

Reliability of seasonal-to-decadal forecasts from a seamless prediction perspective

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with thanks to Tim Palmer

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- Due to inevitable uncertainties in the forecast model formulations and in the initial and boundary conditions, **seasonal-to-decadal forecasts have to be probabilistic forecasts.**
- For seasonal-to-decadal forecasts to be useful in real-life decision making, **they must be reliable.**

The trivial forecast of climatology is a reliable forecast.

Unreliable forecasts can be dangerously misleading and should not be used for decision making.

Probabilistic forecasting for decision making

Agronomist to advice farmers on the type of crop to plant in the coming season or decade

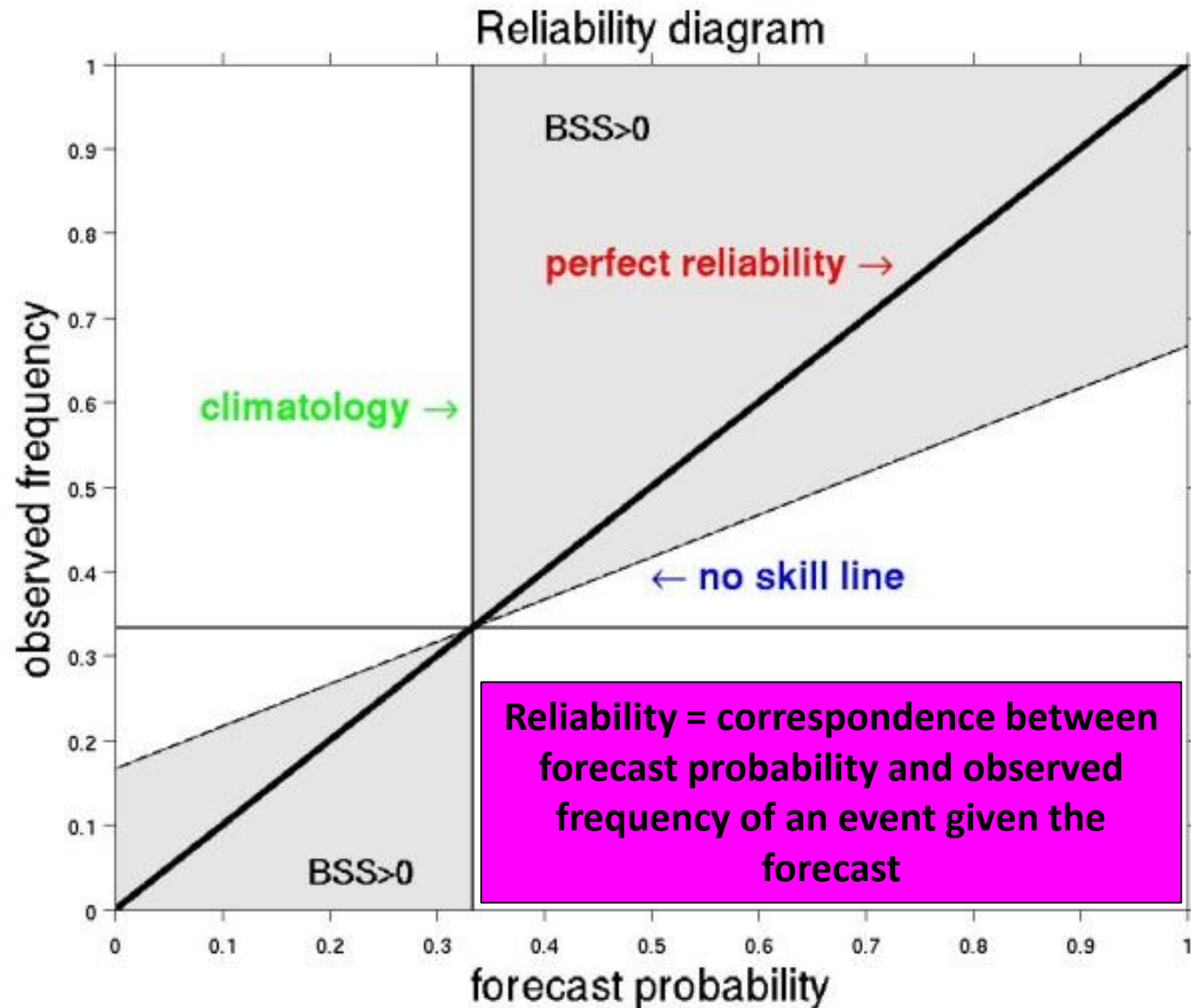
- crop yield $C = C(X)$ with X ... meteorological variables
- seasonal forecast probability distribution $\rho(X)$
- climatological distribution $\rho_c(X)$
- expected crop yield: $\langle C \rangle = \int C(X) \rho(X) dX$
- climatological crop yield expectation: $\langle C \rangle_c = \int C(X) \rho_c(X) dX$
- if $\rho(X) \approx \rho_c(X) \rightarrow$ climatological (reliable) information
- if $\rho(X) \neq \rho_c(X) \rightarrow$ differences in expected crop yield \rightarrow decisions

It is essential that $\rho(X)$ must be reliable

otherwise the advice can be misleading the users

- Due to inevitable uncertainties in the forecast model formulations and in the initial and boundary conditions, **seasonal-to-decadal forecasts have to be probabilistic forecasts.**
- For seasonal-to-decadal forecasts to be useful in real-life decision making, **they must be reliable.**
- **How can we say when a (probabilistic) forecast is reliable?**
- **How reliable are our seasonal and decadal forecasts?**

Suppose an event E has a forecast probability of 70%. The forecasting system is said to be *reliable* if the observed frequency of E is, within its uncertainty ranges, also 70%.



