SKILL ASSESSMENT OF SEASONAL TEMPERATURE AND PRECIPITATION FORECAST OVER EUROPE

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In joint collaboration with - *Barcelona Graduate School of Economics (BGSE)* & *Barcelona Supercomputing Center (BSC)*

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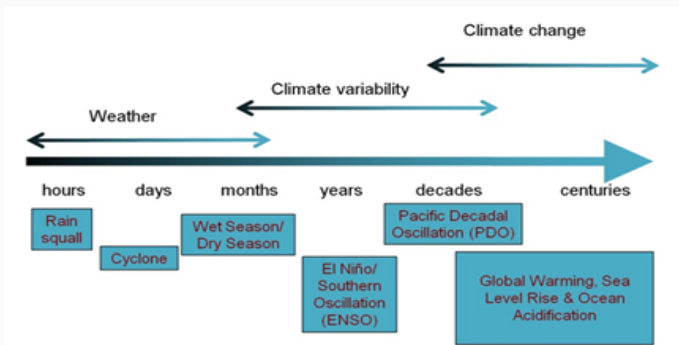
INTRODUCTION

- **Weather forecast** focuses on day-to-day prediction of weather features
- **Climate projection** even longer term changes in climate - 100 years!
- **Climate prediction** focuses on predicting the long-term average of weather
  - Decadal : time scales between decades
  - Seasonal : time scales from few weeks to few months

Source: http://www.pacificclimatefutures.net

Models that employ mathematical equations and simulate Earth's climatic conditions based on:

→ Sea Surface Temperature: **Ex. El Niño Southern Oscillation (ENSO)**
→ Wind Velocity
→ Soil Moisture Condition
→ Snow Cover
→ Aerosols or Greenhouse Gases (GHGs) **Bad source of predictability**

Prediction are often penalized

1. Due to inability accurately represent Earth's climate
2. Due to uncertainities regarding initial conditions
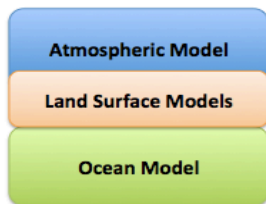3. Leads to the growth of forecast errors in future states.

Data assimilation

Atmosphere, land and ocean initial conditions
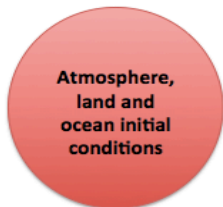
Forecast skill depends on ability to depict initial state

Coupled climate model

Atmospheric Model

Land Surface Models

Ocean Model

**Computer simulations of real world based on equations of physics**

Ensemble of Forecasts

Representing uncertainty and chaos

Collection of several independent forecasts generated by

1. sampling (usually via Monte Carlo techniques) slightly different initial conditions using observations and
2. calculating the evolution of these states using dynamical

Source: http://en.ilmatieteenlaitos.fi
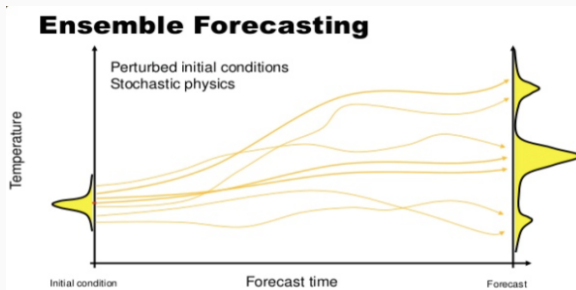
Assess the **forecast quality** of ensemble from 4 prediction systems for:

⇝ Temperature &
⇝ Precipitation

Assess them in terms of their skill against 1 observational dataset

DATA

Dynamical Forecast Models:

1. Global seasonal forecasting system (Glosea5, Met Office) - 24
2. European Centre for Medium Range Weather Forecasts (System4, ECMWF) - 51
3. National Centers for Environmental Prediction (System2, NCEP) - 24
4. Météo-France (System4, MF) - 15

Multi-Model:

· Average of four models

Observation:

↪ Temperature: ERA-Interim
↪ Precipitation: Global Precipitation Climatology Project (GPCP)

- **WHEN?** $\rightarrow$ 1992 - 2012 (21 years)
- **WINTER** $\rightarrow$ Dec-Jan-Feb (Initialized on Nov-1)
- **SUMMER** $\rightarrow$ June-Jul-Aug (Initialized on May-1)
- **WHERE?** $\rightarrow$ 20W 70E - 25N 75N

DATA FORMAT $\Rightarrow$ array of ensemble forecasts of dim

(4 x 51 x 21 x 3 x 71 x 128)

