Monitoring and seasonal forecasting of meteorological droughts

E. Dutra[1], W. Pozzi[2],F. Wetterhall[1], F. Di Giuseppe[1], G. Naumann[3], P. Barbosa[3], J. Vogt[3], L. Magnusson[1], F. Pappenberger[1].

(1) ECMWF, Reading, United Kingdom
(2) Group on Earth Observations, Geneva, Switzerland
(3) Joint Research Centre, Institute for Environment and Sustainability, Ispra, Italy

emanuel.dutra@ecmwf.int

ECMWF

© ECMWF , EGU 2015, HS4.4

CC BY

Outline

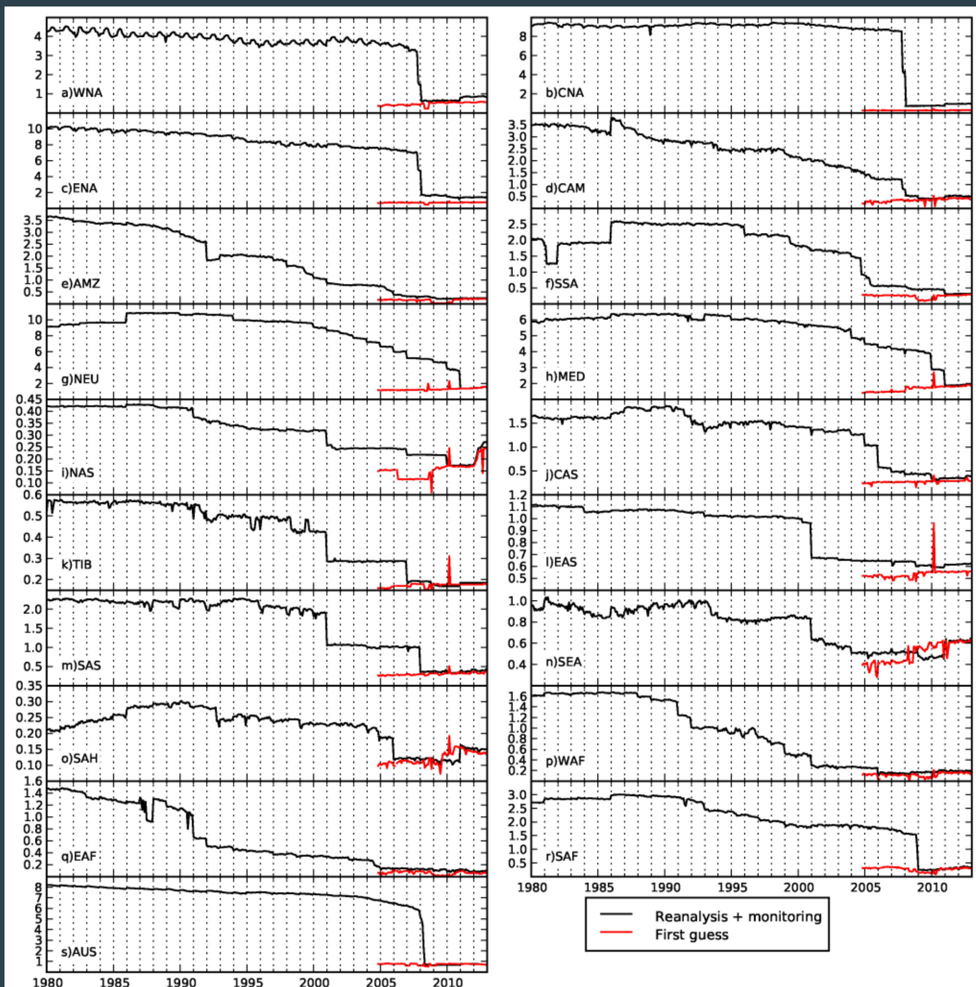
- Probabilistic monitoring:
  - **Observations uncertainty;**
  - **Construction of probabilistic SPI monitoring;**
  - **Comparison with other products.**

