NWP Lectures Day 3

Medium-range Forecasting

and

Ensemble Prediction System

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Daily outcomes

Day 1: Learner will be able to utilize internal and external webpages to navigate between different NWP forecasts.

Day 2: The learner will be able to understand different observational data and downscaling methods

Day 3: The learner will be able to utilize Ensemble Prediction Systems (EPS) in order to indicate forecast uncertainty and probability of event.

Day 4: Learner will be able to interpret NWP output to determine the predictability of the atmospheric motion.

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Outcomes of Day 3

- Background to (EPS).
- Poor-man’s ensemble.
- Traditional EPS product output.
- EPS Products are explained (i.e. Meteograms, Box and Whisker Plots. EPS-grammes, etc.).
- Global Ensemble Forecast System (GEFS).
- Different types of EPS’s are explained.
- Convective Scale Ensemble Prediction System (MOGREPS).
- Short-Range Multi Model Ensemble Prediction System.

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Forecast Process Step	Tool
Meteorological Watch	•Surface analyses •Radar reflectivity and velocity •Satellite depictions
Diagnosing Cause and Effect	•MetWatch tools compared to NWP forecasts • Surface analyses compared to surface forecasts (MSLP, 2-m temperature, precipitation) • Radar compared to forecast precipitation •Constant potential temperature surface analyses •Visible, IR, water vapor satellite imagery
Determining Probable Outcomes	•Plume diagrams •Probability plots •Spaghetti diagrams •Poor man's ensemble
Update	•NWP model forecasts modified by conceptual model •Forecast discussion (NWP and conceptual model comparison) •Graphical Forecast Editor (will be covered in NWP in the NDFD era) •National Digital Forecast Database and derived text products

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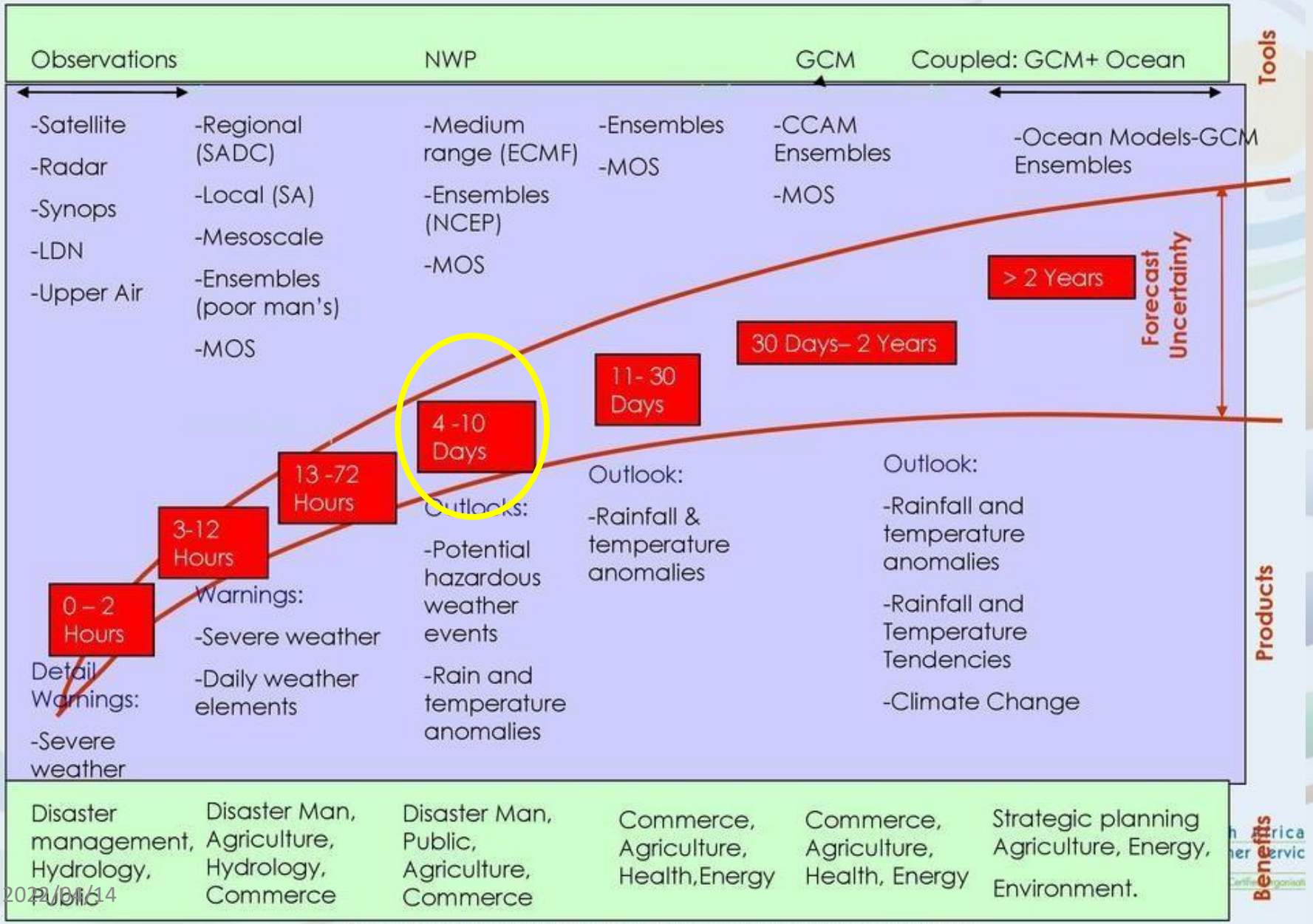
The SAWS "Seamless" Forecasting Systems