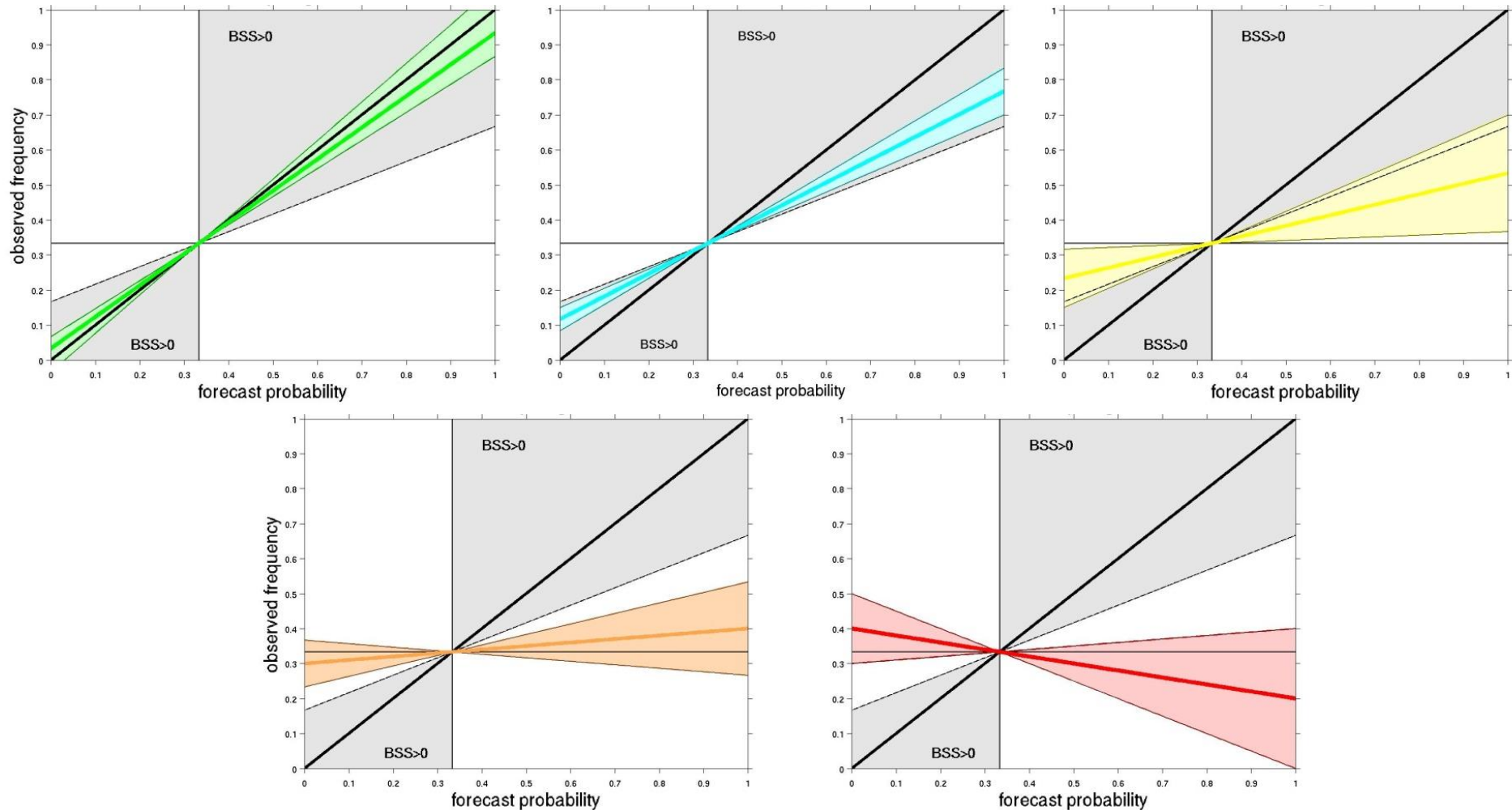
On a scale of 1 – 5, where 5 is very good, how reliable are our seasonal forecasts today?

What does a “5” mean for probabilistic forecasts?

How close are we to achieving a “5”?

**→ Use reliability of non-climatological forecasts
as a measure**

Five categories of reliability



perfect

still useful

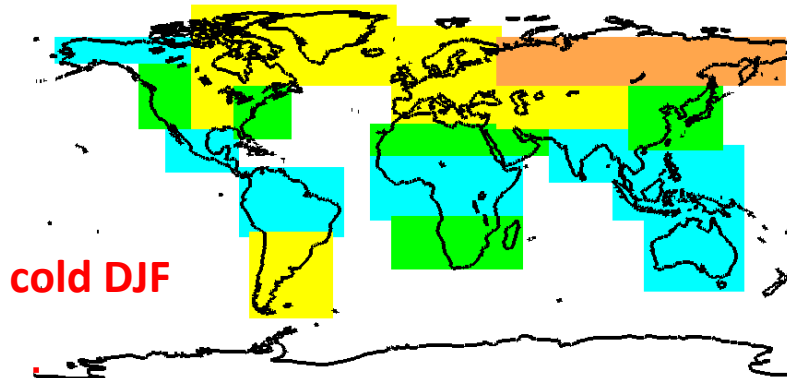
marginally useful

not useful

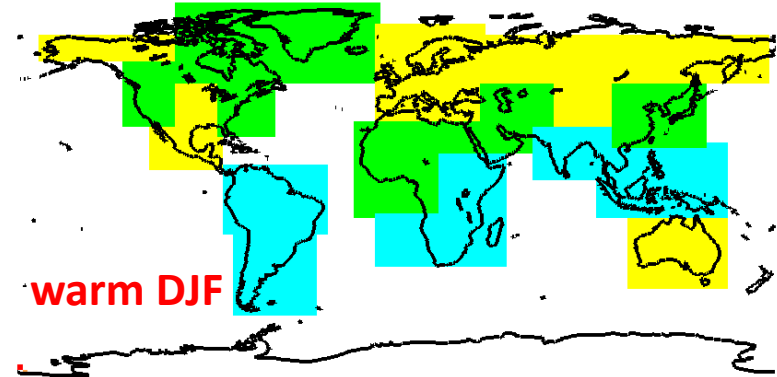
dangerous

Reliability categories for predicting 2m temperature in ECMWF's seasonal forecasting System 4

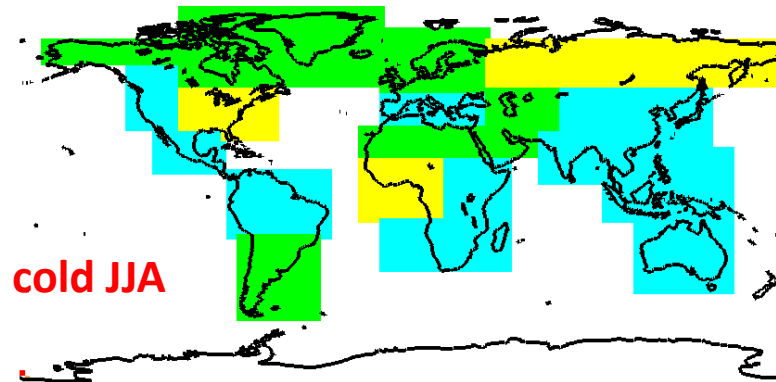
S4 DJF 2to4 1981-2010 167 lower terciles



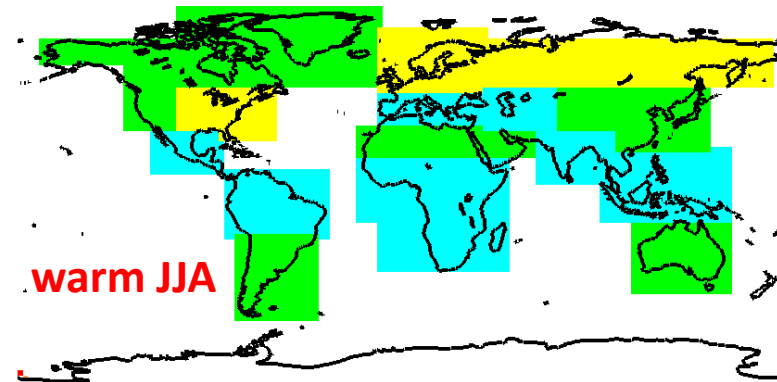
S4 DJF 2to4 1981-2010 167 upper terciles