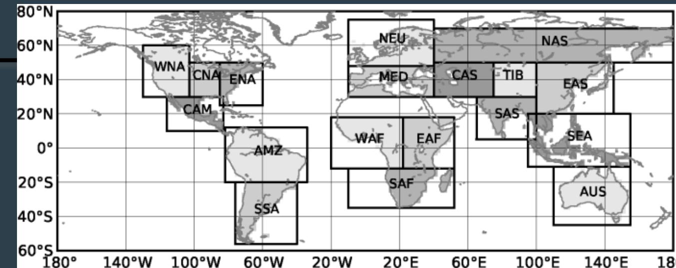
- Seasonal forecasting:
  - **Merging of monitoring and seasonal forecasts of precipitation;**
  - **Evaluation of the forecasts;**
  - **Dynamical versus climatological forecasts;**
  - **Drought Onset .**

- **Final Remarks**

Probabilistic monitoring of SPI

Why probabilistic monitoring ?





Regions definition from:
Giorgi and Francisco, Climate Dynamics 16, 2-3, 169-182, 2000

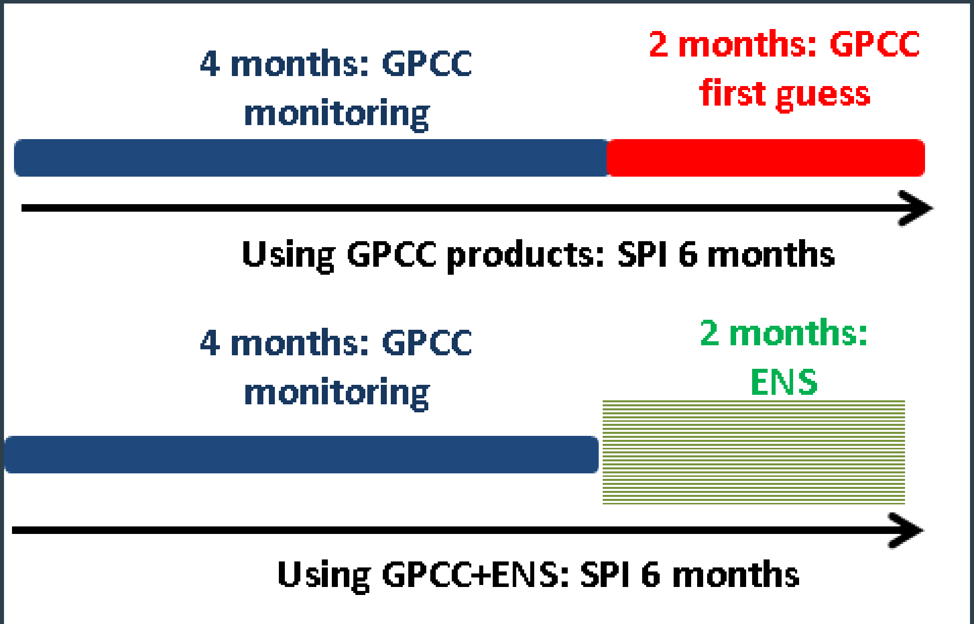
Average number of rain-gauges in 1x1 grid-box in GPCC
Reanalysis v6 (Doi:10.5676/DWD_GPCC/FD_M_V6_100)
First guess (Doi: 10.5676/DWD_GPCC/FG_M_100)

Large reduction of stations reporting in near real time in the last decade.
-> Uncertainty in near-real time precipitation observations

This will affect the SPI monitoring.

Could we use the ECMWF ENS short-range forecasts to generate probabilistic monthly means of precipitation anomalies ?

