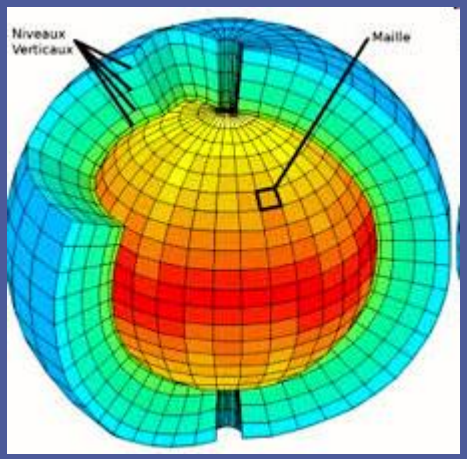
Data and tools for seasonal forecast production



Christian Viel - Météo-France

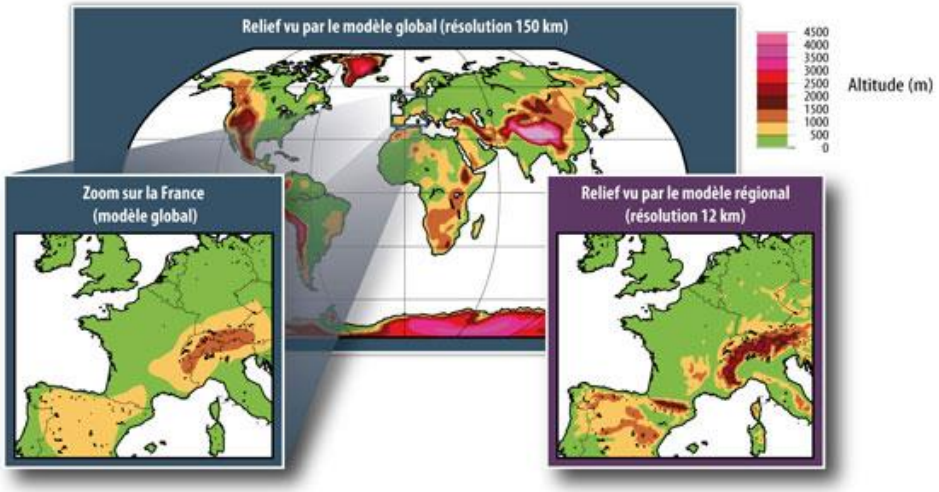
MEDCOF training

Madrid – October 2015

METEO FRANCE
Toujours un temps d'avance

Data and tools

- Global Climate Models (GCM) and multi-models
- Regional Climate Models (RCM)
- Statistical tools



extrapolation from analysis or forecasts : regressions, composites, statistical models…

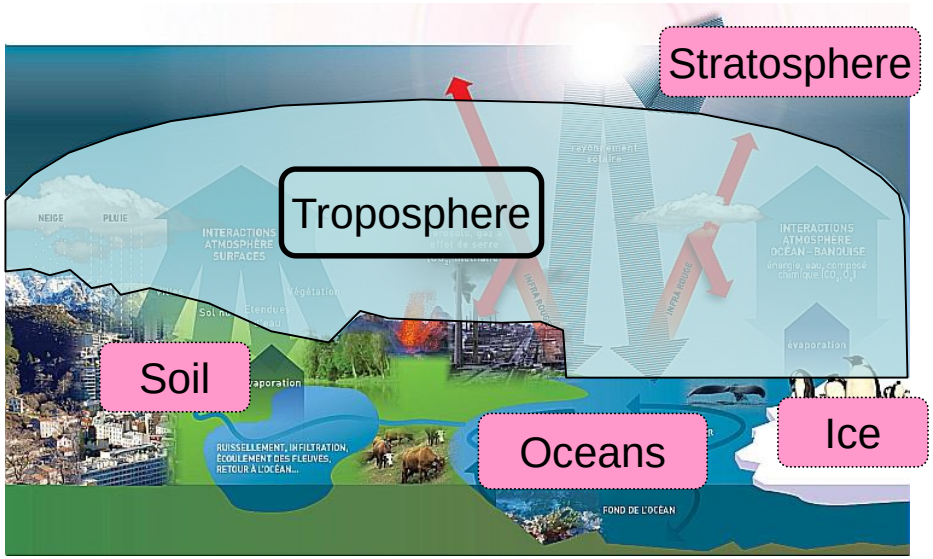
➔ A description of these tools
➔ Their forces and their limits

Plan

1. **Climate Models**
2. **Model outputs**
3. **Other products**
4. **Conclusion**

1. Climate Models

GCM : a tentative to integrate the mains sources of predictability



The climate system

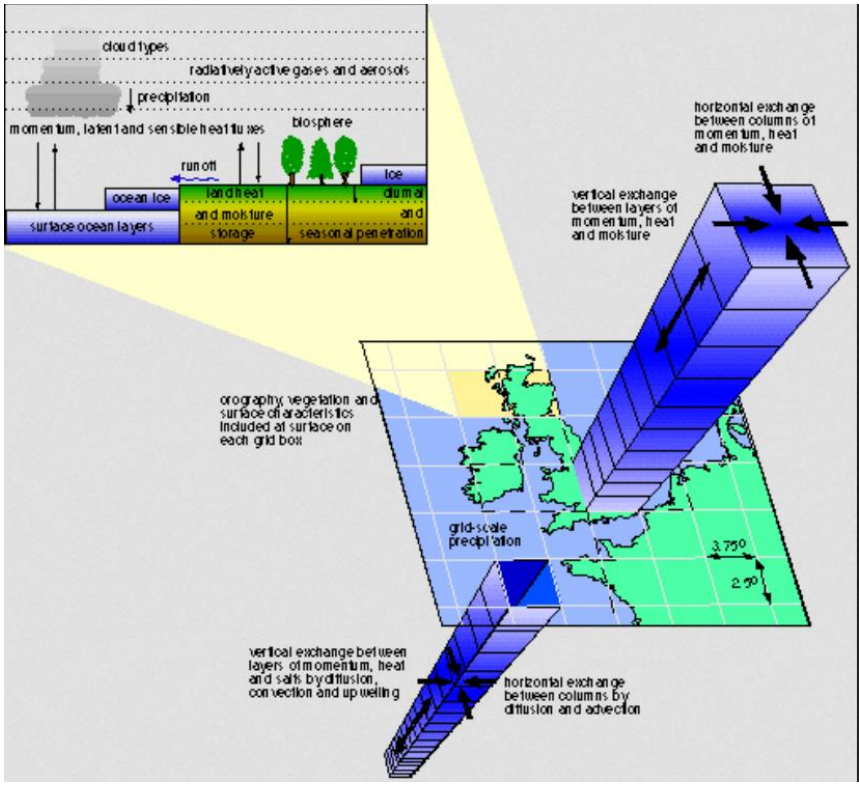
The evolution of the atmosphere is partly driven by the evolution of **external forcing** conditions (SST, continental surfaces, stratosphere).