S4 JJA 2to4 1981-2010 167 lower terciles



S4 JJA 2to4 1981-2010 167 upper terciles



perfect



still useful



marginally useful



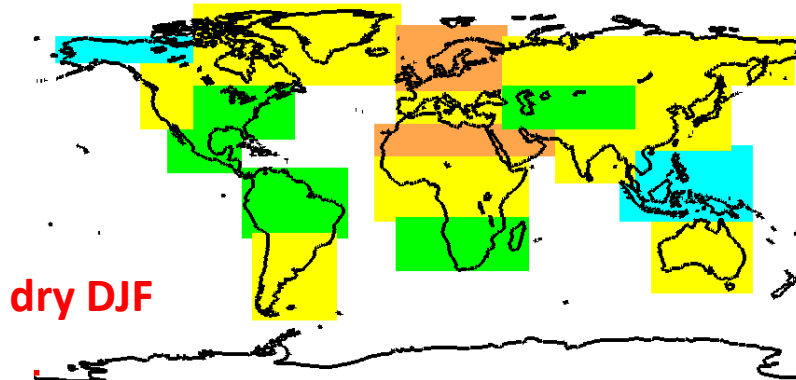
not useful



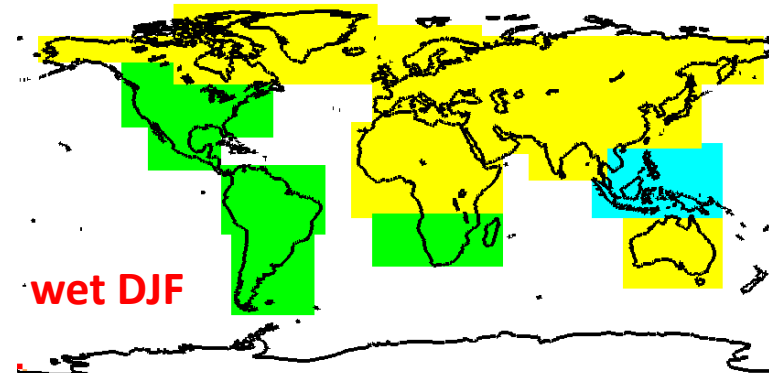
dangerous

Reliability categories for predicting **precipitation** in ECMWF's seasonal forecasting System 4

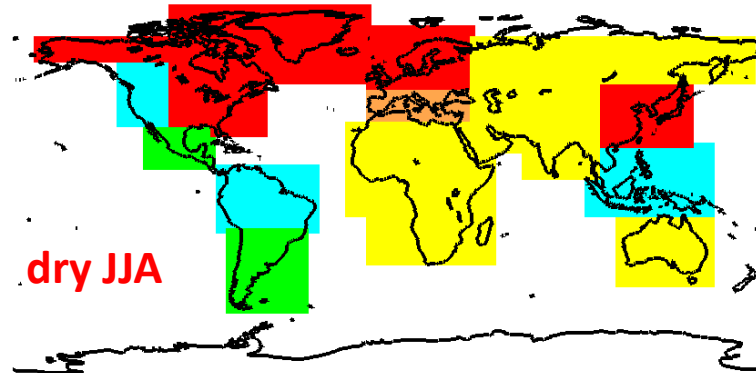
S4 DJF 2to4 1981-2009 228 lower terciles



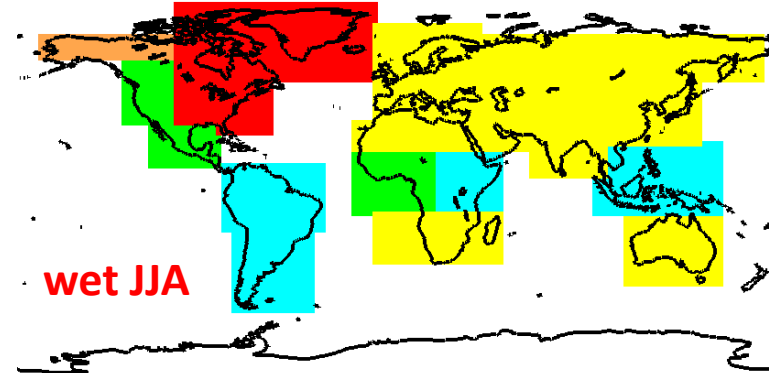
S4 DJF 2to4 1981-2009 228 upper terciles



S4 JJA 2to4 1981-2010 228 lower terciles



S4 JJA 2to4 1981-2010 228 upper terciles



perfect



still useful



marginally useful



not useful



dangerous

How reliable are our decadal forecasts?

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Reliability of decadal predictions

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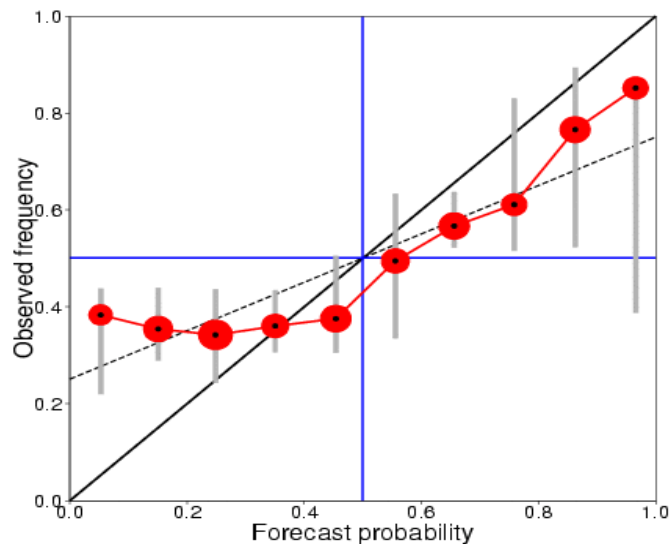
[1] The reliability of multi-year predictions of climate is assessed using probabilistic Attributes Diagrams for near-surface air temperature and sea surface temperature, based on 54 member ensembles of initialised decadal hindcasts using the ECMWF coupled model. It is shown that the reliability from the ensemble system is good over global land areas, Europe and Africa and for the North Atlantic, Indian Ocean and, to a lesser extent, North Pacific basins for lead times up to 10 years.

[4] The word “reliable” has a specific technical meaning in probability forecasting, a meaning that can allow potential users to assess whether decadal forecasts might have value. Suppose a decadal forecast probability of some event E – say that that temperature lies above the long-term climatological median value – is equal to 0.7. For a reliable forecast system, one could assert that E would actually occur on 70% of occasions where E was forecast with a probability of 0.7.