Probabilistic monitoring of SPI



ENS short-range forecasts (0-48h) with 51 ensemble members.
Average all the forecasts of a particular month to generate 51 monthly means (F)

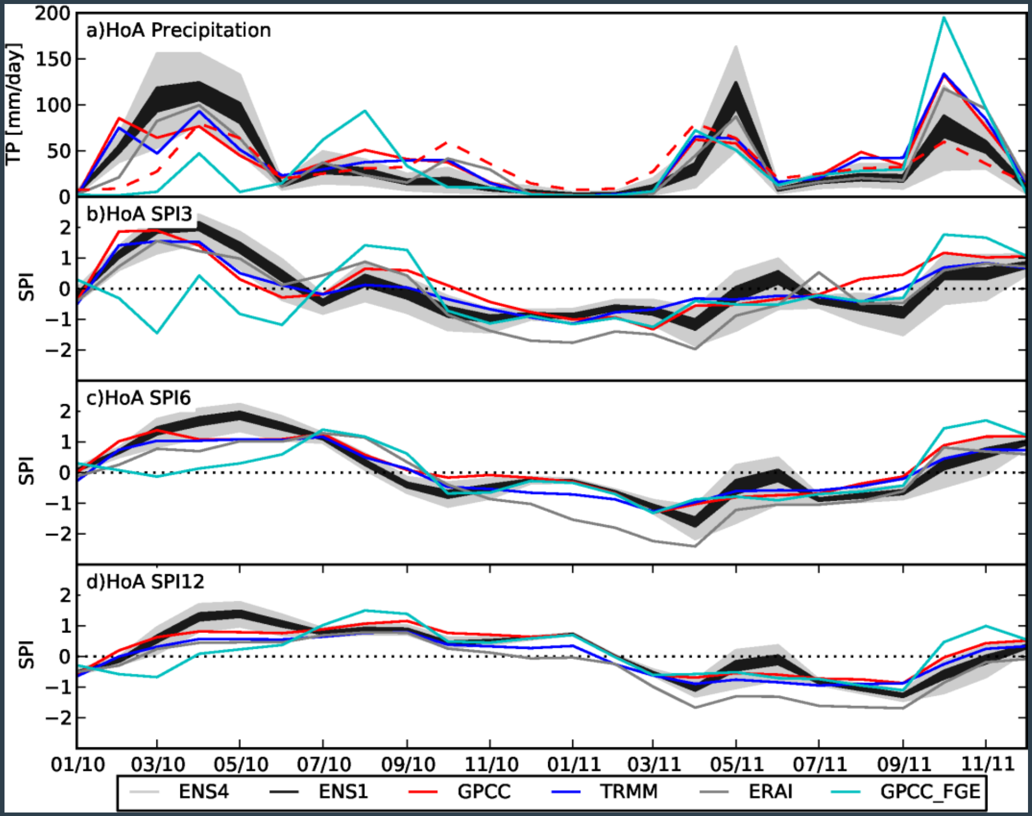
Need to define the precipitation anomaly (will be merged with GPCC data)

- Use the hindcast dataset, available since March 2008;
- For a particular month, the model climate is generated by the 18* past forecast dates +/- 2 weeks : 5 (weeks) x 18* (years) x 5 (ensemble members) : 450 samples (Fc)

Monthly mean anomalies of F'= F/FC are multiplied by the GPCC climatology.