And the evolution of external forcing is often slow and predictable.

➔it gives a slow memory to the atmosphere, the evolution of the latter becoming partly predictable.

An example of GCM : ARPEGE-S4 (Météo-France)

- **<u>ocean-atmosphère coupled model</u>**
  (based on CMIP5 model)
- <u>Atmosphere:</u> horizontal resolution ~150km *(AROME-France : 2.5km)*
- <u>Ocean :</u> horizontal resolution ~100km
- <u>Ensemble forecast :</u> **51 members**
  ➔ *daily fields, up to 7 months*
- <u>Reference period (hindcast):</u>
  15 members 1991-2011 (21 years)
  ➔ *scores, calibration*



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Global Producing Centres

A Global Producing Centre (GPC) for Long-Range Forecasts (LRF) is a new WMO designation that is conferred upon producers of global seasonal forecast products. The first GPCs were recognised at the WMO CBS Extraordinary Session held in Seoul, November 2006.

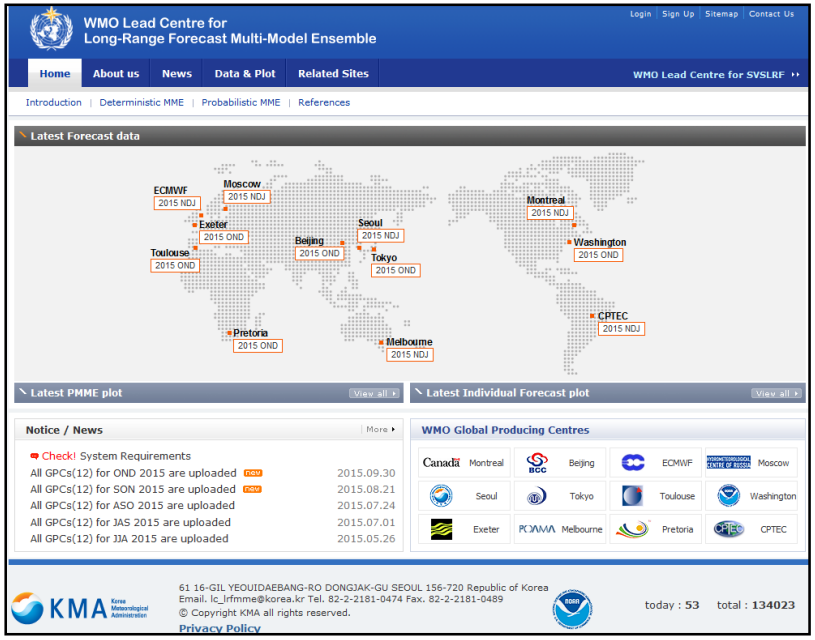
As a minimum a GPC is required to:

1. Have a fixed production cycle and time off issuance;
2. Provide a minimum set of products;
3. Provide verifications as per the WMO SVSLRF;
4. Provide up-to-date information on methodology;
5. Make products available through a web-site and/or disseminated through the GTS and/or Internet.

Global Producing Centres

GPC status was conferred in November 2006 on the National Meteorological Services of the following countries:

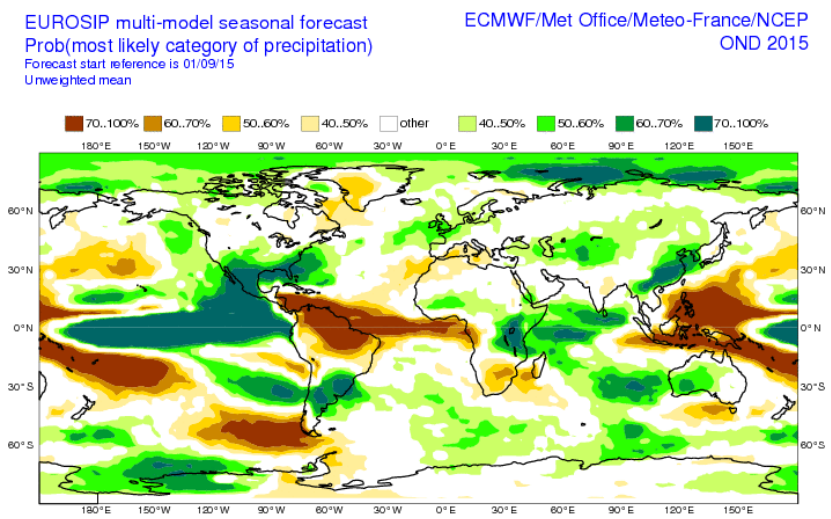
Australia
Canada
China
France
Japan
Korea
United Kingdom
United States of America
ECMWF
Russia
South Africa



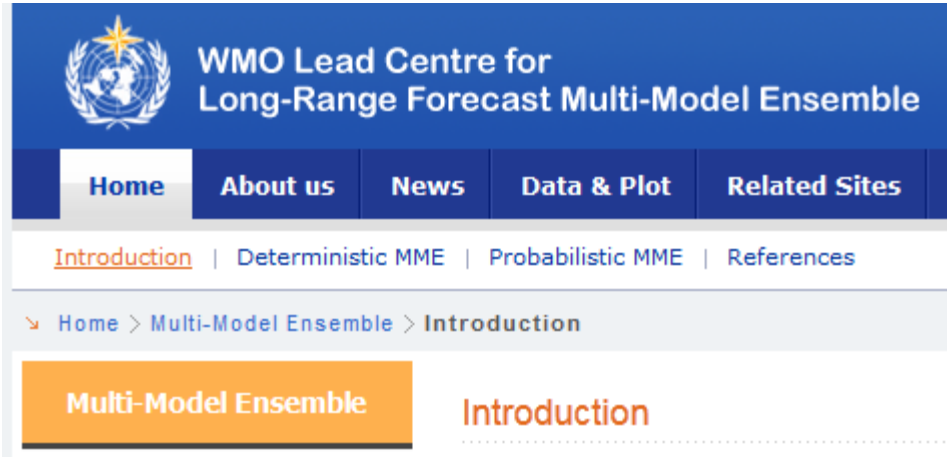
http:///www.wmolc.org/

Multi-models

Origin	Forecast ensemble	Hindcast ensemble	Hindcast period	Hindcast length
ECMWF	51	15	1981-2010	30 yrs
Met Office	variable/42	12	1996-2009	14 yrs
Météo-France	51	15	1991-2011	21 yrs
NCEP	52	12	1982-2010	29 yrs