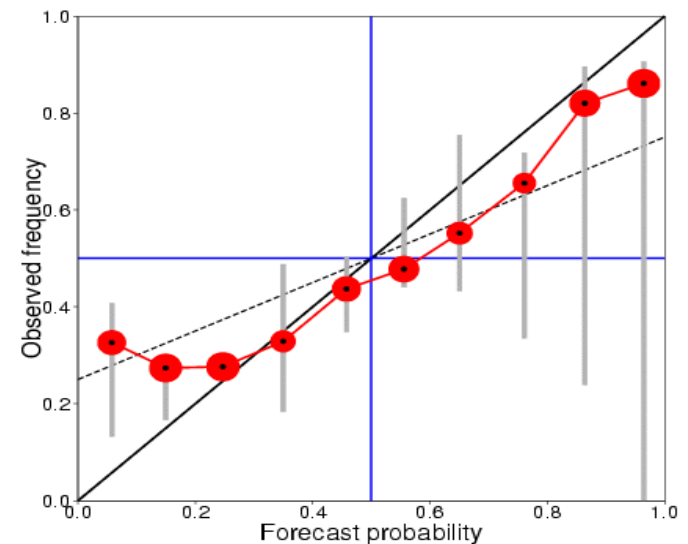
see also Susanna Corti's poster

Reliability diagrams

2m temperature above the median for global land points



2-5 years

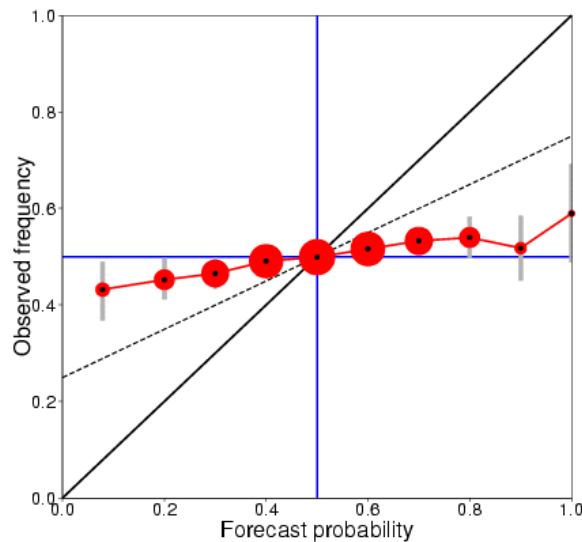


6-9 years

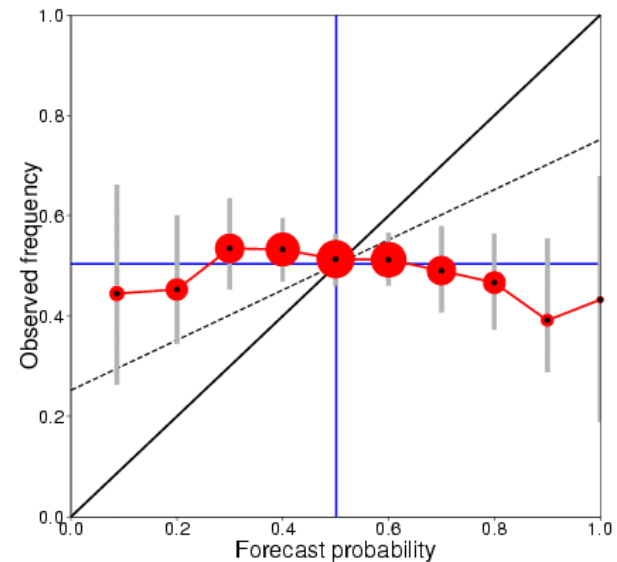
Corti et al., GRL 2012

Reliability diagrams

precipitation above the median for 2-5 years



global land points



Europe land points

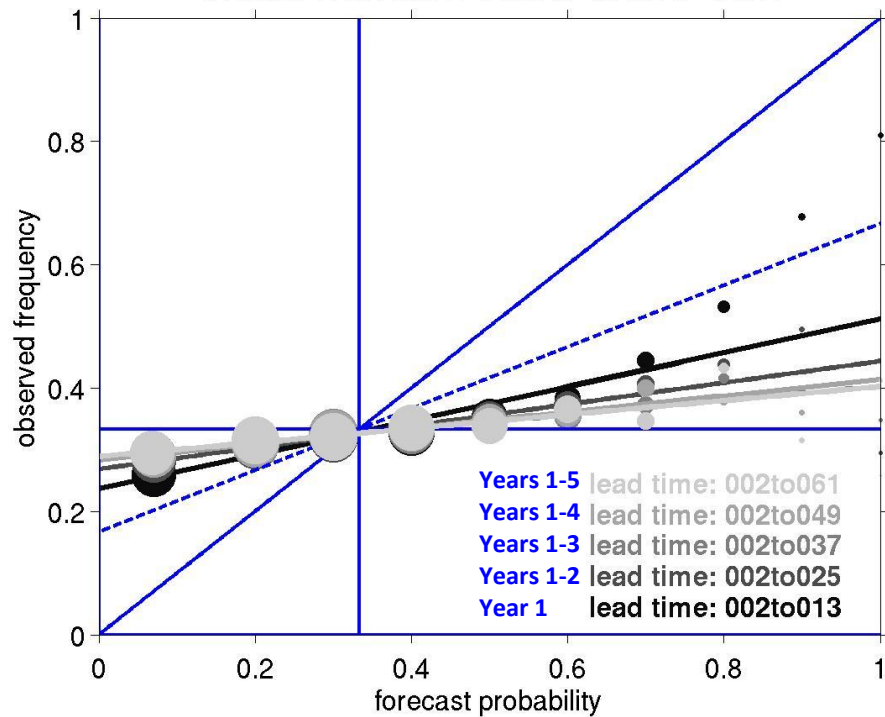
Corti et al., GRL 2012

Seamless reliability analysis from seasonal to decadal time scales

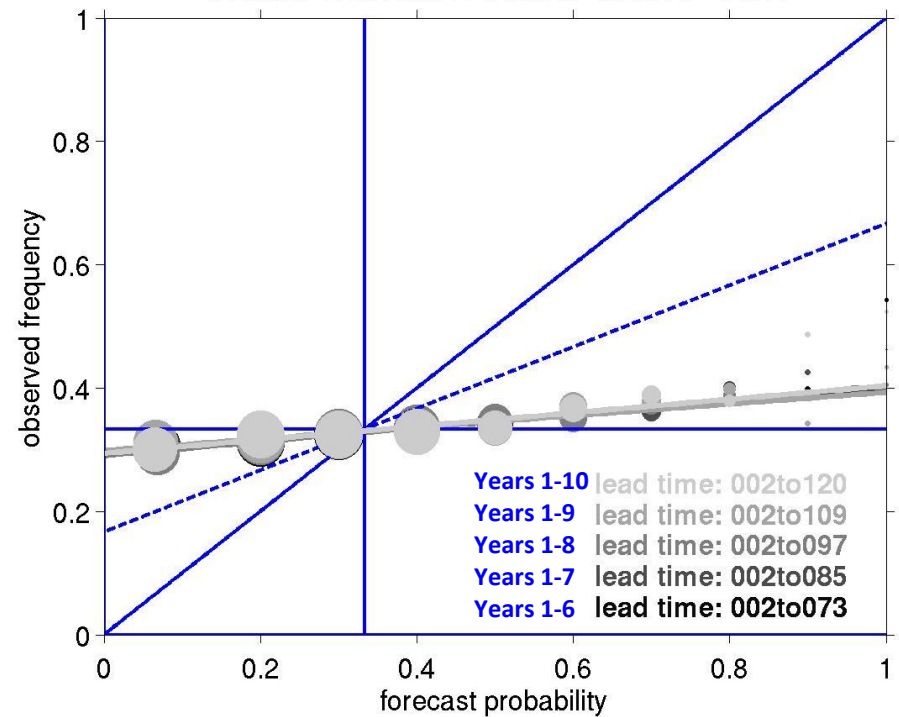
- better estimates of reliability on seasonal time scales
- for decadal forecasts that are not dominated by external forcings, can the reliability information from seasonal time scales provide useful information on the reliability on decadal time scales?
 - Sensitivity of reliability to forecast lead time and forecast averaging time