* 20 years since July 2012

Probabilistic monitoring of SPI

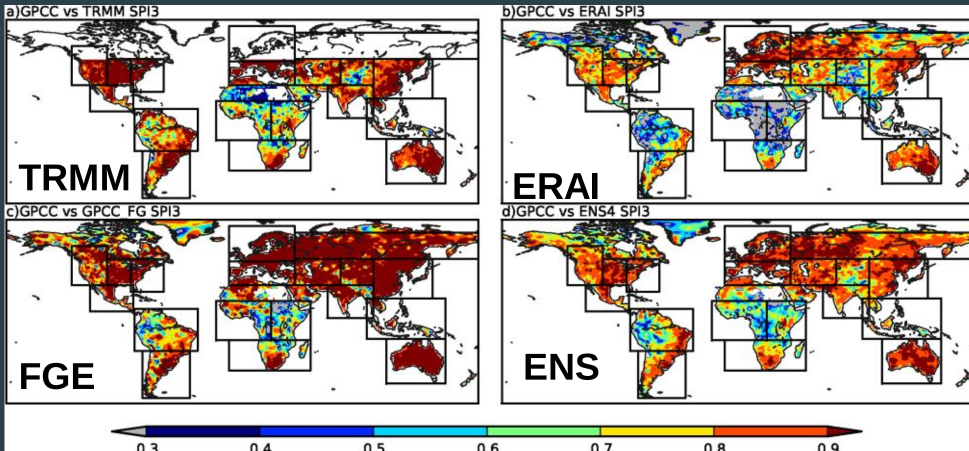


Monthly precipitation in the Horn of Africa

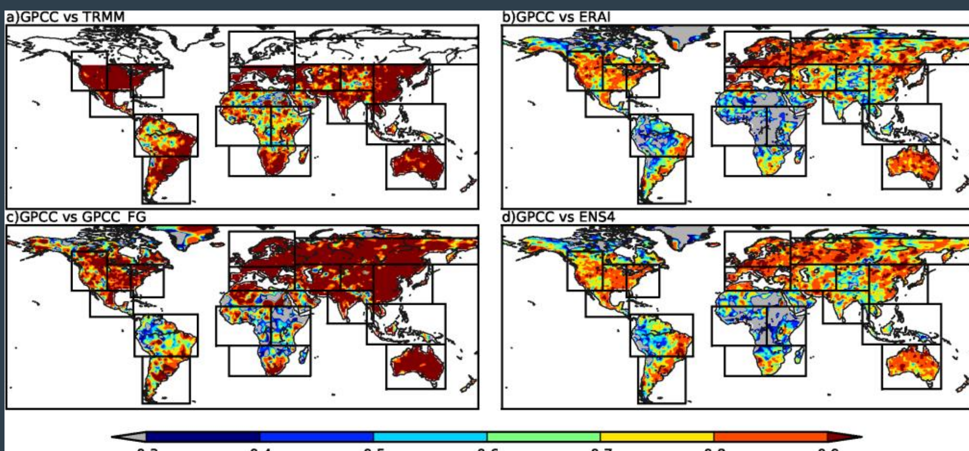
Initial results showed that monthly means of the ENS had a reduced spread (spread error relation):

- **The ENS is not designed to generate a large spread in the first forecast hours and/or to generate monthly means;**
- **If we use a longer forecast lead time (e.g. 5 days), we would increase the spread, but loose skill**
- **Increase the monthly means forecast spread:**
    - **F’ = F a + F* (1-a) ; a – inflation factor (4 was selected, ENS4), F* the forecast ensemble mean**

Probabilistic monitoring of SPI



Grid point temporal correlation (2009-2012) SPI-3 : GPCC versus :