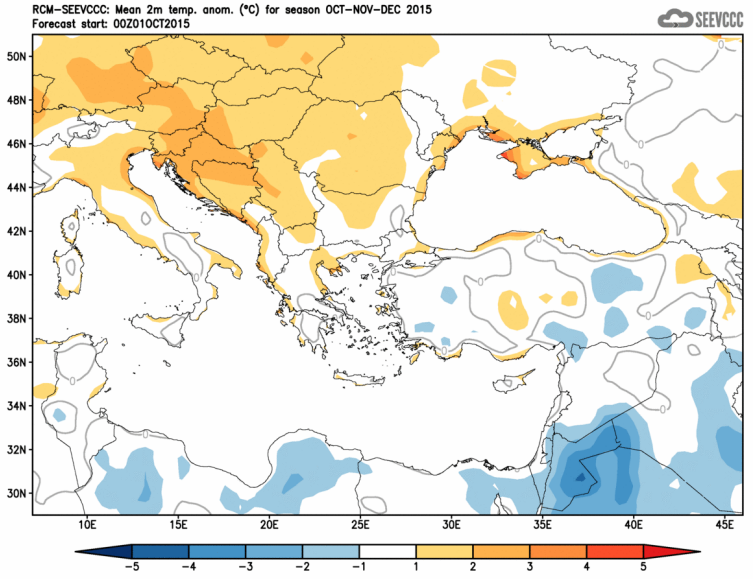


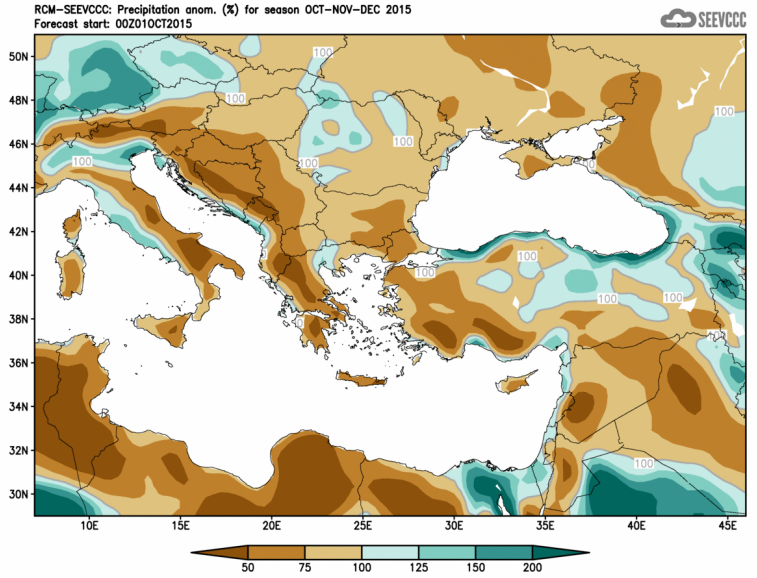
http://www.ecmwf.int/



https://www.wmolc.org/

RCM-SEEVCCC
A Regional Climate Model





Dynamical downscaling of ECMWF seasonal forecast

- regional atmosphere-ocean coupled model (RCM-SEEVCCC)
- 41 ensemble members
- is issued once per month between 15th and 20th
- The forecast run is for 7 months.
- Horizontal resolution is 0.25 degrees for atmospheric model and 0.2 degrees for the ocean model.
- Atmosphere is resolved with 32 and ocean with 21 vertical levels.

http://www.seevccc.rs/?p=7

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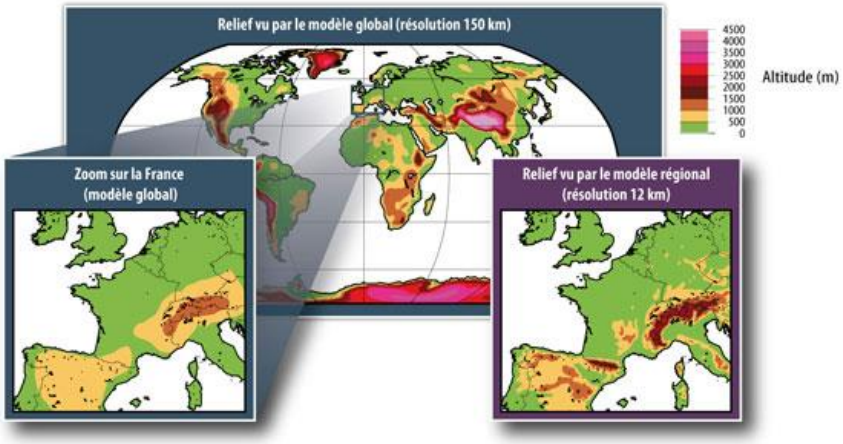
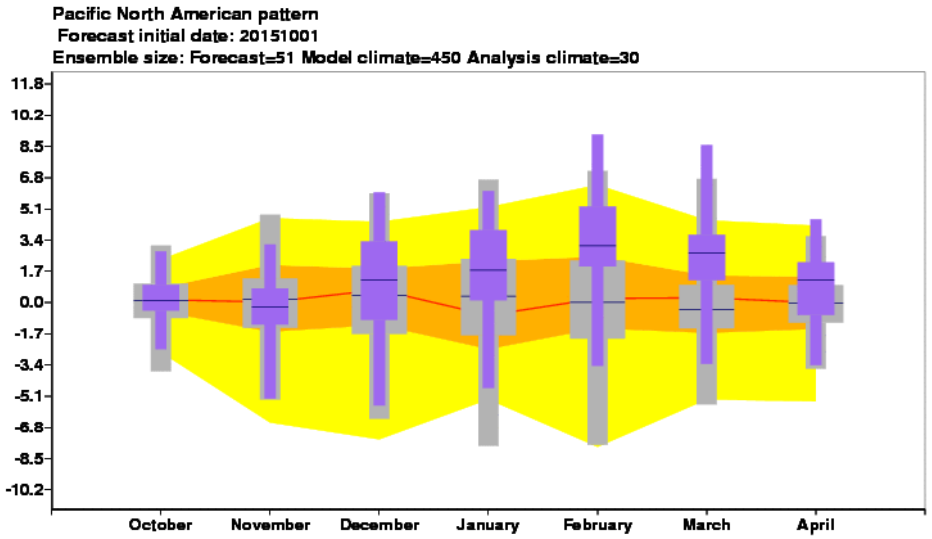
Forces and limits of GCMs (1)