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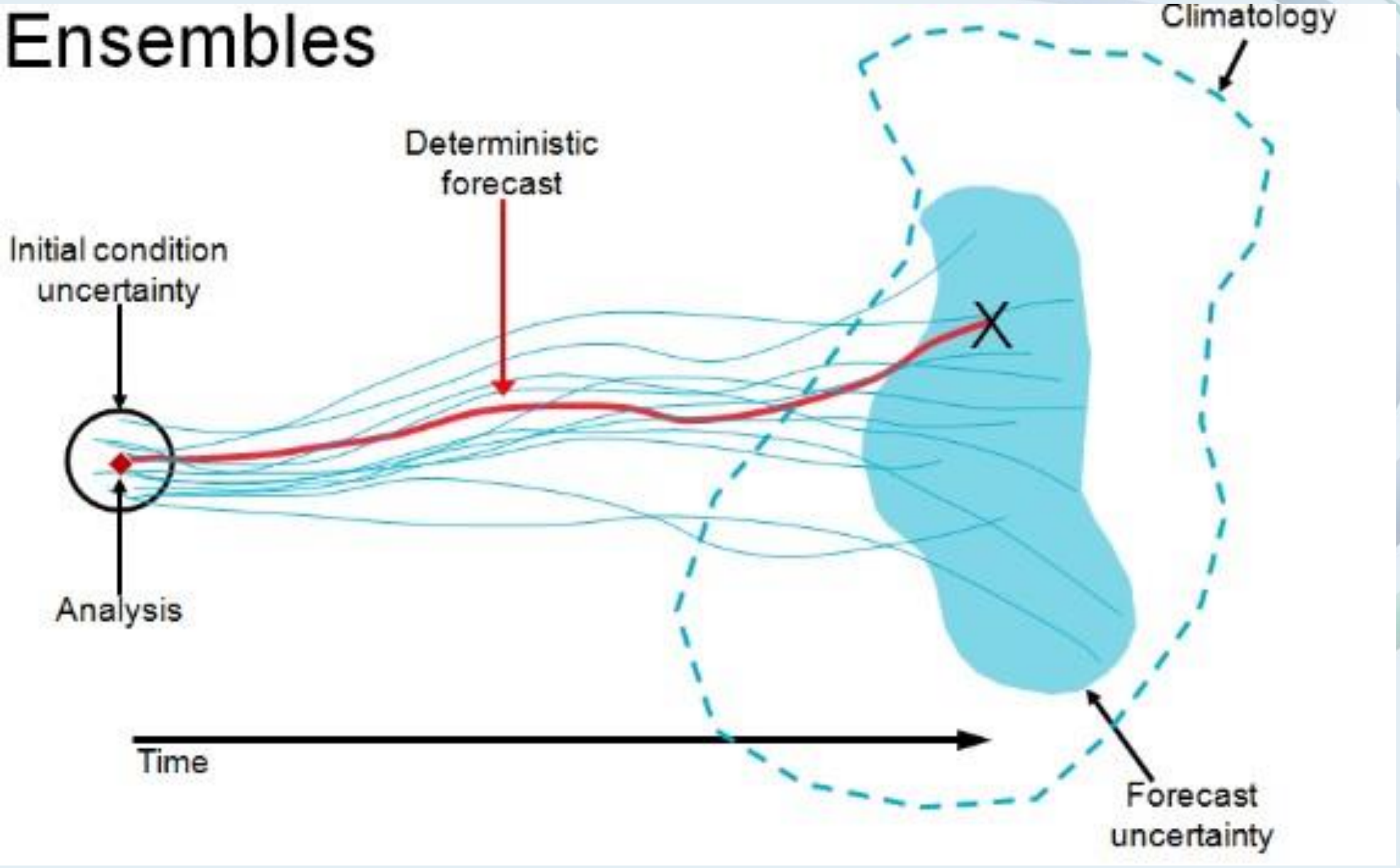
Ensemble Prediction System

An **Ensemble Prediction System**

- is an NWP system that produces many outcomes, allowing us to estimate probabilities of weather variable values. Instead of running an NWP model once, as with deterministic model runs, scientists run the model many times using slightly different initial conditions or changes to the model physics.
- Some ensembles contain more than one different model (multi-model EPS) while others use the same model but with different combinations of physical parameterization schemes or varied initial conditions (multi-physics EPS).

Ensembles



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Ensemble Prediction System : Products

- Ensemble mean
- Ensemble spread
- Basic probability
- Quantiles
- Spaghetti maps
- Postage stamp maps
- Site-specific meteograms

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Global EPS: ECMWF

www.ecmwf.int

Most commonly used ensemble system (separate lecture)

Ensemble Prediction System

- 15 days ahead
- 51 members (control + 50 perturbed)
- First 10 days run at T639 (32km)
- Days 10-15 runs at T319 (63km)
- Days 15-32 runs at T319 (63km)
- 62 levels

Country	Centre	Model 'name'	No.
USA	National Centers for Environmental Prediction (NCEP)	Global Ensemble Forecast System (GEFS)	21
USA	US Navy	Navy Operational Global Atmospheric Prediction System (NOGAPS)	
France	MeteoFrance	Prevision Ensemble ARPège (PEARP)	35
Germany	Deutscher Wetterdienst (DWD)	COnsortium for Small-scale MOdelling (COSMO-DE-EPS)	20
Canada	Canadian Meteorological Centre (CMC)	Global Environmental Multiscale Model (GEM)	21
Japan	Japan Meteorological Agency (JMA)		51

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Benefits of EPS

- **Addressing uncertainty in atmospheric modelling: Initial Conditions**
  - Errors in initial conditions are reduced by adding/subtracting perturbations to the analysis
  - Ensemble give a better representation of the possible future states of the atmosphere
    - Observed future state should fall within the forecast
    - distribution
    - Forecast distribution should be as narrow as possible
    - Promotes confidence and increases skill in forecast

Benefits of EPS

- **Addressing uncertainty in atmospheric modelling: Internal model errors**
  - Internal model variability is determined through inter-
  - ensemble member and signal-to-noise ratio
  - Ensembles of different models can utilize unique advantages of each model in providing a forecast that has more skill than any individual model
    - Multi-model ensemble approach

Benefits of EPS

- **Objective calculations of probability forecasts:**
  - Probability of an event is the percentage of ensemble members that forecast the event relative to the total number of members
- **Overall improvement in forecast skill:**
  - The mean generally outperforms any member on most time-scales
    - Smoothing effect of averaging different forecasts
    - Producing a spread of forecasts whose mean is closest to the observed
    - Advantage of the improvement in skill is the extension of the predictability limit by a number of days

Ensemble mean (EM)

Ensemble Mean: The ensemble mean (EM) forecast is a simple but effective product. The averaging serves as a filter to reduce or remove atmospheric features that vary amongst the members and are therefore likely to be regarded as less predictable at the time. Such non-predictable features are effectively removed from the EM.

Significant high-impact events are often weakened or absent in the EM. Use of probabilities is therefore essential in conjunction with the EM.

EM is most suited to parameters like temperature and pressure, which usually have a rather symmetric Gaussian distribution.

