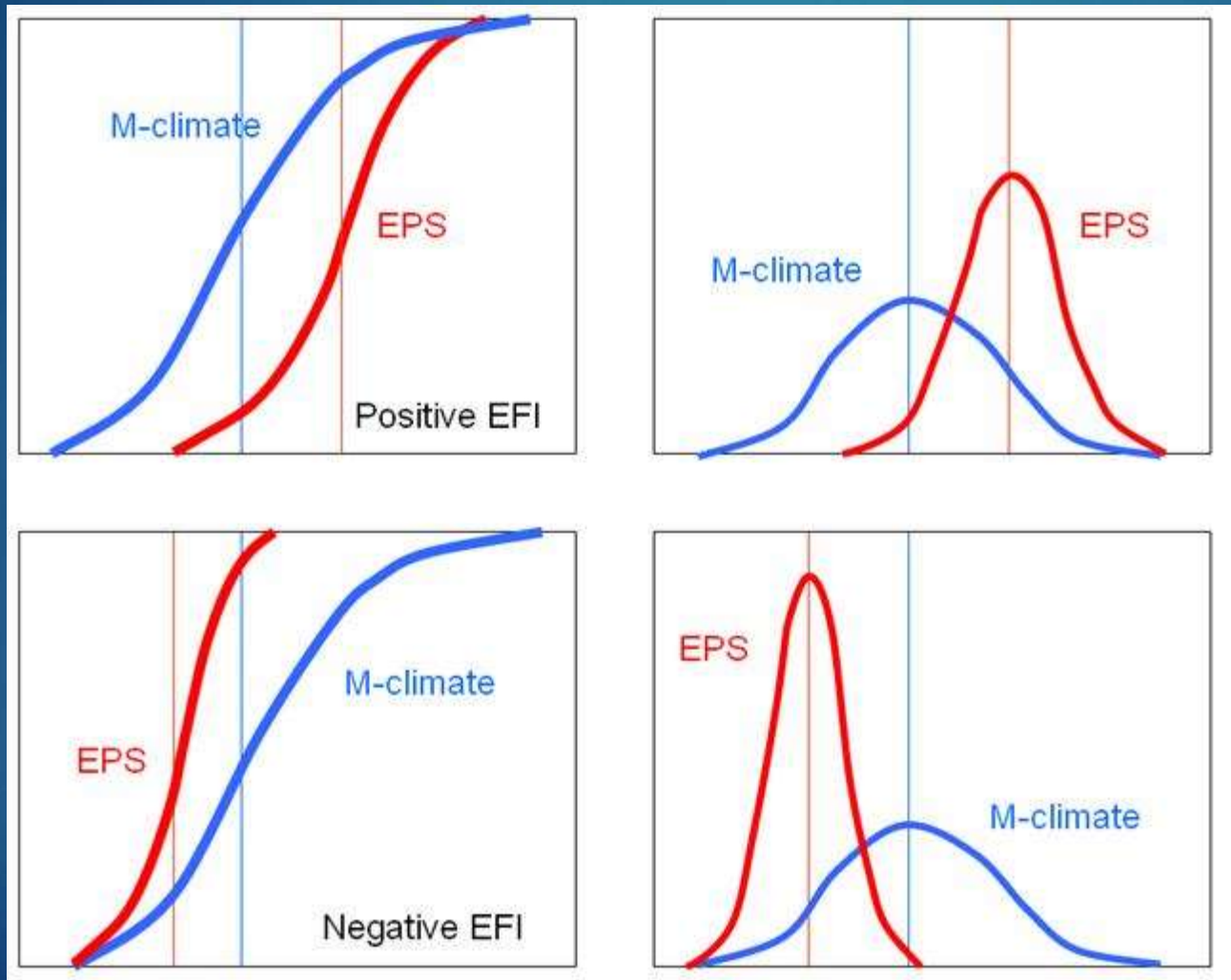
Extreme Forecast Index

- EFI measures the distance between the EPS cumulative distribution and the model climate distribution
- Takes values from -1 (all members break climate minimum records) and $+1$ (all beyond model climate records)



Extreme Forecast Index

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EFI ~ +50%

EFI ~ -50%

Using & Interpreting EFI

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- ▶ If the EPS probability distribution agrees with the M-climate distribution then $EFI = 0$. If the probability distribution (mean, spread and asymmetry) does not agree with the climate probability distribution, the EFI takes non-zero values. In the special case where all the EPS members forecast values above the absolute maximum in the M-climate, the $EFI = +1$; if they all forecast values below the absolute minimum in the M-climate the $EFI = -1$.
- ▶ Negative EFI values are only really of interest for temperature anomalies, since temperature is the only variable which is of particular interest when it has negative anomalies, such as cold spells. Absence of precipitation might be important for certain agricultural activities, similarly weak winds are of significance for sailing; however, although such weather may be regarded as “unusual” in some locations, it is not catered for in the EFI.
- ▶ Experience suggests that EFI values of 0.5 - 0.8 can be generally regarded as signifying that “unusual” weather is likely and values above 0.8 as usually signifying that “very unusual” or extreme weather is likely.

Using & Interpreting EFI

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- ▶ Although higher EFI values indicate that an extreme event is more likely than usual, the values do not represent probabilities, as such. Any forecasts or warnings must be based on a careful study of probabilistic and deterministic information.
- ▶ Although the EFI index is a useful tool that allows the easy identification of extremes with respect to location and season, its simplicity is achieved by a rather complex mathematical treatment and should only serve as an “alarm bell”, a warning of potentially extreme events.

www.ecmwf.int

Working with the EPS

- ▶ Ensemble mean acts as a dynamic filter and removes normally unpredictable features
- ▶ The removed features are put back in a consistent way as probabilities