- Global Climate Models have quite a “rough” resolution (~100km)

  ➔ not enough to describe fine physical processes
  ➔ not enough to represent regional climate
  ➔ well adapted to forecast large scale circulation





http://www.ecmwf.int/

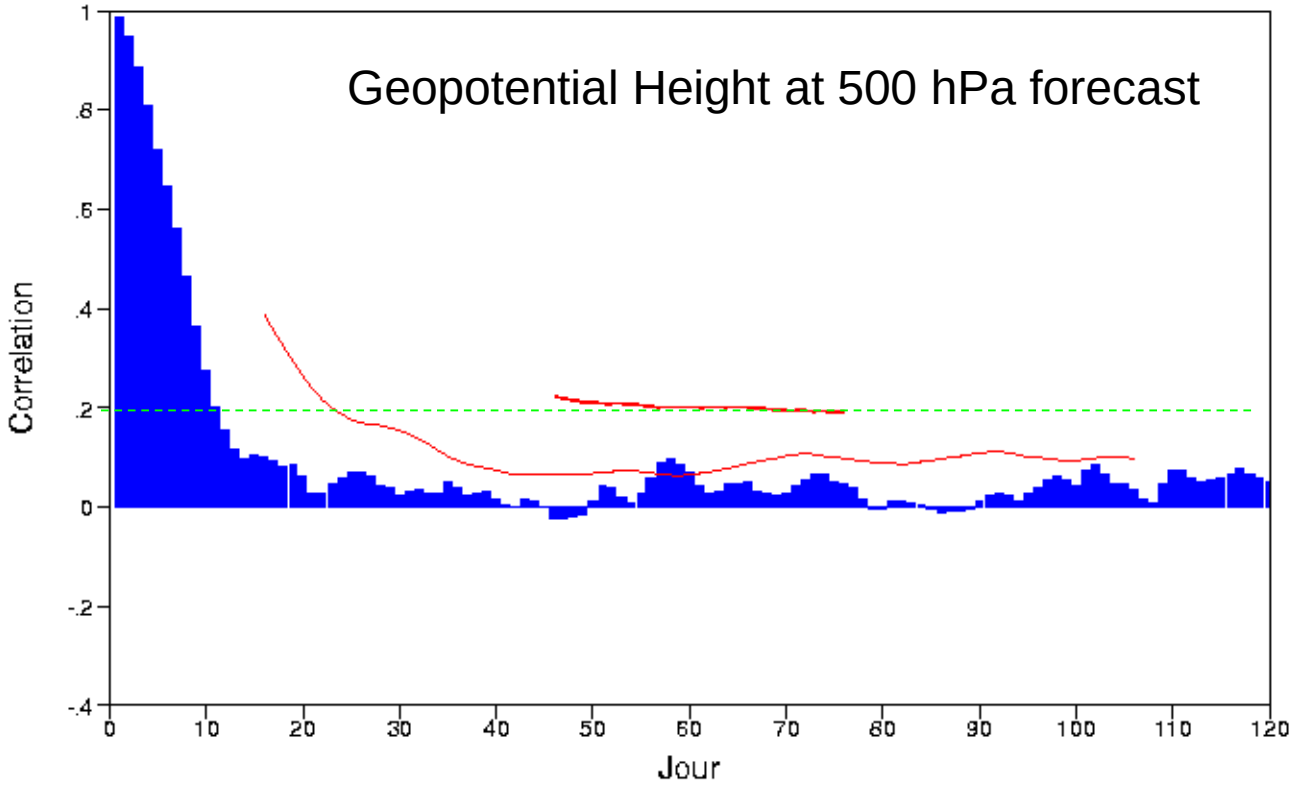
Forces and limits of GCMs (2)

- The successive instantaneous states of the atmosphere have a limited predictability while the mean states of the atmosphere have a greater predictability.

Daily Scores over Northern Hemisphere

+ monthly running mean scores

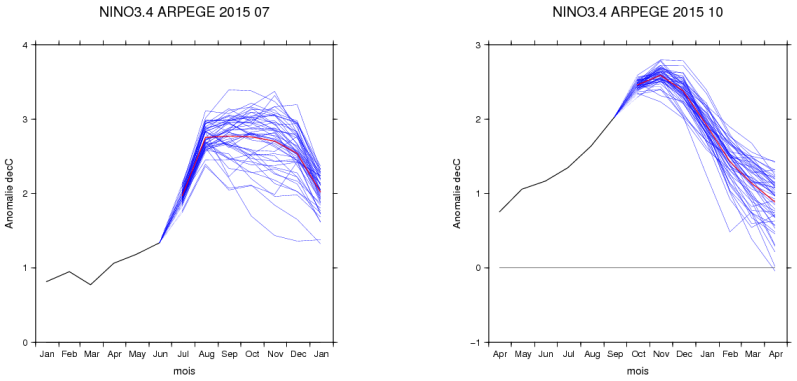
+ **seasonal running mean scores**



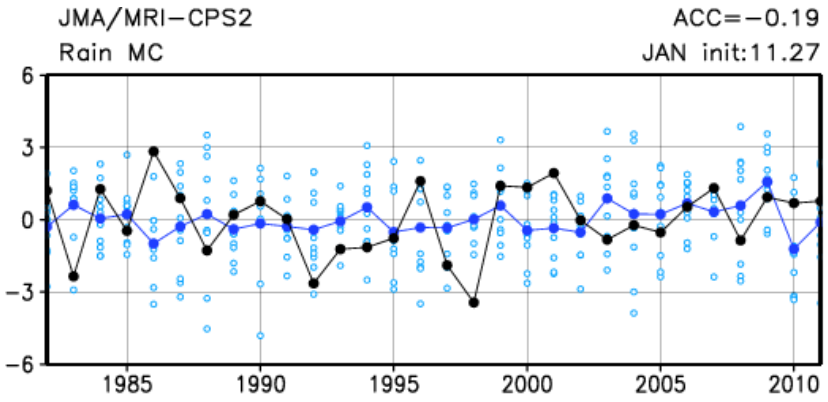
➔ **The temporal mean state is partly predictable (but not the successive instantaneous states of the atmosphere)**