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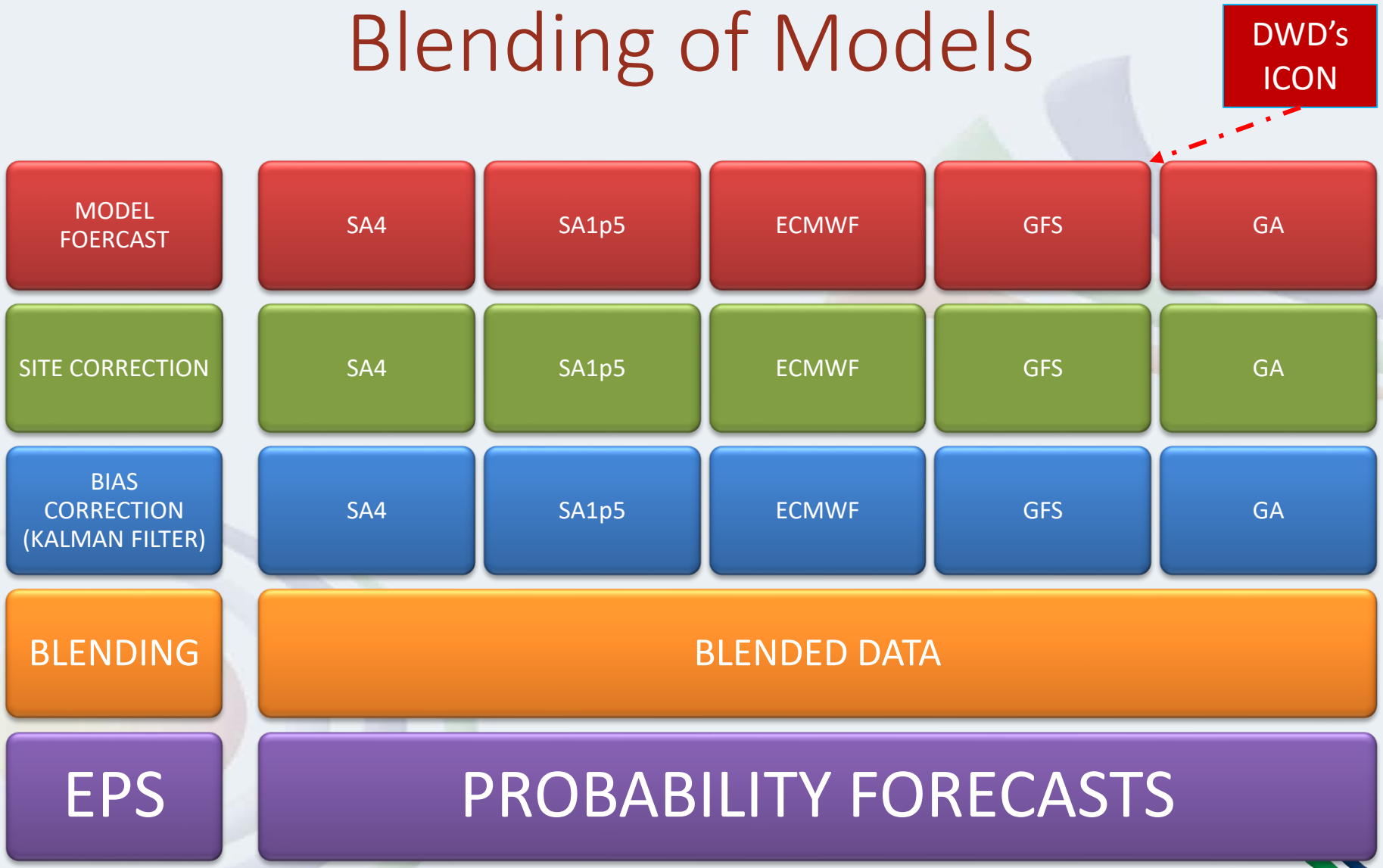
Blending of Models



Blending of different models provides single source of data
Downstream products not affected by model upgrades and system changes

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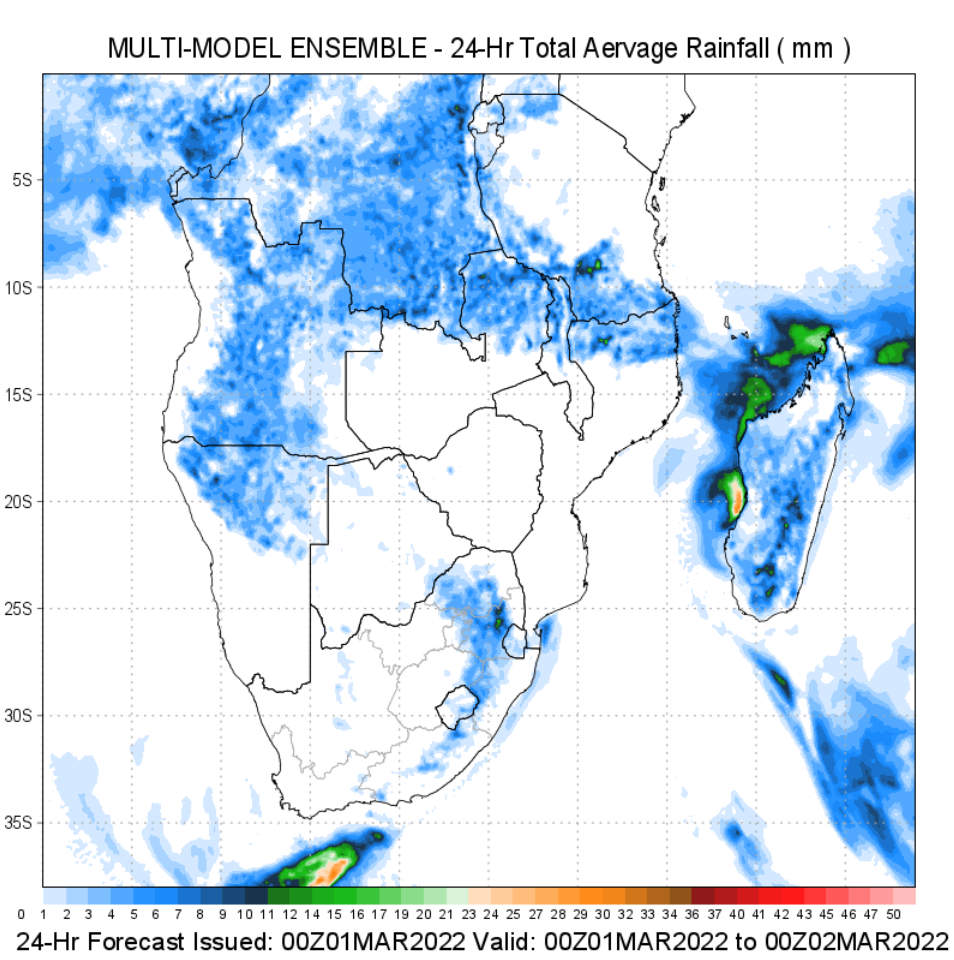
Short-Range Multi Model Ensemble Prediction System.



Within SAWS, there is a multi-model ensemble generated once a day. This model consist of three global model forecasts and the SA4 output. These models are, GA (UKMO), GFS (NOAA/NCEP) and ICON (DWD – German Weather Service). Work is being done to increase the number of members by using previous runs as well.