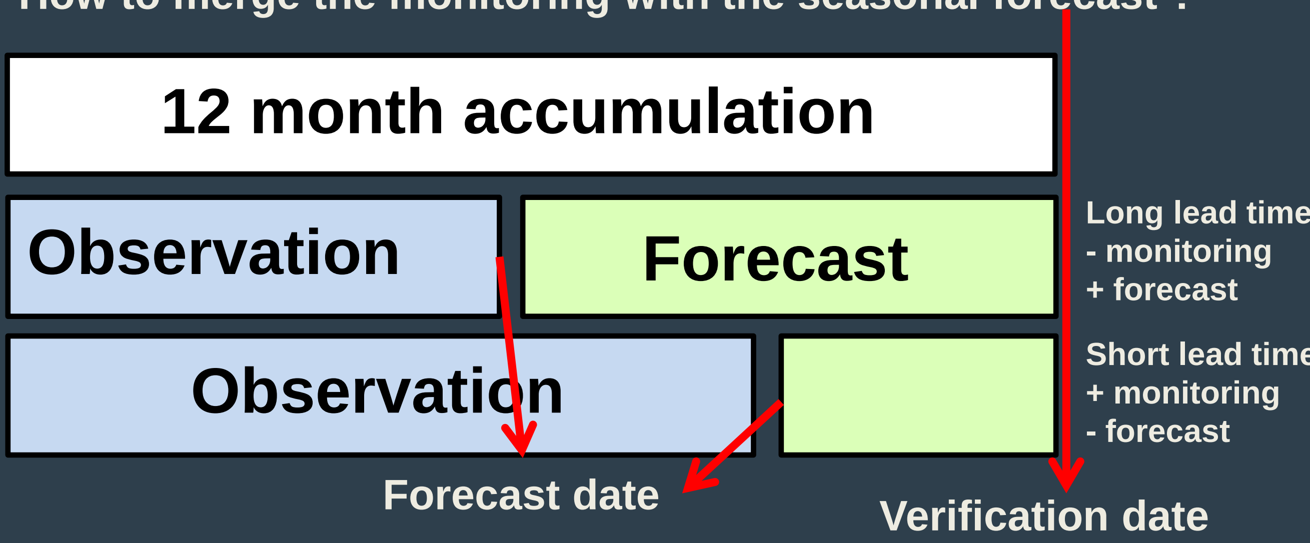


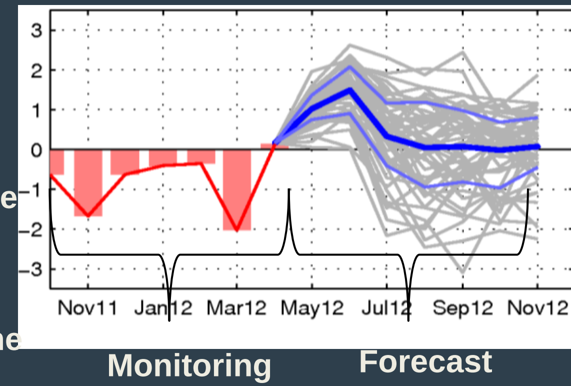
Grid point temporal correlation (2009-2012) monthly precipitation anomalies

- ENS performs better then ERAI, and comparable to TRMM and FGE in the tropical regions.
- ENS has the added value of providing a probabilistic information of the SPI: partially accounts for the near-real time uncertainty of precipitation "observations".
- Part of the "better" performance of ENS, compared with ERAI comes from the merge with GPCC (we verify against GPCC)

Seasonal forecasting of SPI: merging data

How to merge the monitoring with the seasonal forecast ?





Probabilistic forecasts

1) Bias correct seasonal forecast
2) Merge monitoring and forecasts of precipitation to create the SPI (GPCC, ERAI)

ECMWF System 4 seasonal forecasts: 6 months lead time, issued once per month

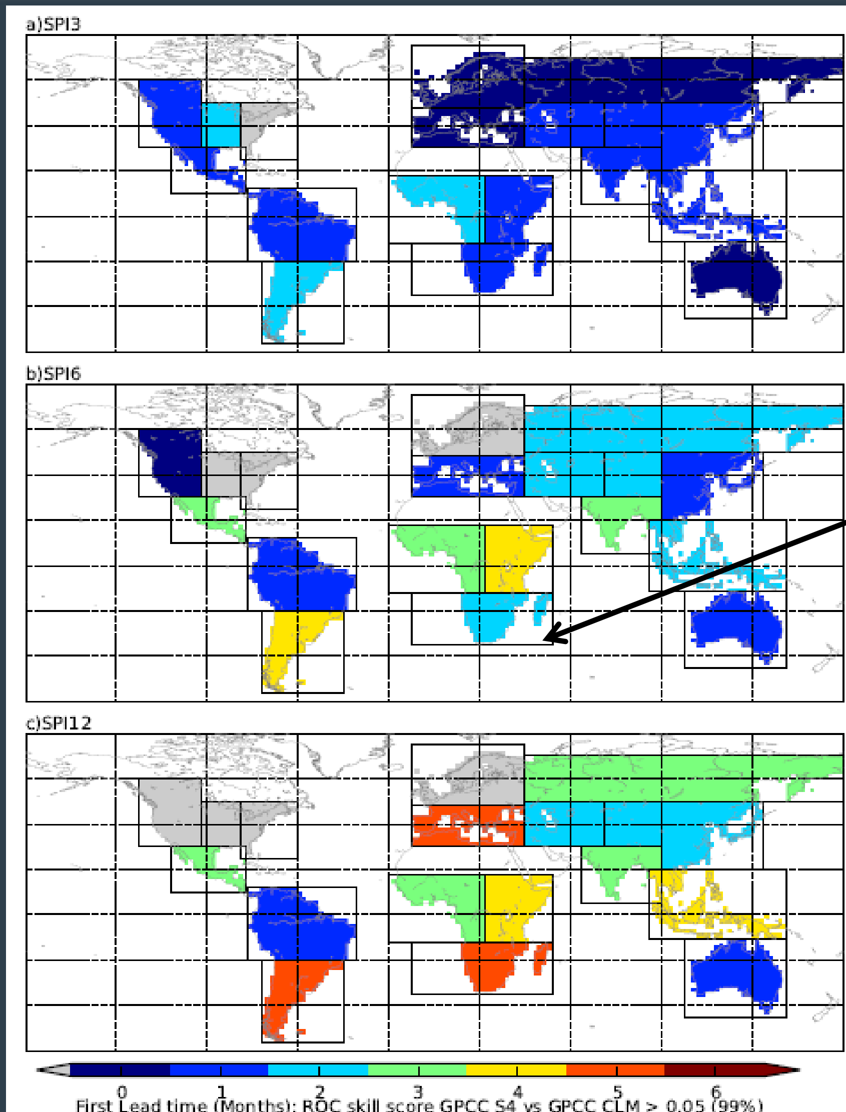
Seasonal re-forecasts of the SPI 3, 6 and 12 using four configurations:

a) GPCC monitoring and S4 forecasts (GPCC S4);
b) GPCC monitoring and climatological forecasts (GPCC CLM);
c) ERAI monitoring and S4 forecasts (ERAI S4);
d) ERAI monitoring and climatological forecasts (ERAI CLM);

Forecasts verified against GPCC: GPCC S4/CLM share part of the verification data

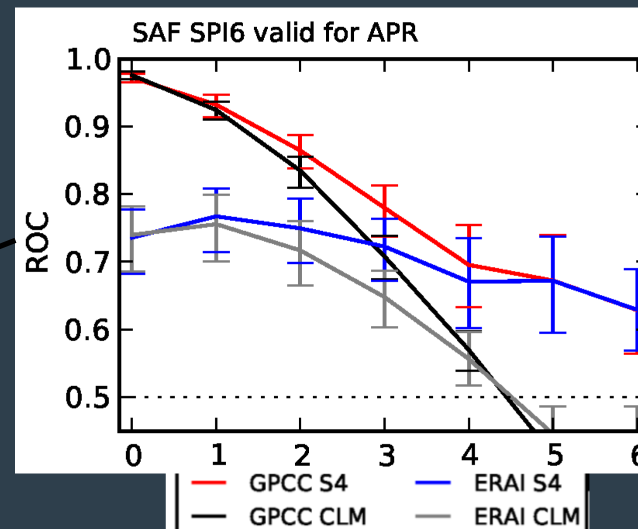
Yoon et al 2012, *J. Hydrometeor*
Dutra et al. 2013 HESS