Forces and limits of GCMs (3)

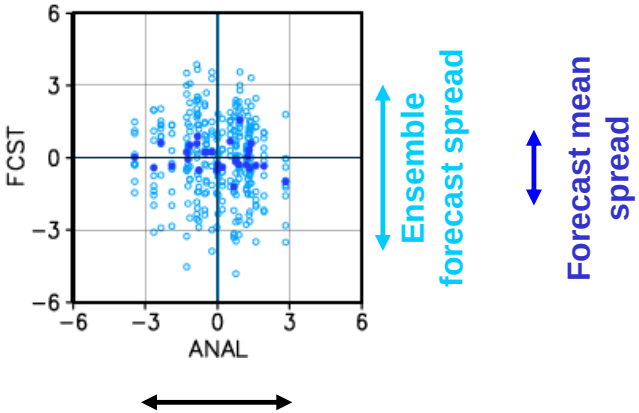
- GCMs produce probabilistic forecasts



Precipitation
Maritime Continent



Black: analysis
Deep Blue: ensemble mean
Blue: each member(ensemble size=10)



Analysis spread

➔ **Don't summarize a SF to its ensemble mean**

http://ds.data.jma.go.jp/gmd/tcc/tcc/products/model/hindcast/CPS2/shisu/shisu.html

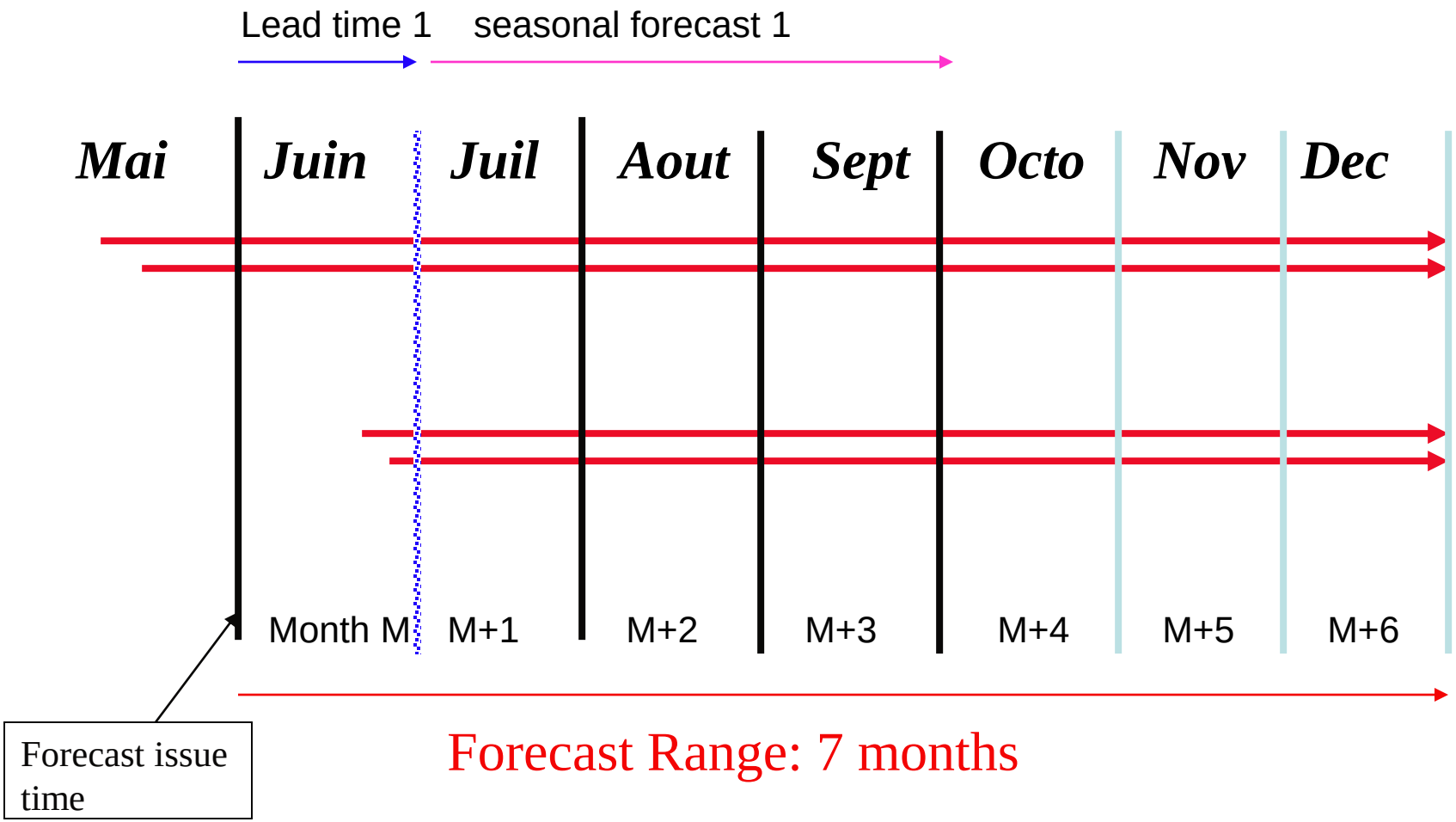
2. Model Outputs

Seasonal Forecasting Models

- Ensemble forecast
  - Several simulations with small perturbations in the initial conditions
  - Launched once a month

- A “hindcast” = simulations over an historical period (typically, 20 to 30 years)
  - To calculate scores
  - To correct bias and variance problems