Decadal reliability diagrams for S4 precipitation below the lower tercile for global land points

decadal 1980-2000 228 lower terciles GLOL



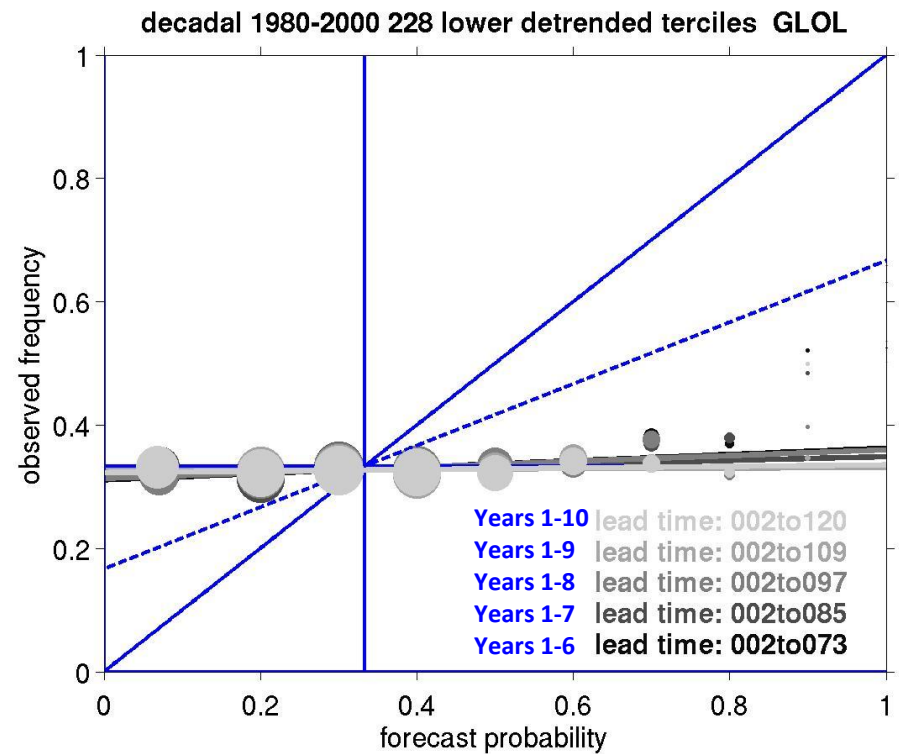
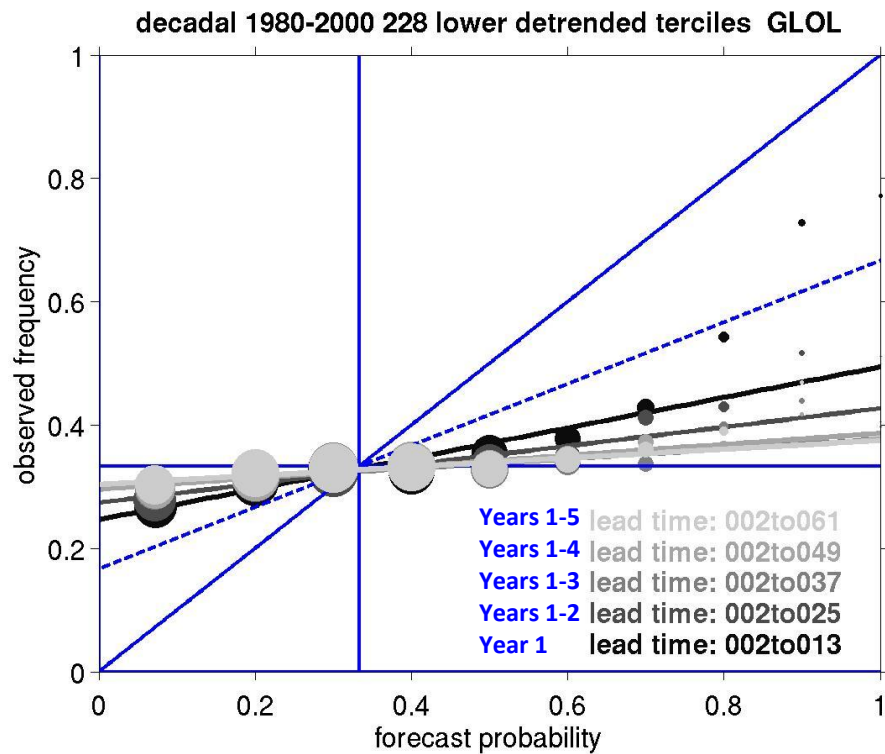
decadal 1980-2000 228 lower terciles GLOL