http://cyclone-web.saws.co.za/MMensemble_products.shtml

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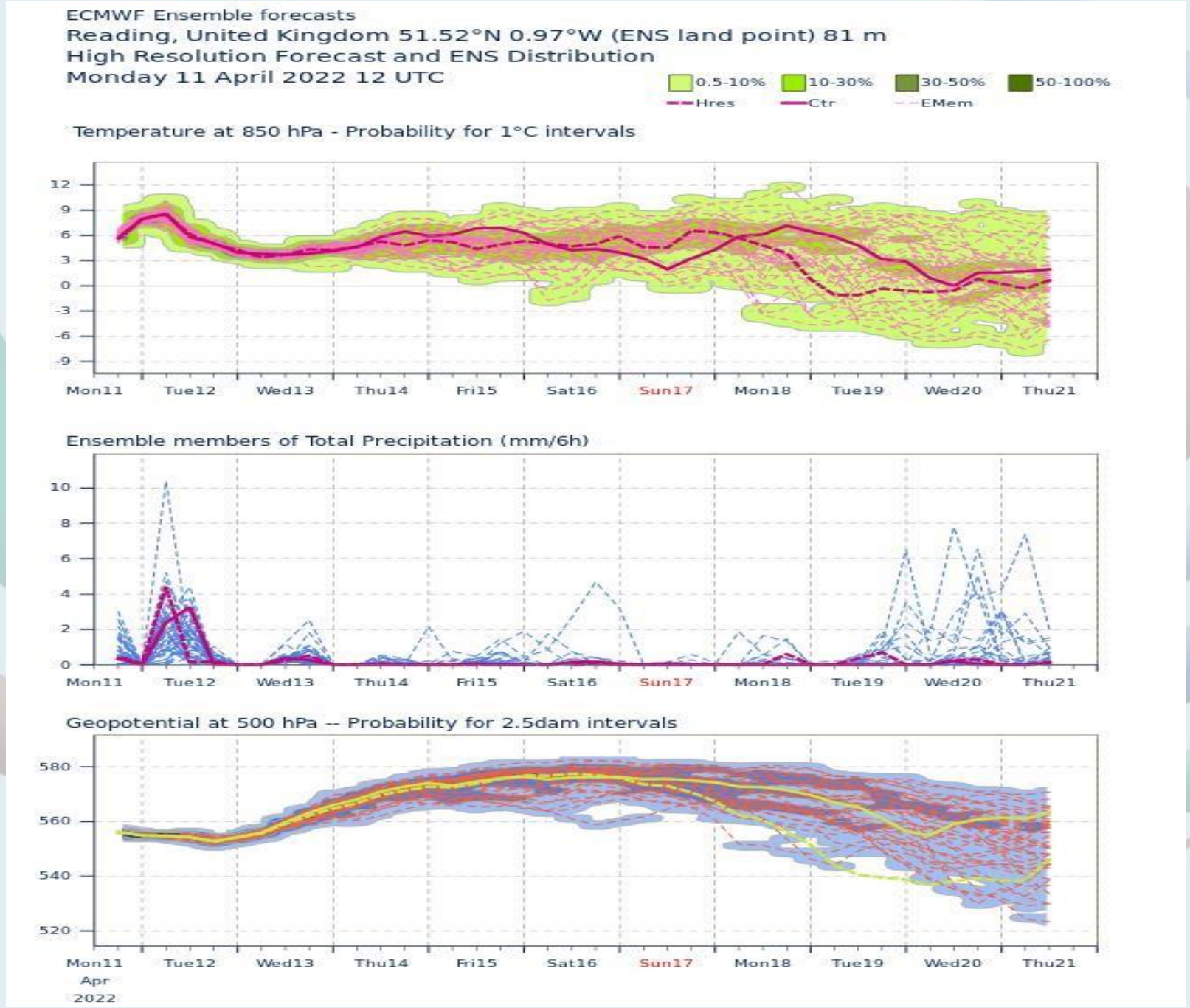
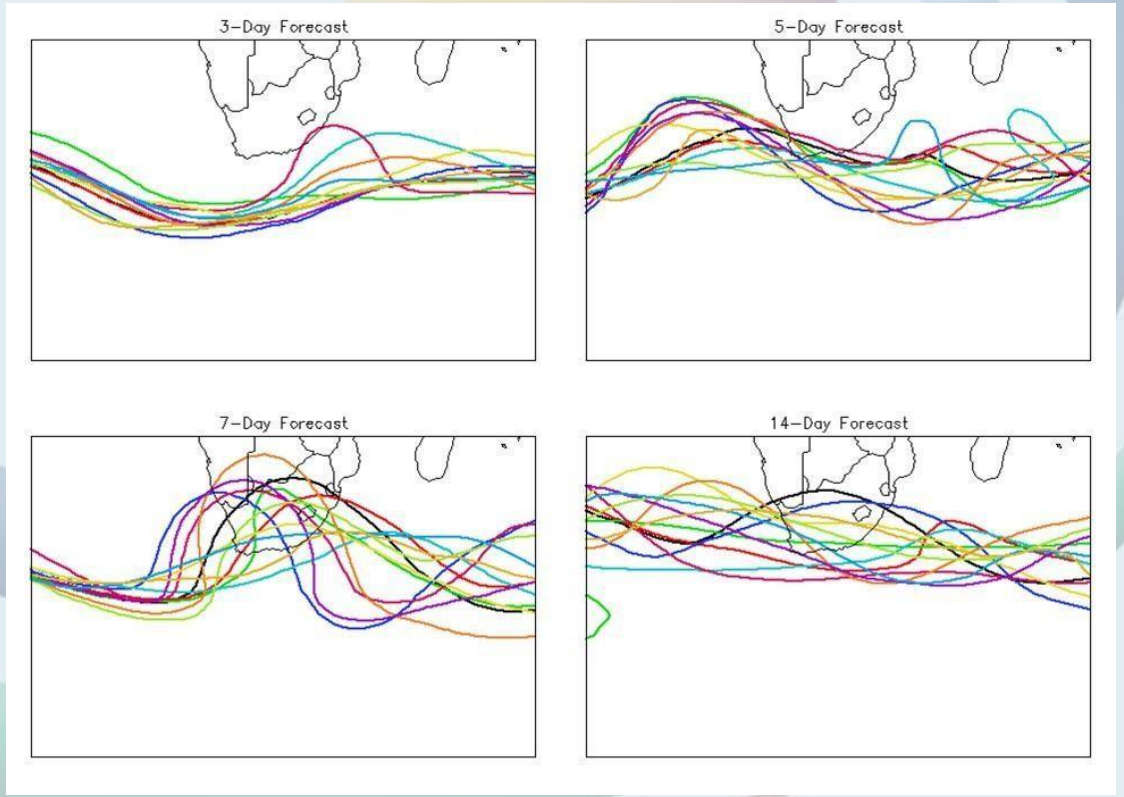

ECMWF Ensemble forecasts
Reading, United Kingdom 51.52°N 0.97°W (ENS land point) 81 m
High Resolution Forecast and ENS Distribution
Monday 11 April 2022 12 UTC
0.5-10%
10-30%
30-50%
50-100%
Hres
Ctr
EMem
Temperature at 850 hPa - Probability for 1°C intervals
12
9
6
3
0
-3
-6
-9
Mon11
Tue12
Wed13
Thu14
Fri15
Sat16
Sun17
Mon18
Tue19
Wed20
Thu21
Ensemble members of Total Precipitation (mm/6h)
10
8
6
4
2
0
Mon11
Tue12
Wed13
Thu14
Fri15
Sat16
Sun17
Mon18
Tue19
Wed20
Thu21
Geopotential at 500 hPa -- Probability for 2.5dam intervals
580
560
540
520
Mon11
Apr
2022
Tue12
Wed13
Thu14
Fri15
Sat16
Sun17
Mon18
Tue19
Wed20
Thu21

Spaghetti plots
Drop in forecast confidence with increasing lead-time

Spaghetti diagrams display certain predefined isolines (for a specific value of geopotential or temperature at 850 hPa or 500 hPa, for example) drawn for each member. While the isolines are initially very tightly packed, they spread out more and more with increasing lead time, reflecting the flow-dependent increase in forecast uncertainty.