Simulations



Forecast for July/August/September

Generalities on scores

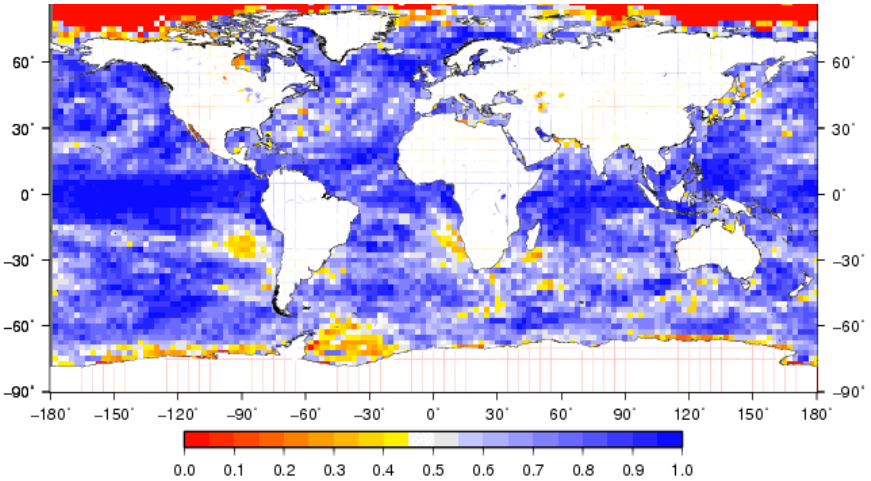
- models have different **performances depending on** the considered **regions and years**.
- It is important to get the evaluation of the model over a long time period in order to take these evaluation into account in the interpretation of the forecasts of the model (particularly the confidence in the forecast)…
- … with some limitations : the climate is non-stationary
- **The performance generally depends on the forcing** (namely the stronger is the forcing the better is the model)
- so it should be better to get the evaluation by large type of forcing events (e.g. El Niño, La Niña and Neutral conditions).

→ **importance of the hindcast experiment**

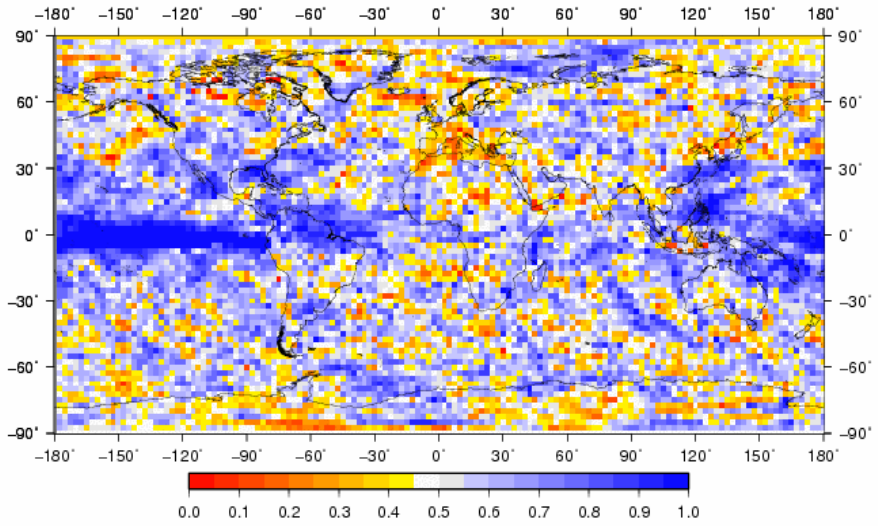
Some scores (ARPEGE-S4)

Scores : AUC upper tercile for DJF (LT=1 mois)

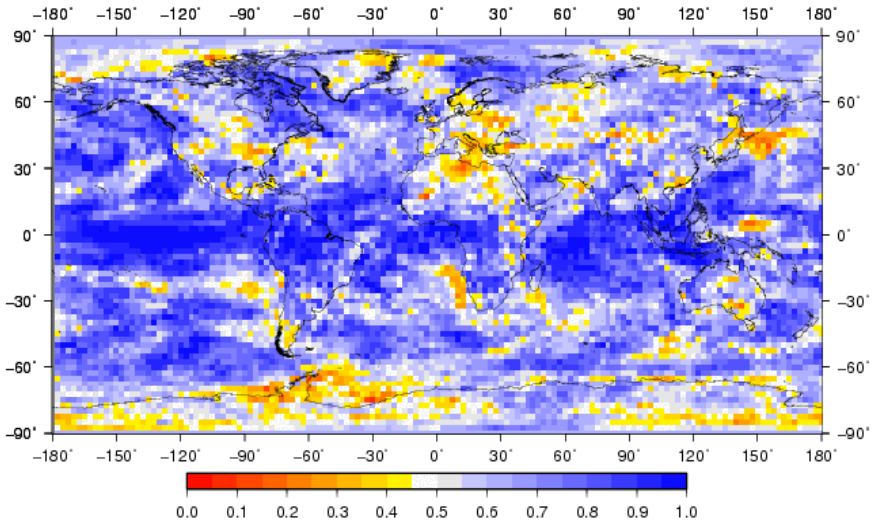
SST



Precipitations



Temperatures



Elaboration of numerical products

Direct Methods (deterministic and probabilistic products)
formulation as Indices or Anomalies