METHOD

1. Temporal Correlation Coefficient (TCC)
2. Continuous Ranked Probability Skill Score (CRPSS)
3. Fair Continuous Ranked Probability Skill Score (FCRPSS)

· Quantifies **maximum skill** that can be obtained in a particular region given a forecast system

· Pearson's Correlation Coefficient over time average

· $\rho = cor(X, \hat{X}) = \dfrac{cov(X, \hat{X})}{\sqrt{var(X), var(\hat{X})}}$

· Test statistic is distributed as one-sided Student t-distribution with $n - 2$ degrees of freedom at 95% confidence level

- Meaningful comparison between two forecast models

- $Skill\ score = \dfrac{Score - S_{ref}}{S_{perf} - S_{ref}}$ $-1 \longleftarrow 0 \longrightarrow 1$

- **Climatology** is our reference model
- The average conditions over some recent reference period

- $\widehat{X}_{CLIM} = E(X) = \dfrac{1}{N} \sum\limits_{t=1}^{n} x_t$

- Integrated squared difference between CDFs of the forecasts and the observations
- Appropriate for forecasts on continuous scale
- Takes into account the full distribution obtained from the ensemble members
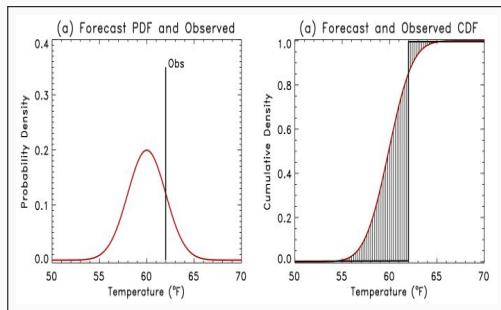
$$CRPS = \frac{1}{N} \int_{-\infty}^{\infty} \left(F_t^f(x) - F_t^o(x) \right)^2 dx$$

- Fair scoring rule for ensemble should elicits random samples of forecasts (Ferro, 2013).
- Favor ensembles that behave as if they were drawn from the same distribution as the observation (Diebold et al., 1998)
- Evaluates the **underlying ensemble distribution and not just the empirical distribution**
- Accounts for the number of ensemble members & the ensemble spread
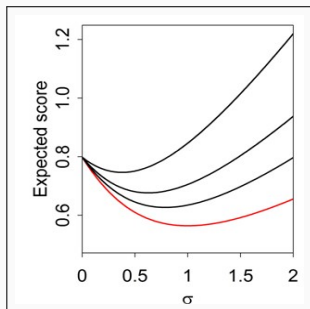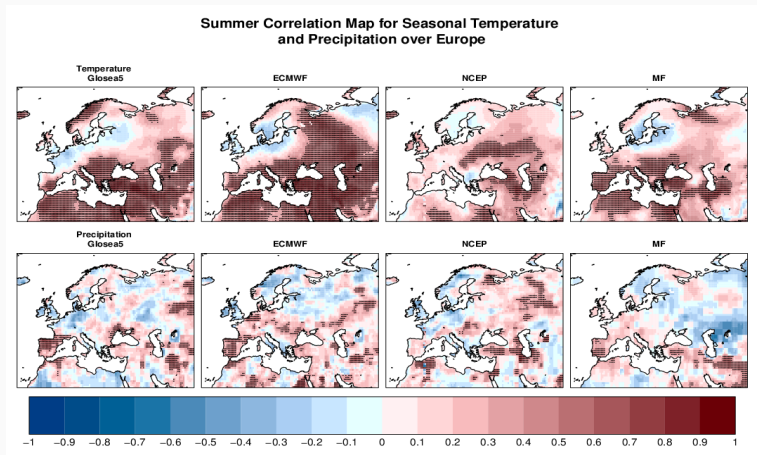