Drop in forecast confidence with increasing lead-time

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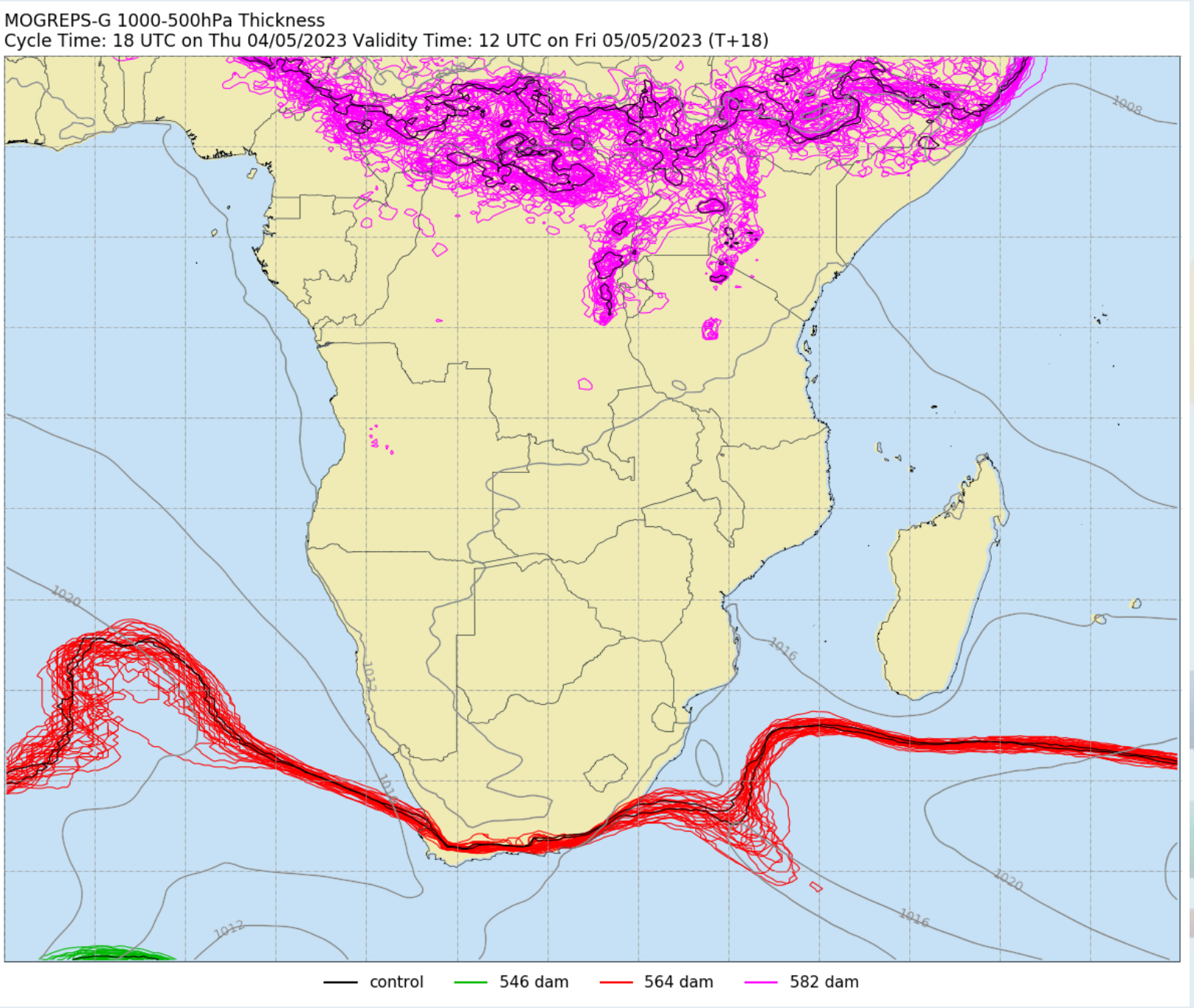

Spaghetti plots

With spaghetti plots, it is easy to recognise when ensemble members start to deviate significantly from each other. This difference increase with lead time. As you might expect, your confidence in the future state of the atmosphere drop and you yourself also become uncertain of the possible outcome.

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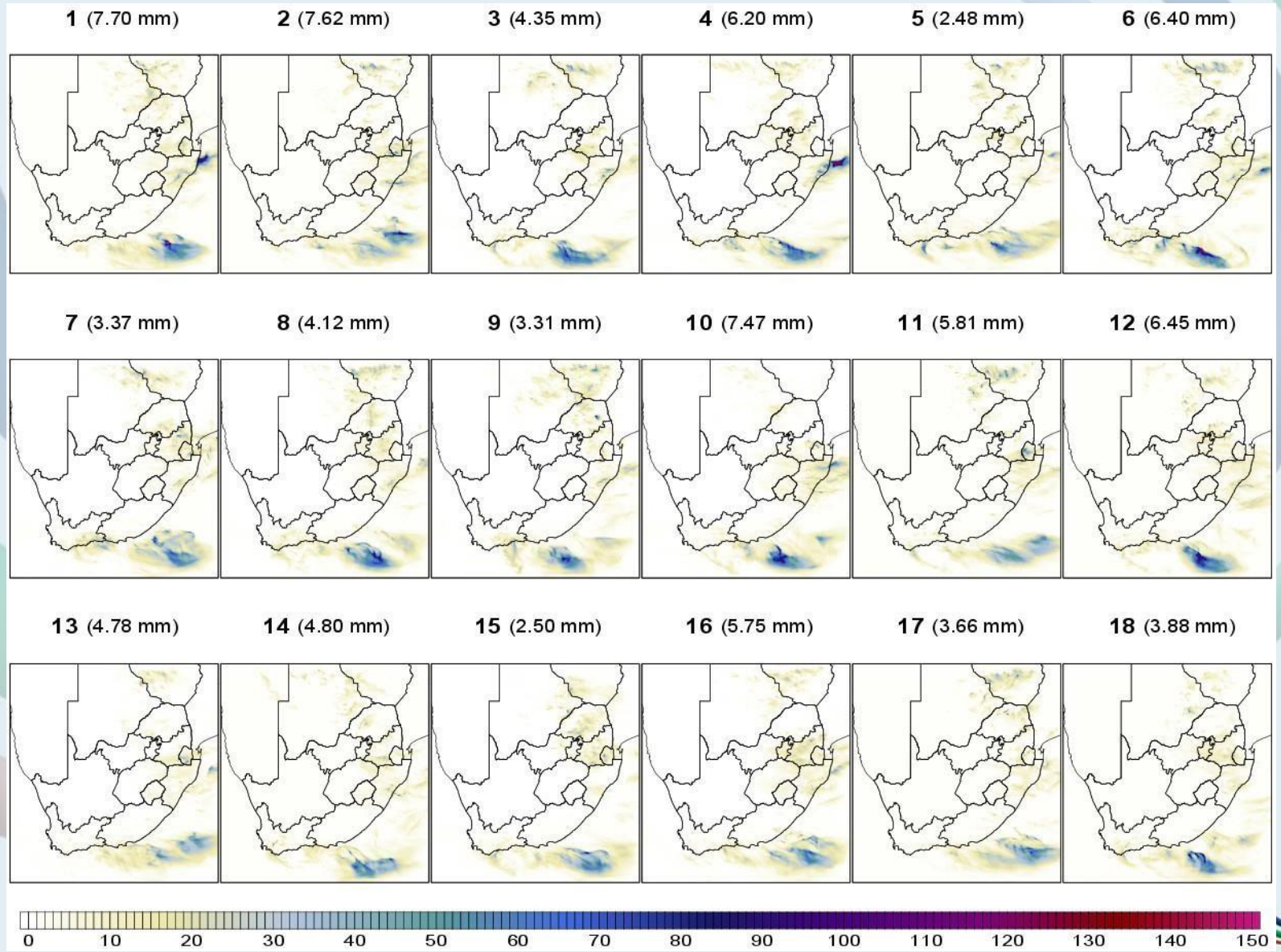
Postage stamps

Postage stamps from Convection Permitting Ensemble Prediction system. CSEPS derived from MOGREPS UK.