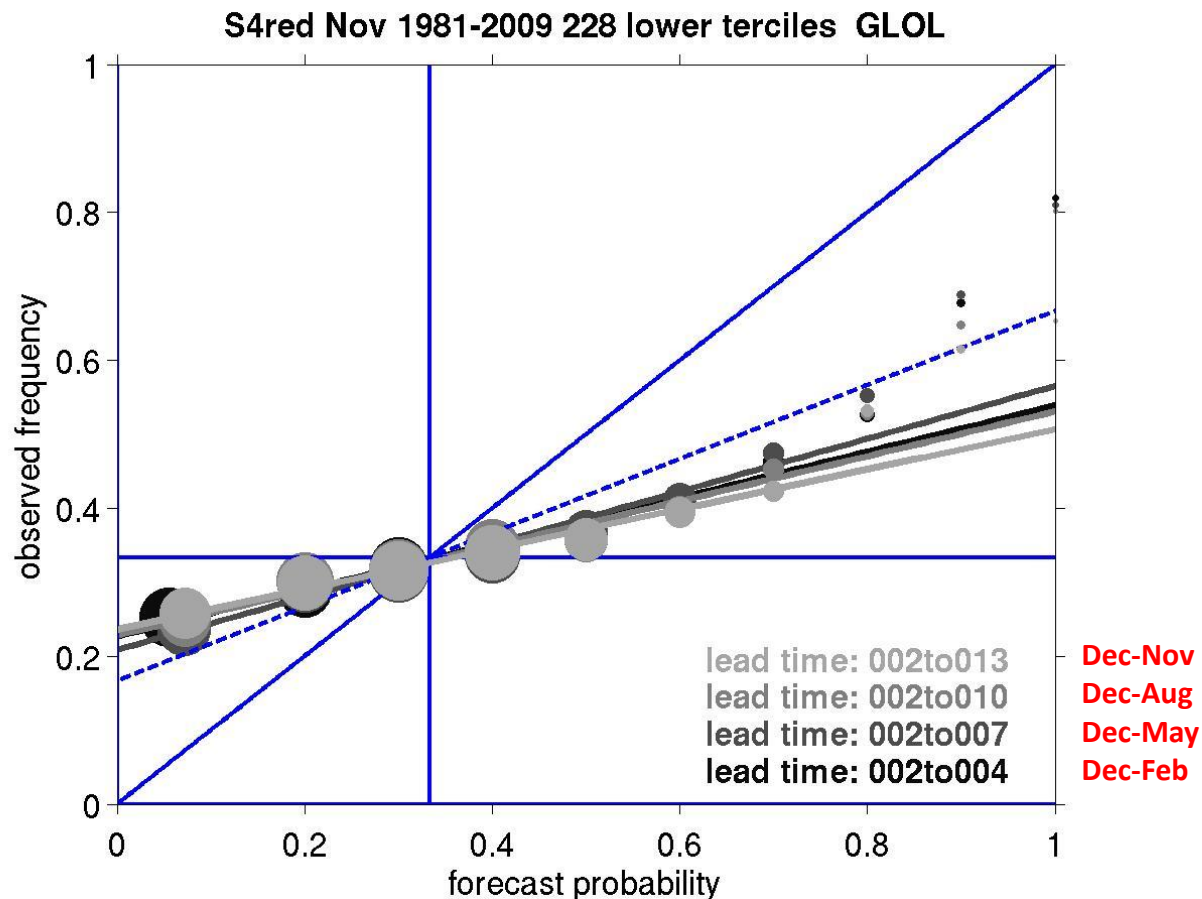
Decadal reliability diagrams for S4

2m temperature below the lower tercile for global land points

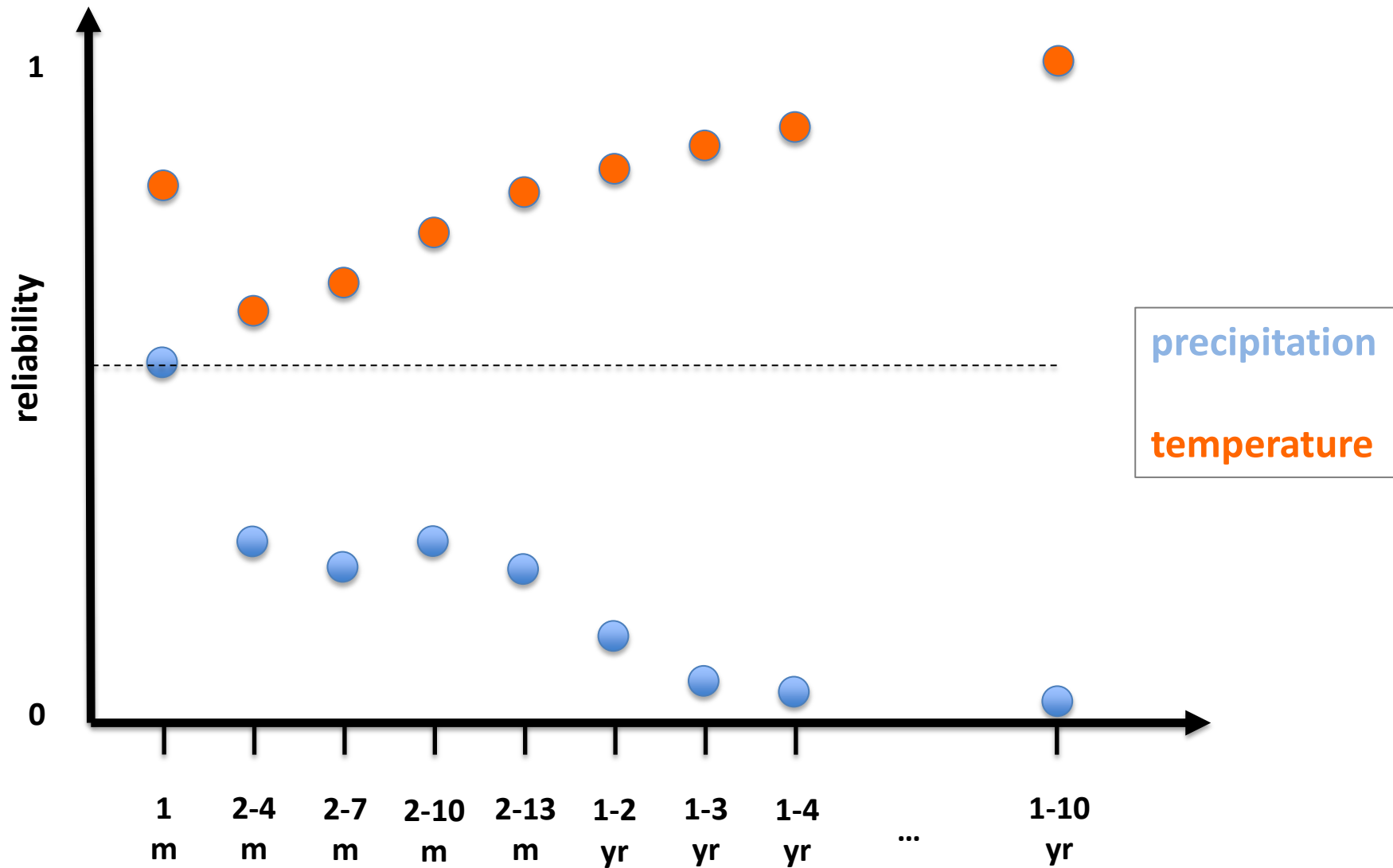
- detrended -



Seasonal-to-Annual reliability diagrams for S4 precipitation below the lower tercile for global land points



Reliability versus forecast averaging time



Conclusions

- For seasonal-to-decadal forecasts to be useful in real-life decision making, they should be probabilistic and reliable.
- Seasonal forecast reliability for temperature from the ECMWF System 4 is good for most regions and seasons studied.
- Seasonal forecast reliability for precipitation is much poorer than temperature with little useful information in many parts of the world.
- “Seamless” prediction: Calibrating the decadal forecasts using reliability information from seasonal forecasts would make decadal forecasts reliable. In the extreme of no seasonal reliability, this would mean issuing a climatological decadal forecast (reliable and not misleading).

→ Need to improve (the reliability of) weather and climate models



Over **Europe** the prediction skill decreases when the climate trend is filtered out, but **reliability is preserved**.