Source: Ferro et al., 2013

$$FCRPS = s(\hat{x}, x) = \int_{-\infty}^{\infty} \left\{ \frac{i(t)}{m} - \frac{j(t)}{n} \right\}^2 dt - \left(\frac{\sum_{i \neq j} |\hat{x}_i - \hat{x}_j|}{2m^2(m-1)} \right)$$
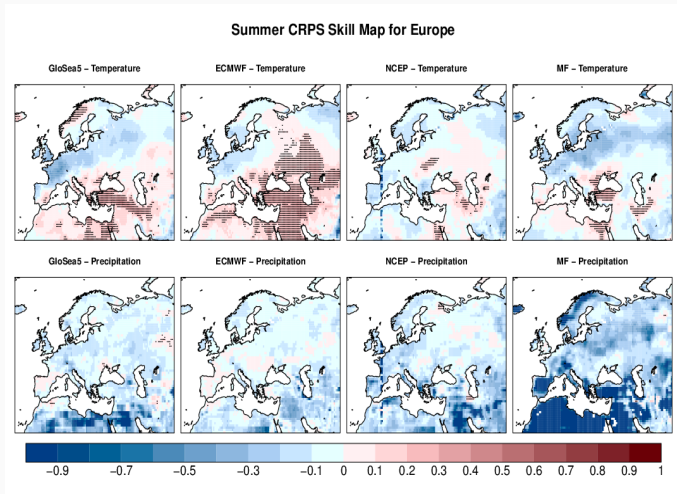
RESULTS

- Skill for temperature in Summer is Optimistic!
- Skill for precipitation is very low


Summer Correlation Map for Seasonal Temperature and Precipitation over Europe

- ECMWF has positive and significant skill in Central Europe at 95 % confidence level
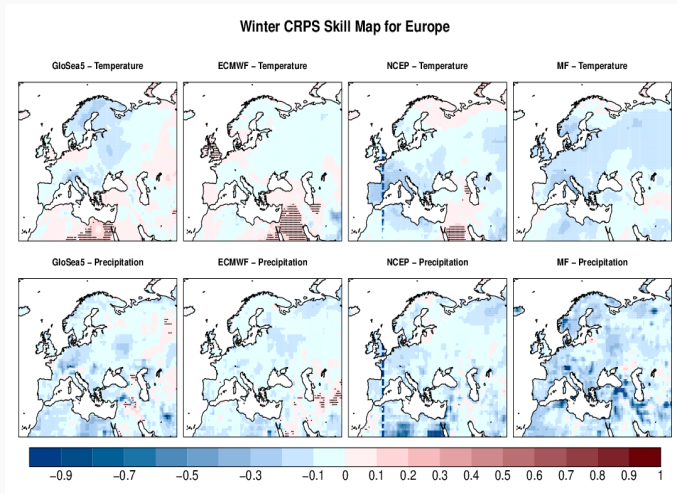- Skill for precipitation is very low

Summer CRPS Skill Map for Europe

- ECMWF still shows positive and significant skill in Central Europe at 95 % confidence level
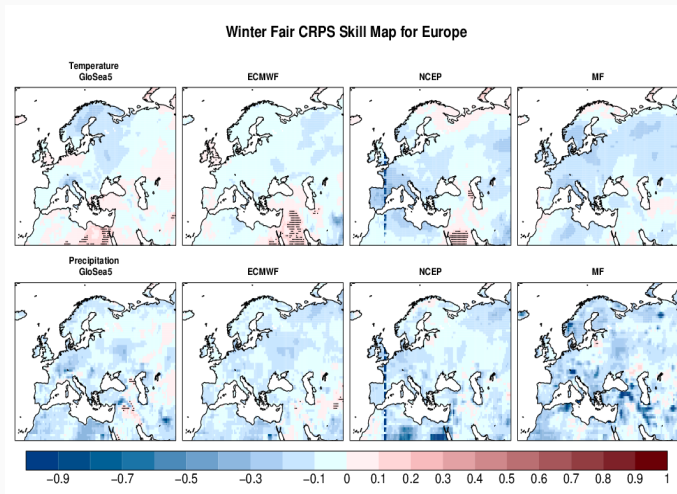- Skill of MF continues to be low

Summer Fair CRPS Skill Map for Europe
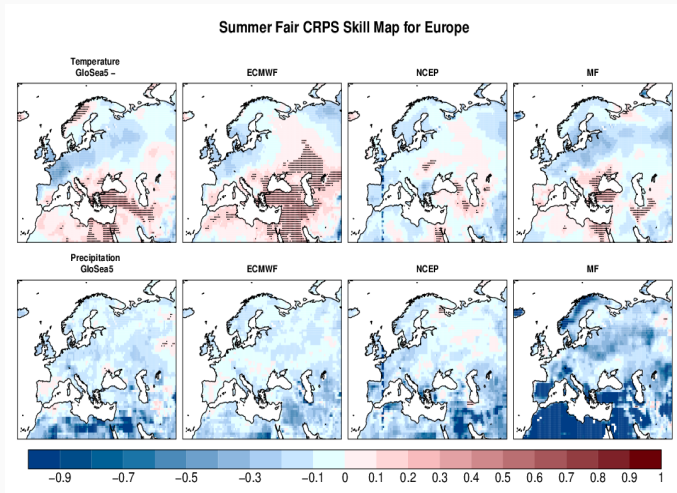
· Skill for winter is low and concentrated in the South-East