Anomalies: Adaptation to « local » observation properties

$$A = P - \overline{P}$$

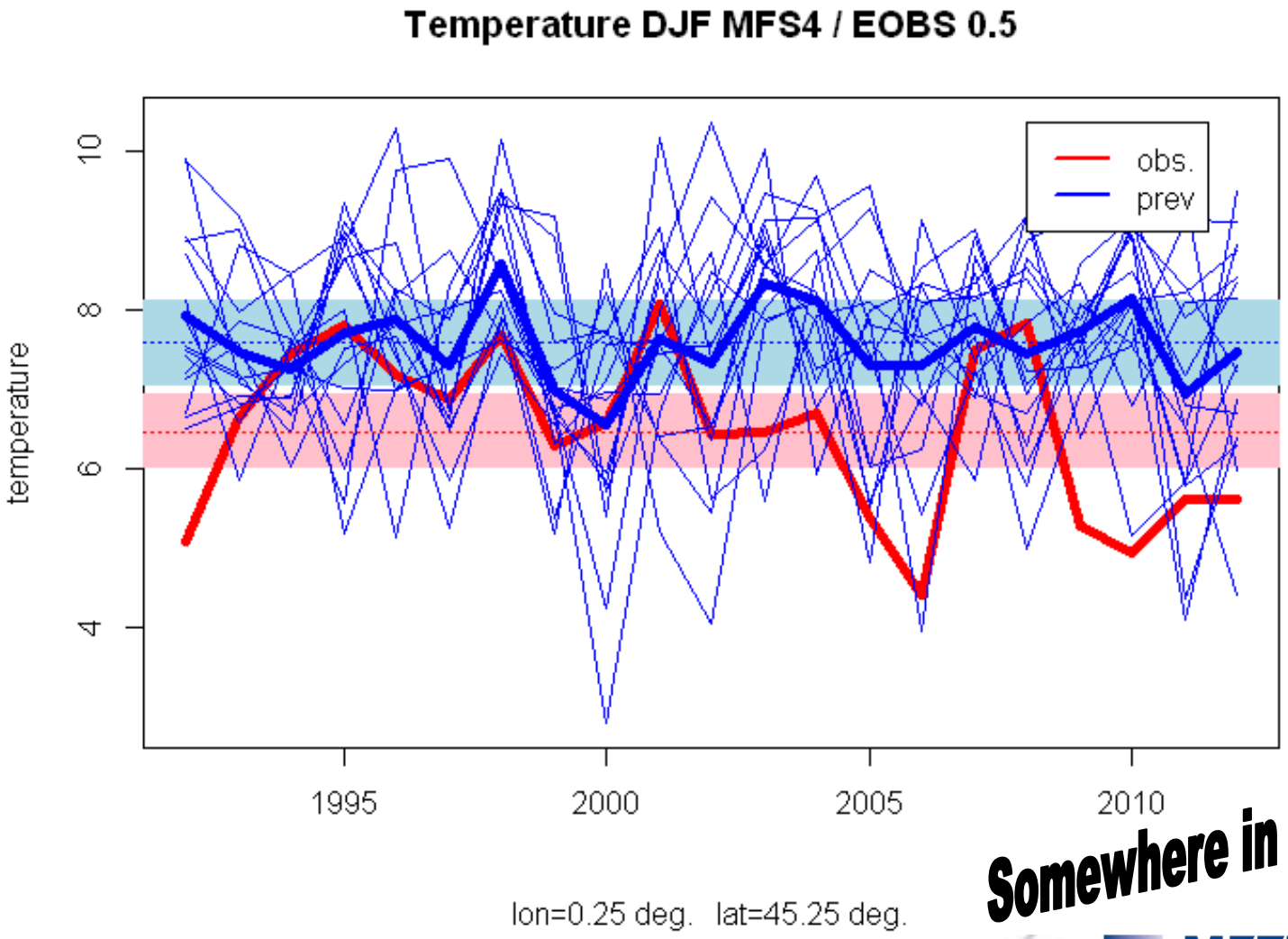
°C, *mm/D*, *m/s*,...

Indices: Model forecats compared to its own climatology

$$I = \frac{P - \overline{P}}{\sigma_P}$$

%

Mean and variance : seasonal forecast vs observation



Somewhere in Europe...

Deterministic and Probabilistic products

- **Deterministic products**
  - One forecast : **the ensemble mean**
    (for MF model, ensemble = 51 runs)
  - Average normalized anomaly or mean index of the model
  - Statistical test to know where the index is meaningfully different from the climatology (t-test)

Deterministic and Probabilistic products

- **Probabilistic products** :

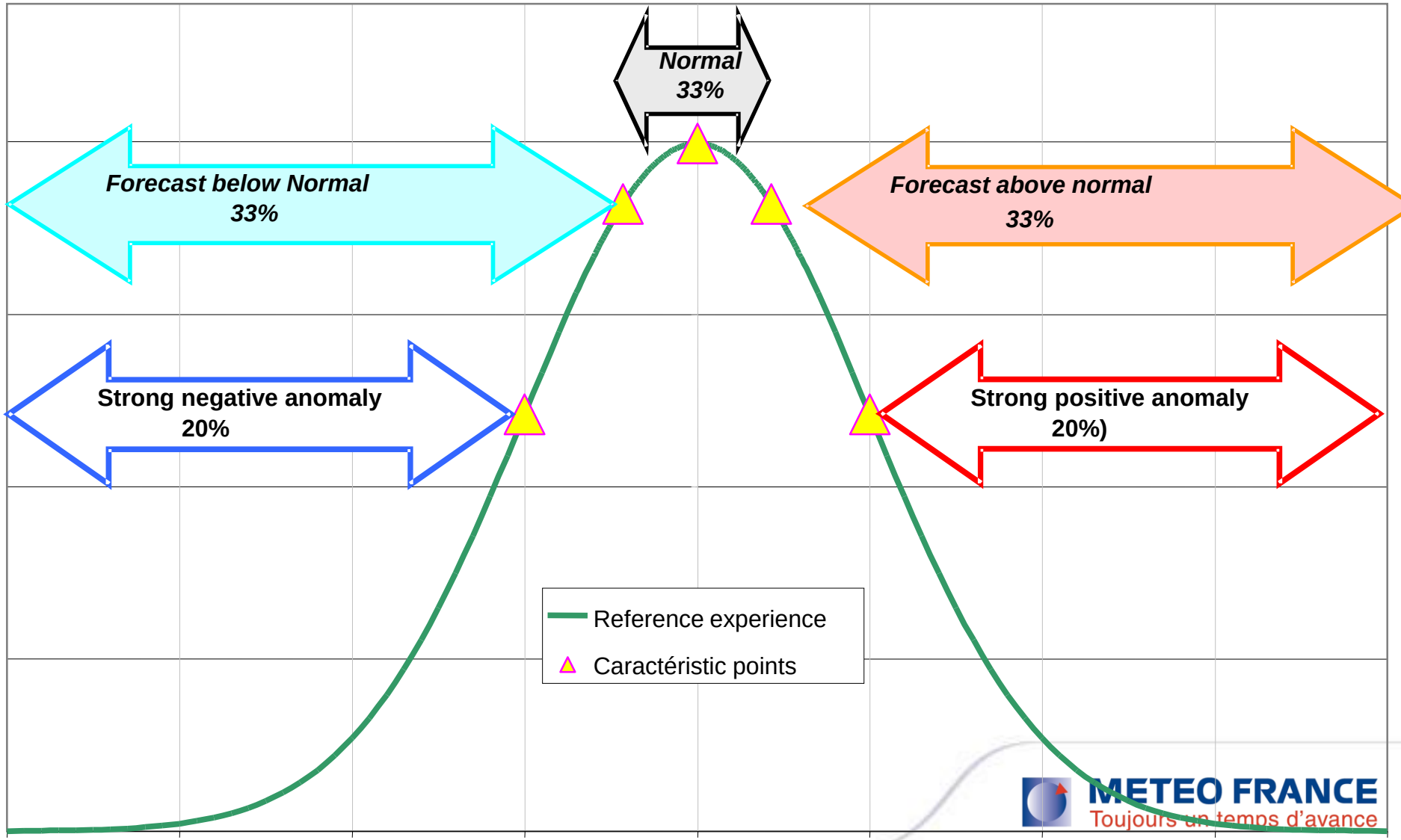
  3 categories are specified using **the terciles** of the forecast distribution : forecast below normal, normal or above normal

  + 2 extremes : probabilistic forecasts of strong anomalies (negative et positive) are also calculated (generally extreme quintiles)

  ➔ Probabilistic maps show the frequency of forecast members in each category.