- ❖Unified Model Convective Scale Ensemble Prediction System
- ❖4.5 km Horizontal Resolution (SA4)
- ❖18 member Ensemble Products
- ❖18 UTC run
- ❖Lead time = 48hr



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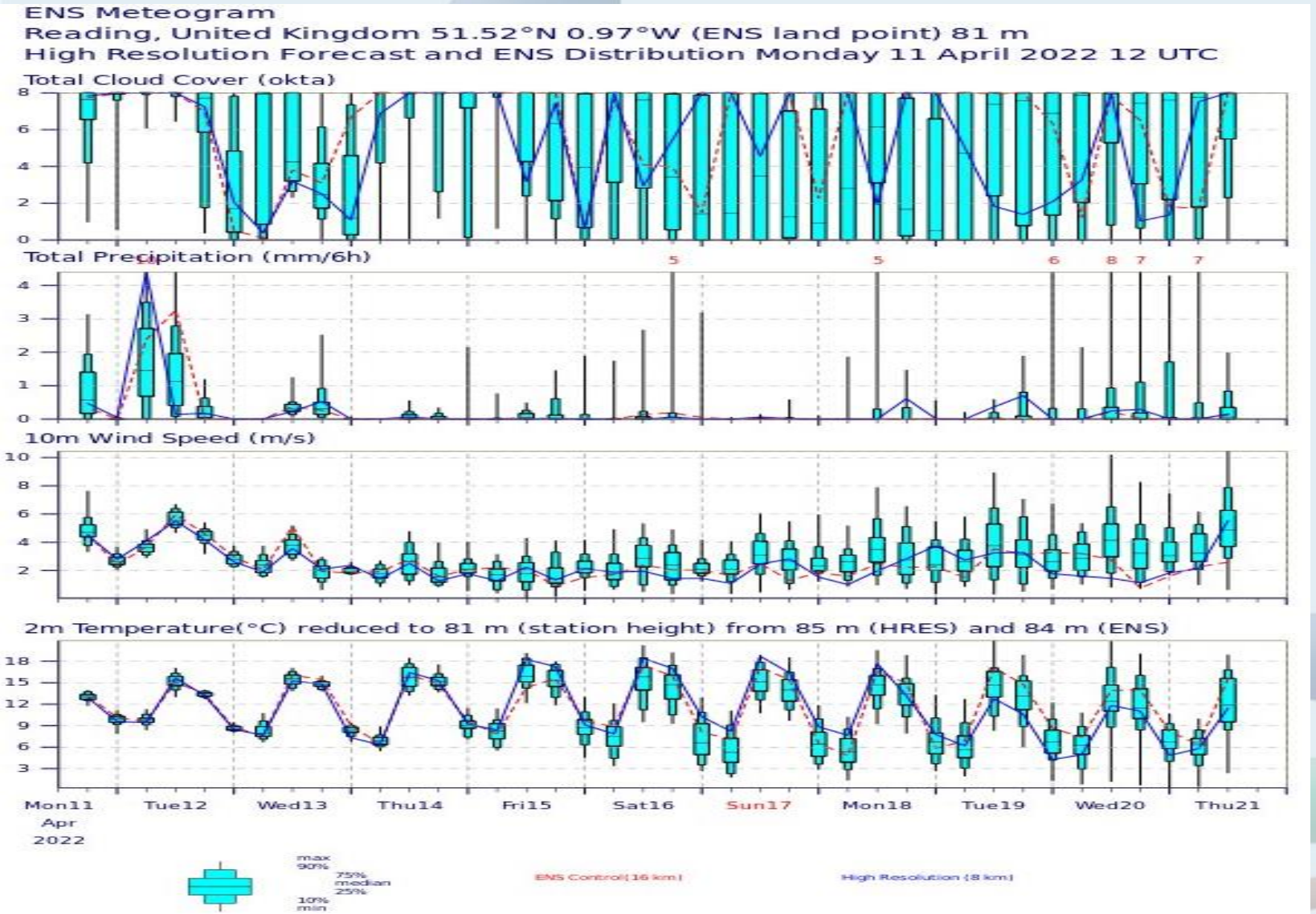
Site-specific meteograms or EPSgrams



Example of meteograms

https://www.cpc.ncep.noaa.gov/products/international/gfs_meteograms/00/00_gfs_meteogram.shtml

EPSgram provides a probabilistic interpretation of the ENS for specific locations. It displays the time evolution of the distribution of several meteorological parameters from the ensemble at each forecast range by a box and whisker plot.

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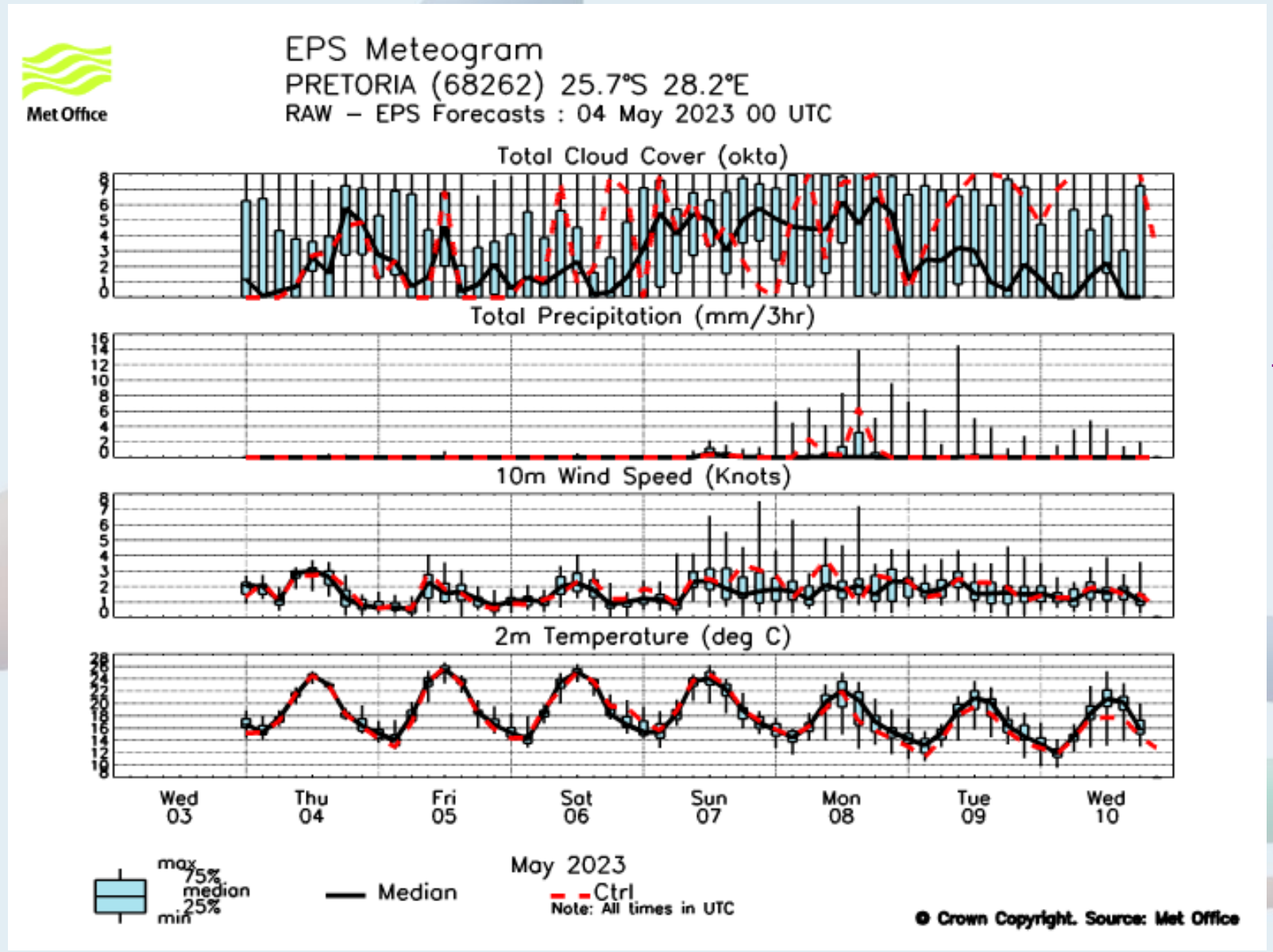
Site-specific meteograms or EPSgrams