Probabilistic Forecasting of SPI



First lead time ROC skill score GPCC S4 vs GPCC CLM > 0.05

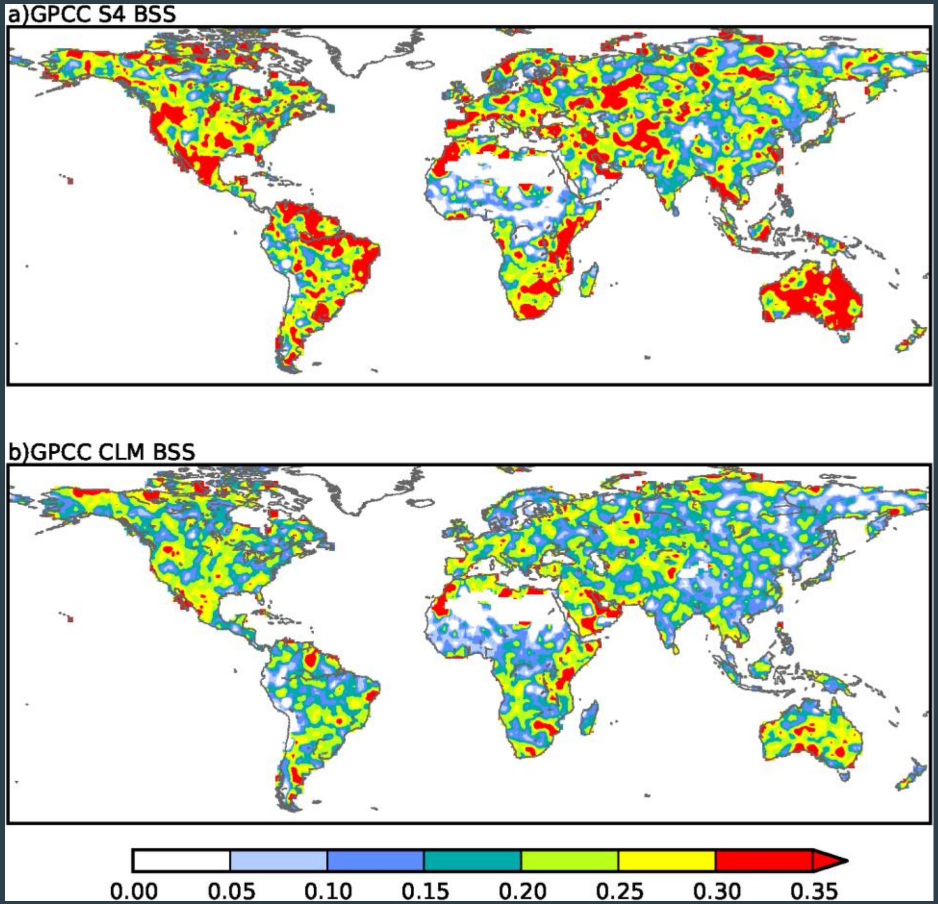
S4 (dynamical forecast) beats climatology
Red vs Black



Difficult to beat the climatological forecasts for long SPI time scales (much of the information comes from the monitoring) .

Regions where S4 precipitation has skill

Drought onset - brier skill score



Drought event: SPI-6 < -0.8 for at least 3 months
Drought onset month: first month SPI6 < -0.8

GPCC S4 has more skill then GPCC CLM (climatological vs. dynamic forecasts), but the fields are "noisy" (even after a 3x3 smoothing).

Regions vs. maps evaluation ?

Citation: Yuan, X., and E. F. Wood (2013), Multimodel seasonal forecasting of global drought onset, *Geophys. Res. Lett.*, *40*, doi:10.1002/grl.50949.

Final Remarks

- **Large uncertainty in near-real time monitoring of precipitation, in particular over the tropics: drop in the number of rain-gauges;**
- **The use of ECMWF ensemble forecasts provides an alternative for precipitation monitoring, with comparable quality to ERA-Interim and TRMM;**
- **Probabilistic monitoring of precipitation provides uncertainty estimates of SPI that could be potentially useful in decision making.**
- **Difficult to beat the climatological forecasts for long SPI time scales (much of the information comes from the monitoring).**
- **Poor quality of the monitoring can reduce the skill of the forecasts significantly;**
- **Regions with higher S4 forecast skill are also regions with more uncertainties in near-real time monitoring;**
- **We can only test the probabilistic monitoring since 2009 onwards; the global SPI forecasts provide a large amount of data: Further verification is needed, in particular focusing on case studies: Ideas, suggestion are welcome.**

  - Dutra, E., et al. .: Global meteorological drought – Part 1: Probabilistic monitoring, **Hydrol. Earth Syst. Sci.**, 18, 2657-2667, doi:10.5194/hess-18-2657-2014, **2014.**
  - Dutra, E., et al..: Global meteorological drought – Part 2: Seasonal forecasts, **Hydrol. Earth Syst. Sci.,** 18, 2669-2678, doi:10.5194/hess-18-2669-2014, **2014.**

emanuel.dutra@ecmwf.int