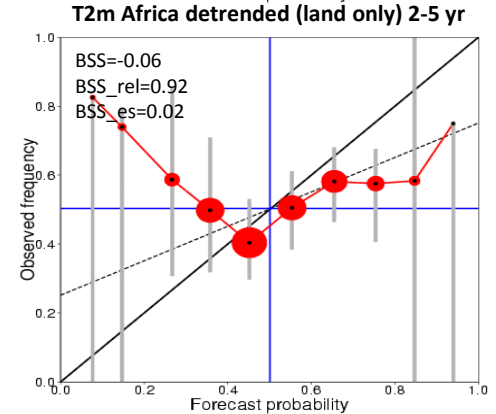
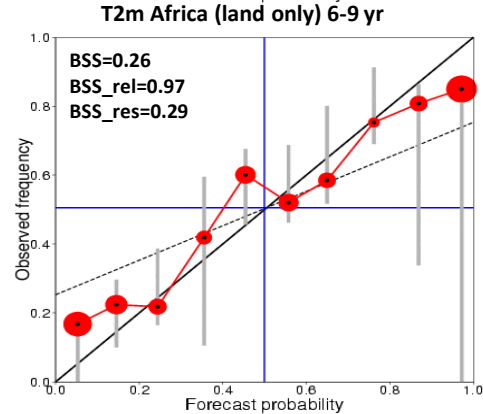
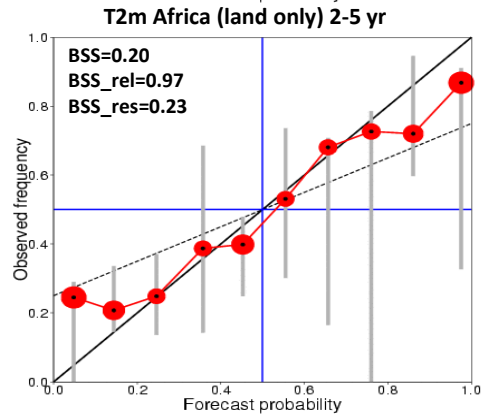
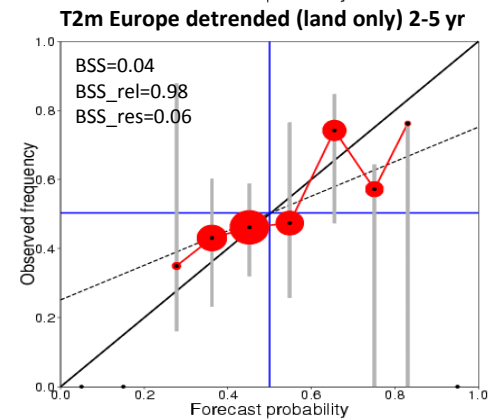
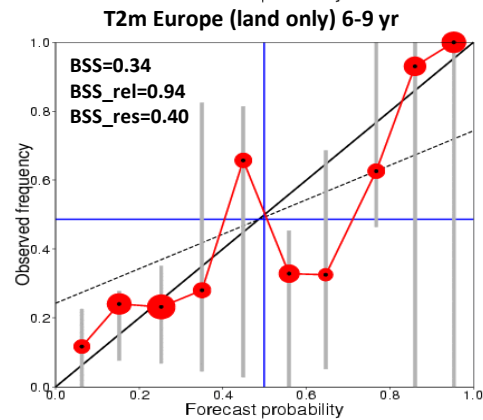
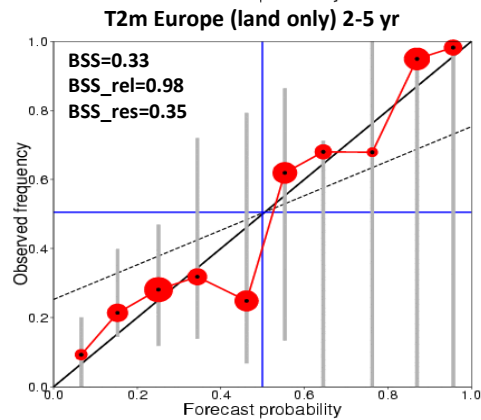
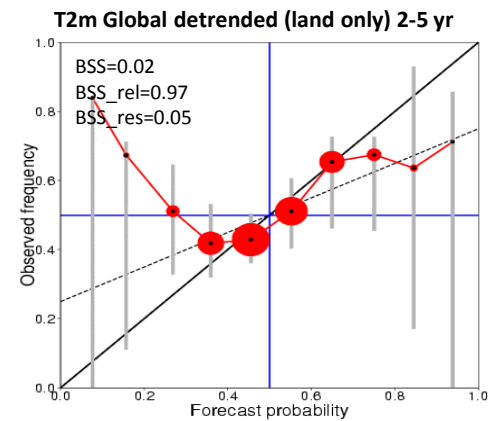
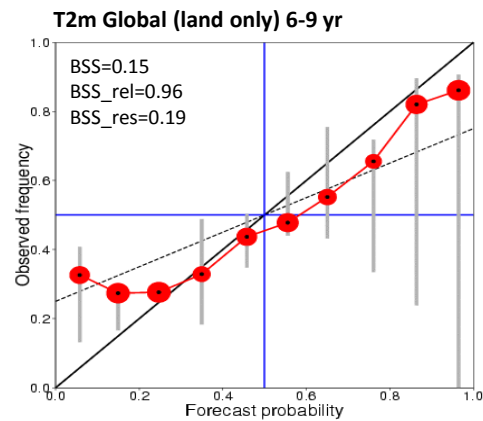
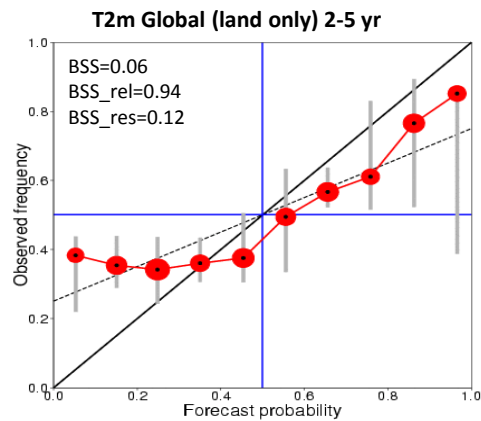
Over the **North Atlantic** the **hindcasts are both sharp and reliable**, even after detrending, confirming the importance of initialisation in that region.

In the **Indian Ocean**, the region where the ratio of internally-generated to the externally-forced variability is the lowest, **predictions are reliable only for the trend component**.

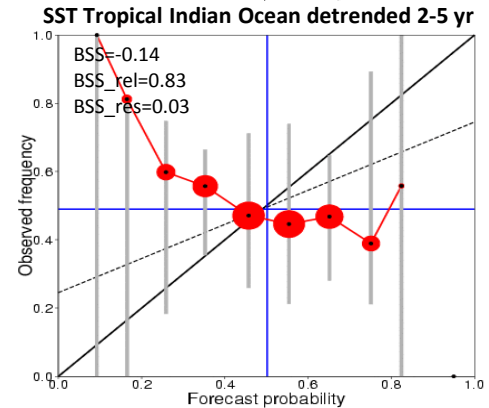
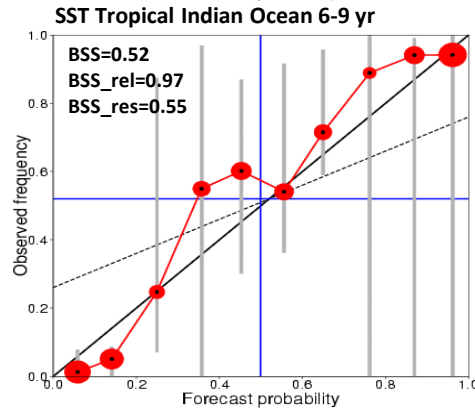
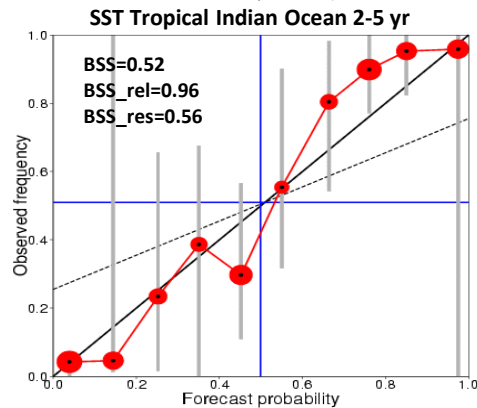
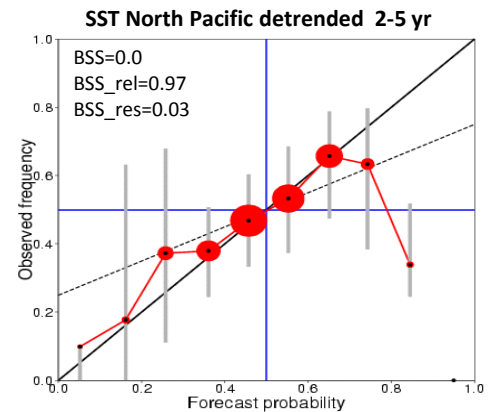
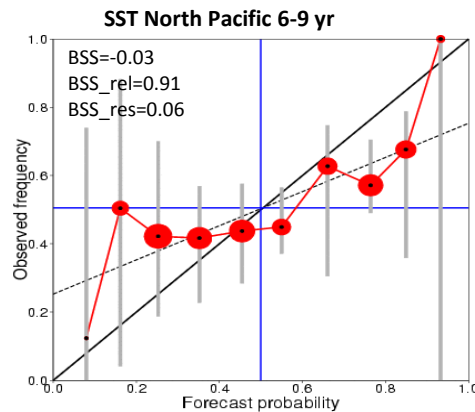
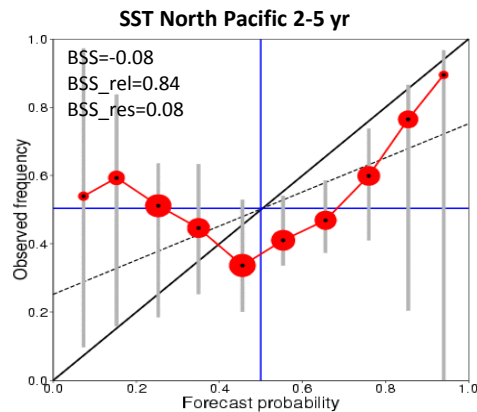
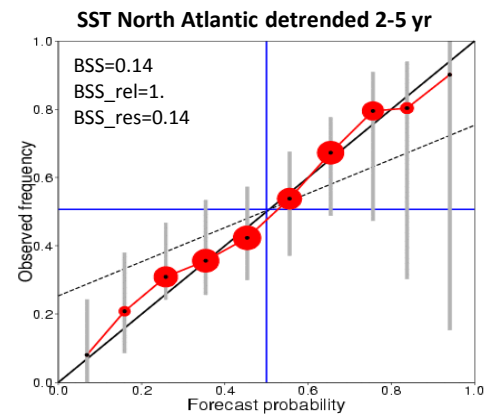
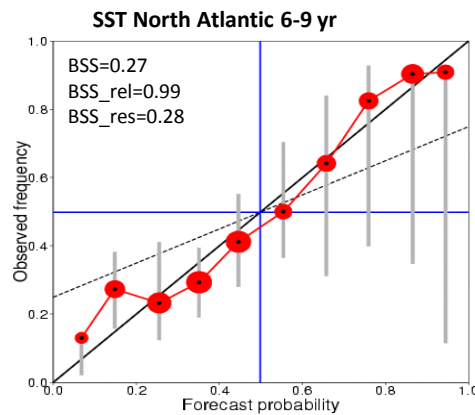
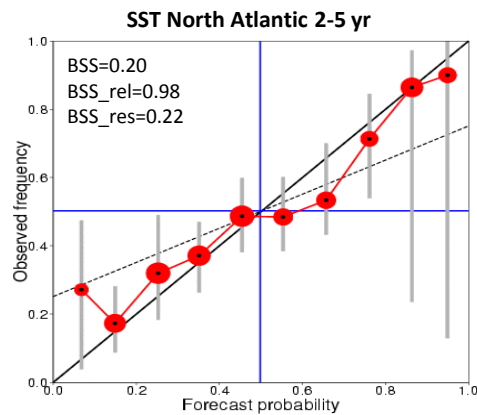
Decadal predictions are less reliable (and skilful) over the North Pacific where very strong natural variations are observed.