http://rsmc.weathersa.co.za/

Based on MOGREPS - UK

For different SADC countries

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Probabilities

The most consistent way to convey forecast uncertainty information is by the probability of the occurrence of an event. The event can be general or user specific representing the exceedance of a threshold. The event threshold often corresponds to the point at which the user has to take some action to mitigate for the potential damage of a significant weather event.

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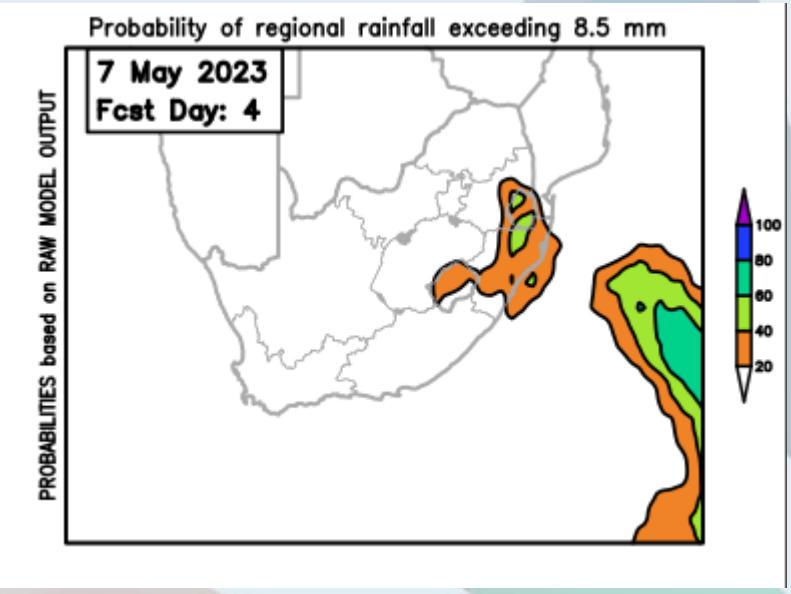
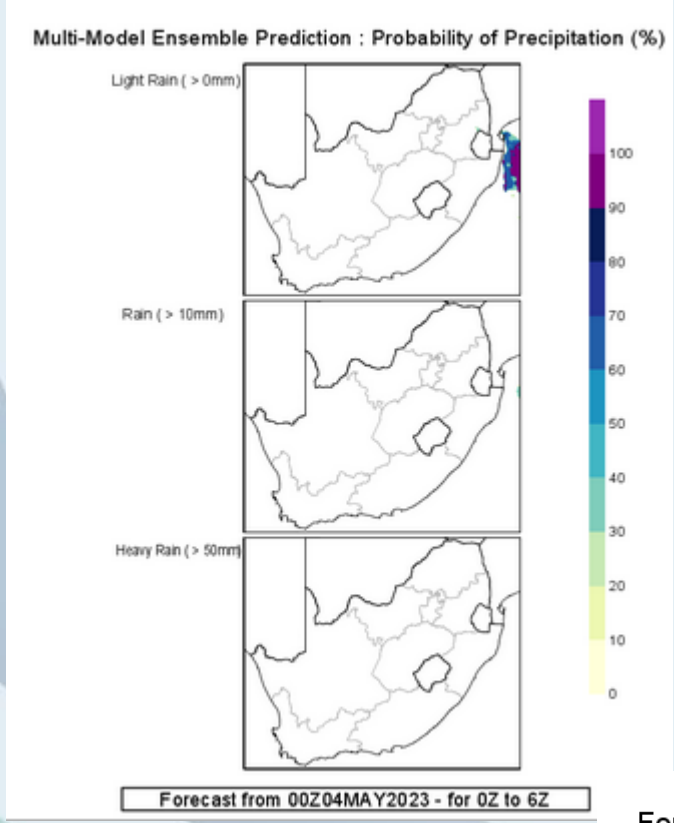
Probability maps