Winter CRPS Skill Map for Europe

- Adjusting for ensembles members and spread show expected decrease in skill for winter
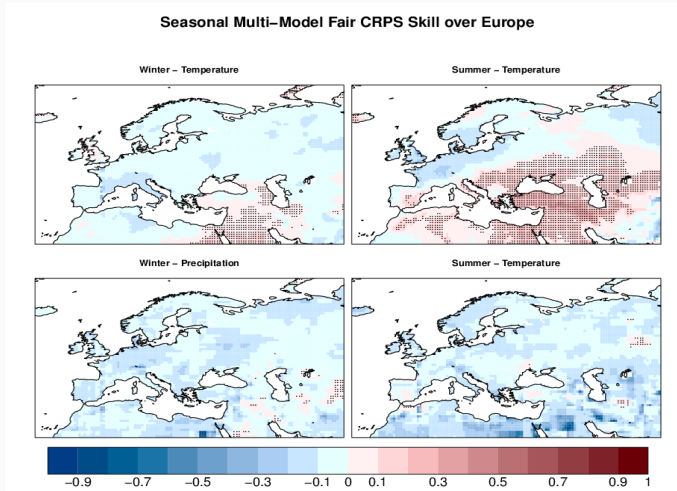

Winter Fair CRPS Skill Map for Europe

- Shows improvement in skill for some geographical area
- However, skill decreases in the North of Scandanavia

Seasonal Multi–Model CRPS Skill over Europe
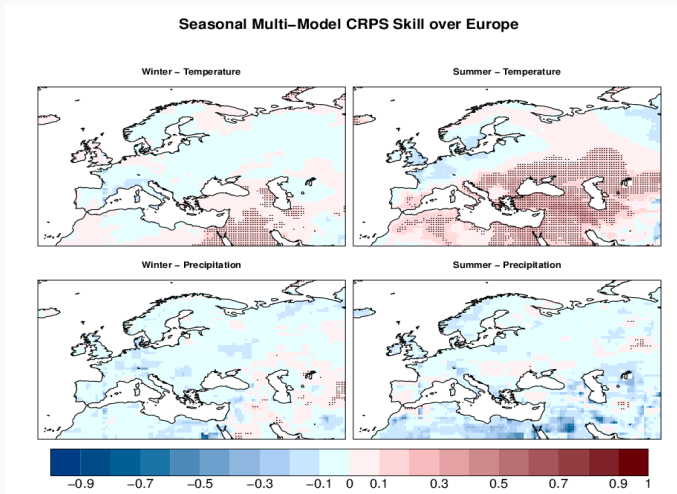
- Decrease in skill is noticed
- However, skill remains in the Central European region

Seasonal Multi–Model Fair CRPS Skill over Europe

SUMMARY

What I learned?:

· Promising opportunities exist for forecast skill of seasonal temperature
· Forecast skill for seasonal precipitation is still complex and difficult

What can be improved?:

· Improvements in forecasting models is required
· Need higher number of observations
· Better observing systems of ocean, land and atmosphere to understand climate phenomena better
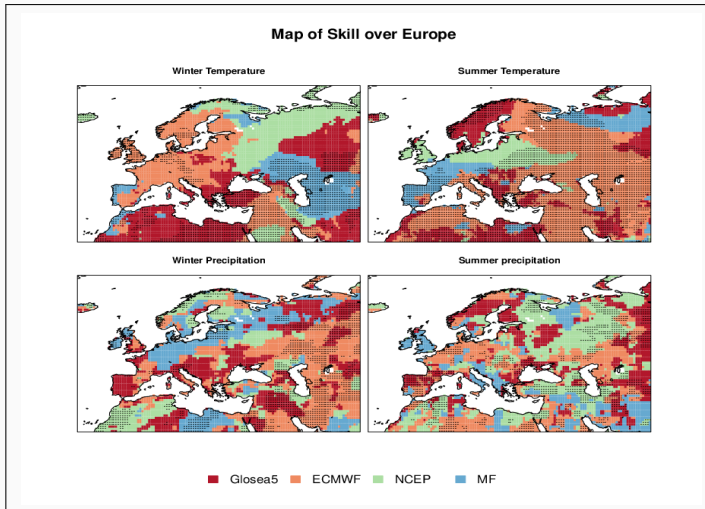
Future work:

· Further analyses in areas that show higher magnitude of potential

Future work:

· Test the skill of weighted multi-model forecasts!

QUESTIONS?