The results have to be tempered by the fact that the sample size is small and hence error bars in the Reliability Diagrams are relatively large.

It should be stressed that **these results are for sea surface and near-surface temperature only**. It is not expected (and preliminary results seem to confirm) that decadal precipitation forecasts will be reliable in the same way as temperature is.



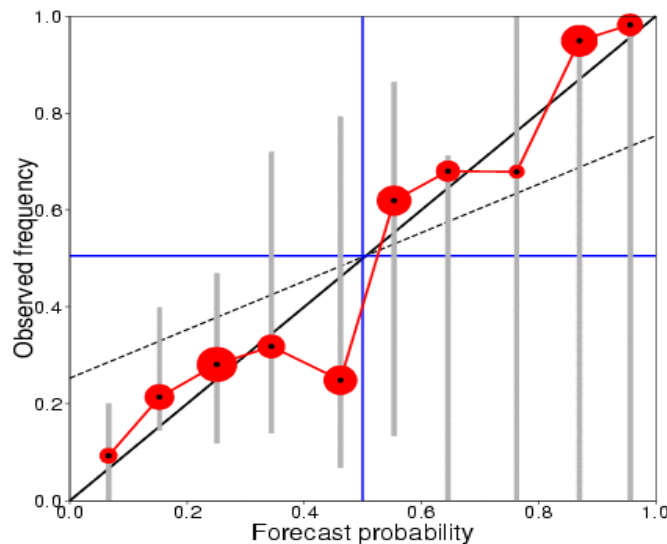
Reliability diagrams for temperature being above the median over land



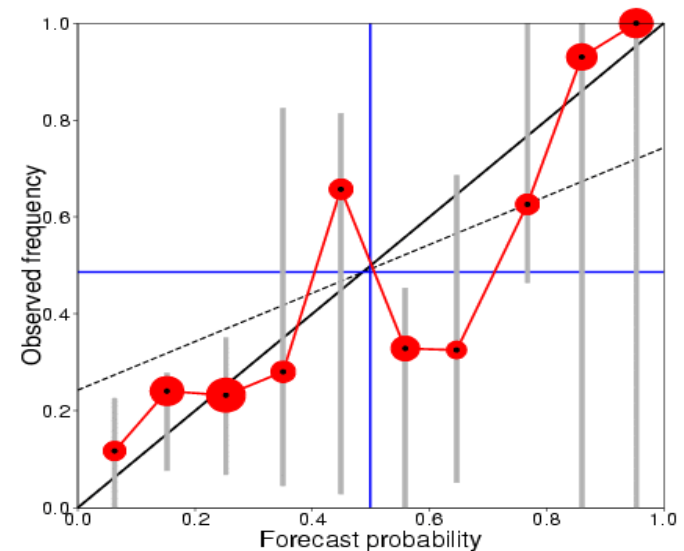
Reliability diagrams for SST being above the median

Reliability diagrams

2m temperature above the median for Europe (land points)



2-5 years

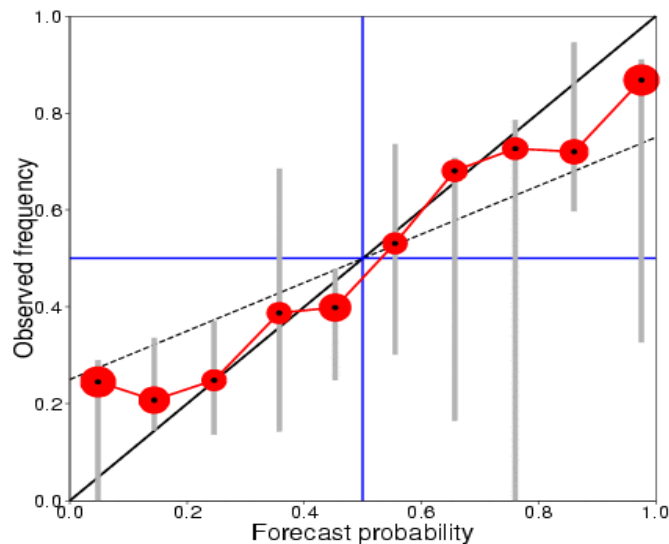


6-9 years

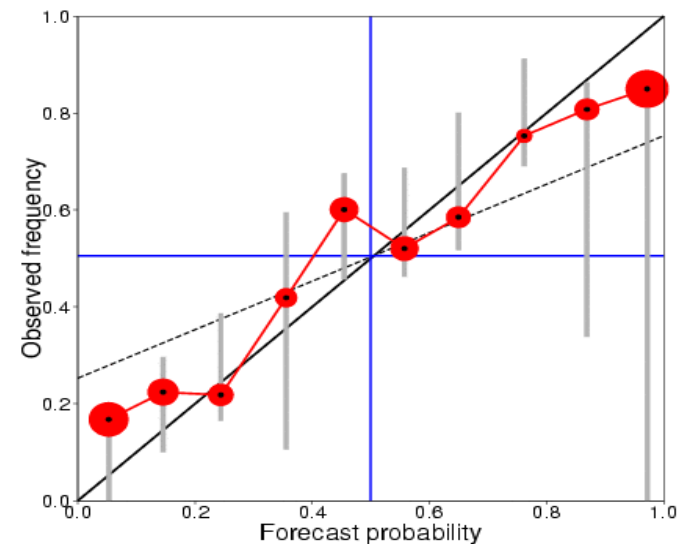
(Corti et al., GRL 2012)

Reliability diagrams

2m temperature above the median for Africa (land points)



2-5 years



6-9 years

(Corti et al., GRL 2012)