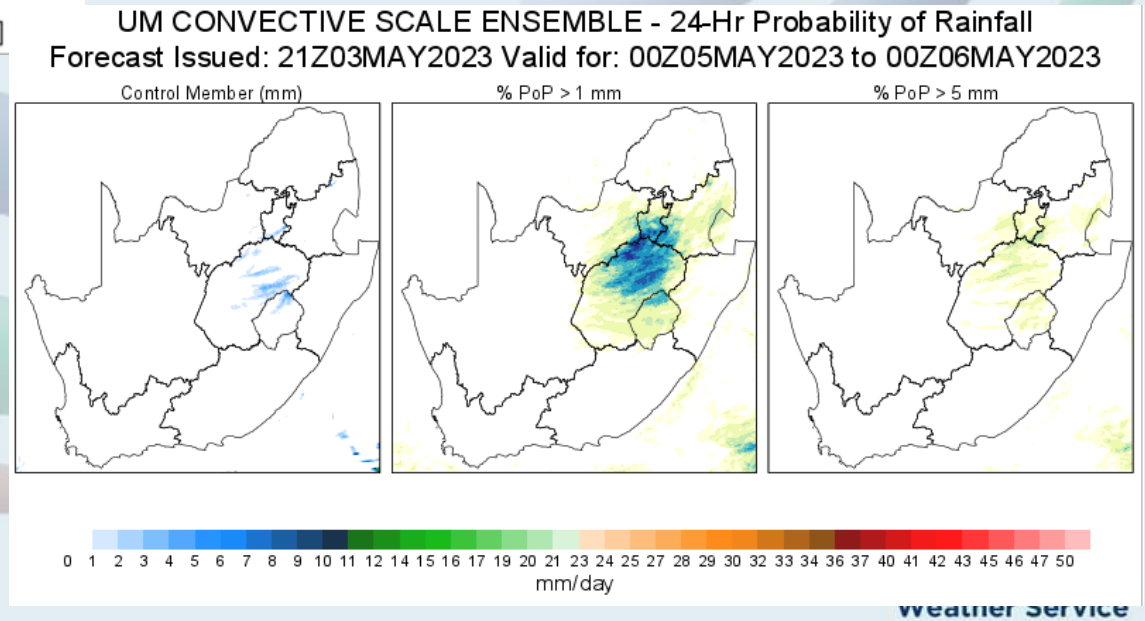


From a GEPS i.e NCEP GFS

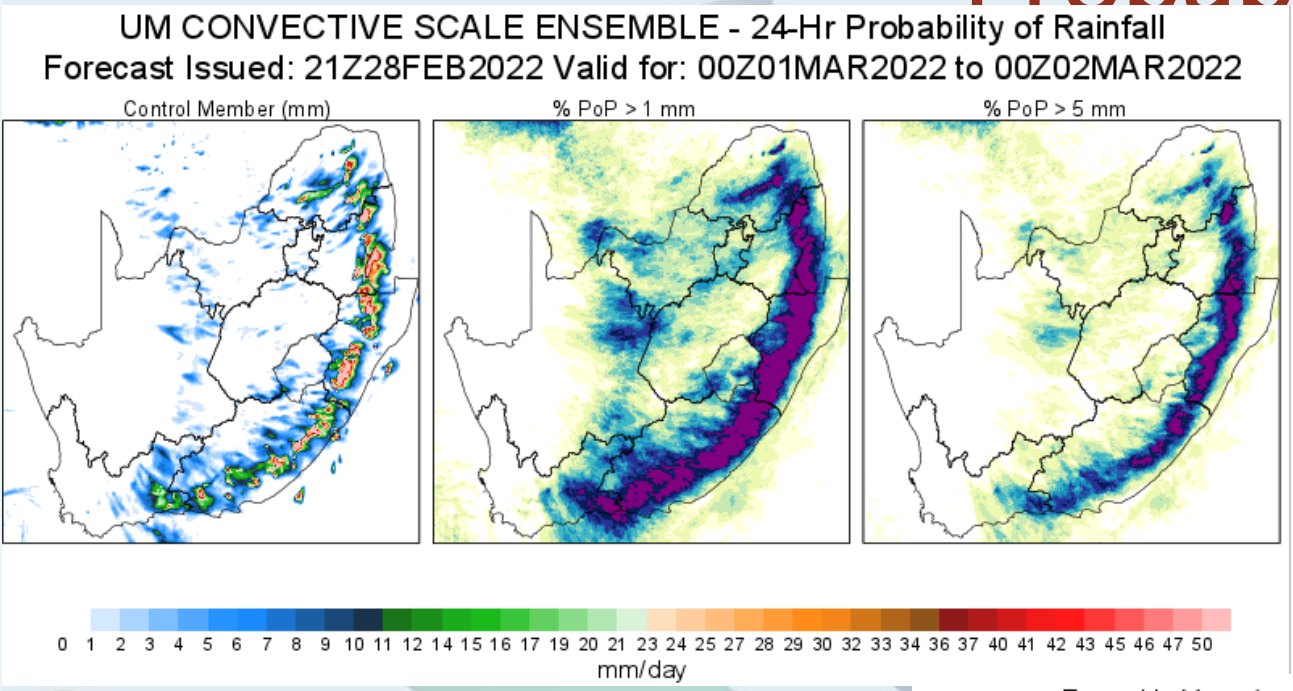


From a Multi-model Ensemble Prediction System

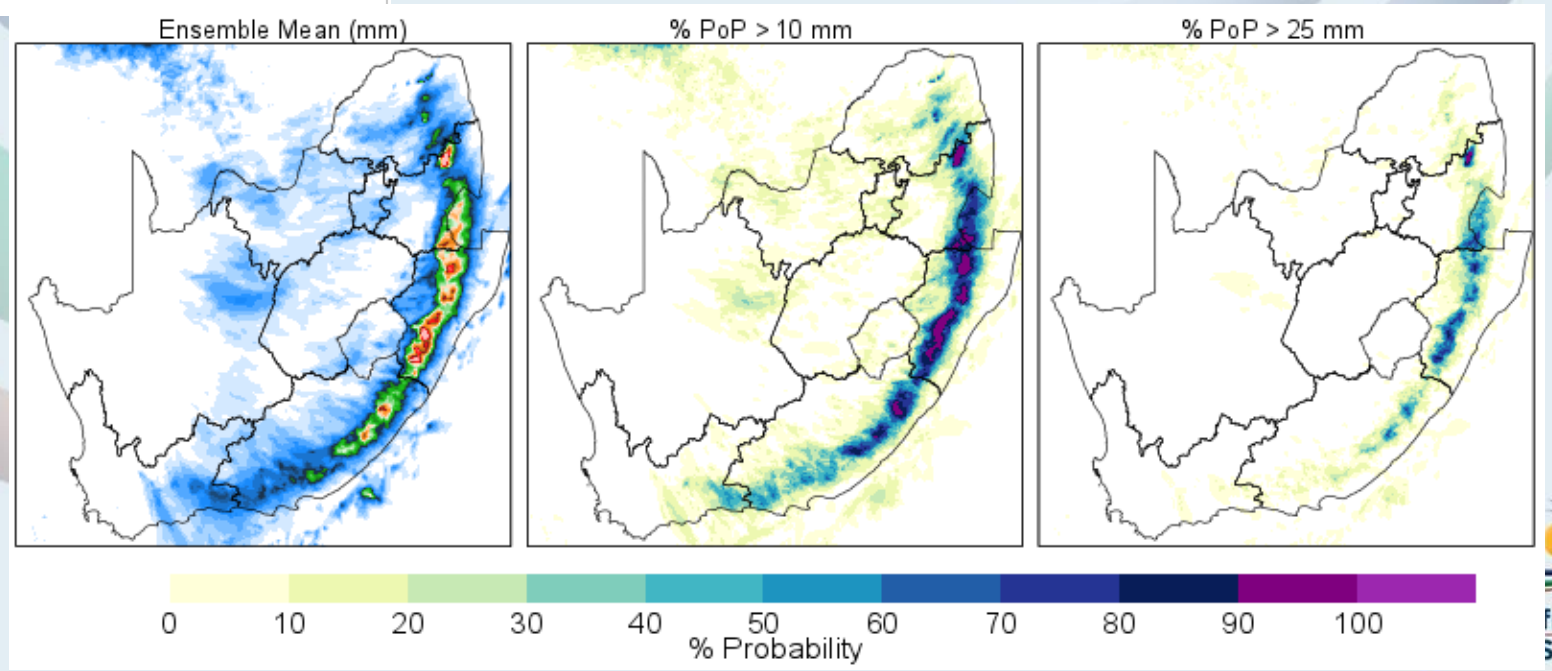
From a Convection Scale Ensemble Prediction System



Probability maps SAWS Example



http://cyclone-web.saws.co.za/CSEPS_products.shtml



Sites for EPS products/Training

More information

http://www.wpc.ncep.noaa.gov/ensembletraining/

Ensemble-based warning for severe weather event

ECMWF JMA NCEP UKMO

http://gpvjma.ccs.hpcc.jp/TIGGE/tigge_warning.html

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