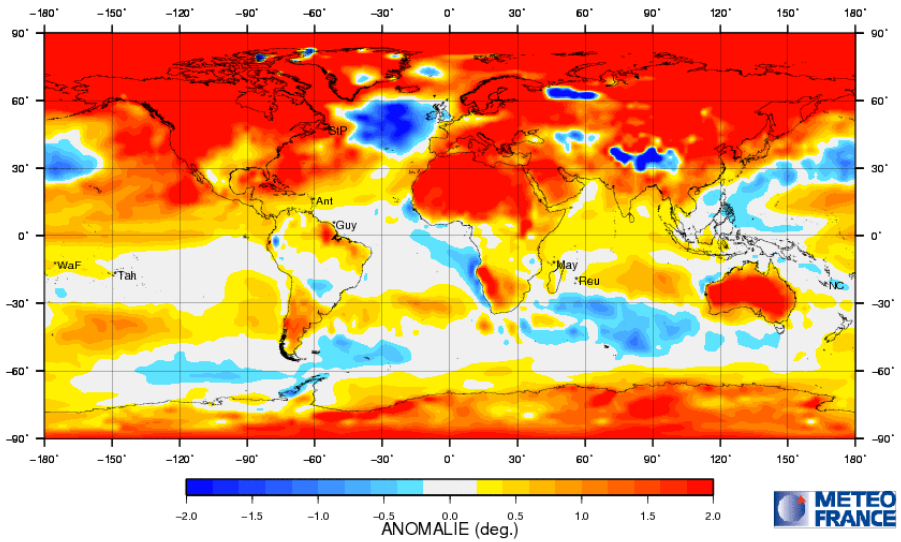
Probabilistic products

to position the members in relation to the hindcast experience

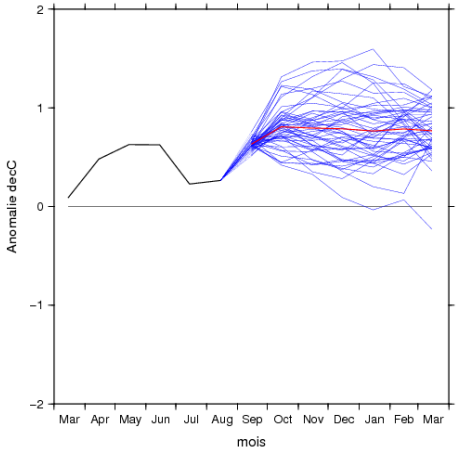


Examples

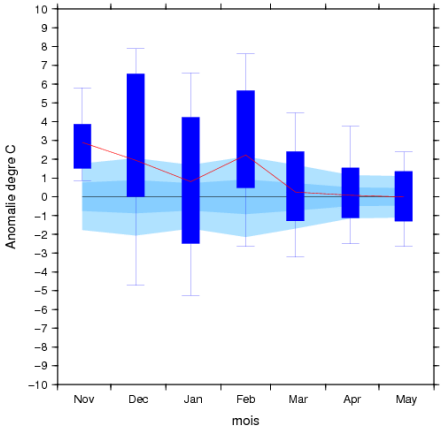
T 2 M PREVISION ARPS4 DECEMBRE–JANVIER–FEVRIER RUN DE NOVEMBRE 2014



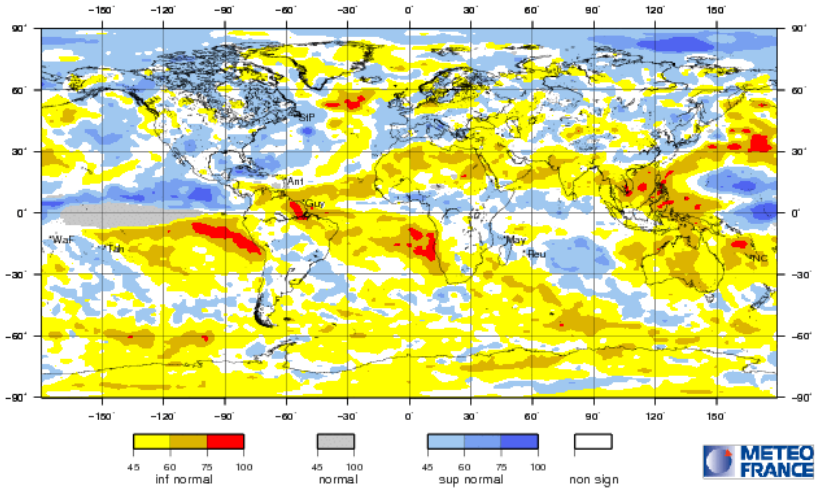
NINO3.4 ARPEGE 2014 09



T2M Europe_N 2014 11



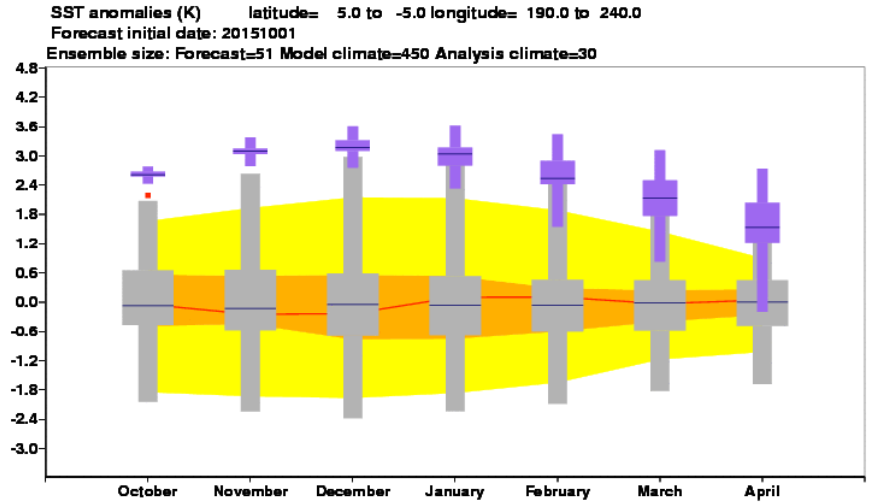
PRECIPITATIONS PREVISION ARPS4 DECEMBRE–JANVIER–FEVRIER RUN DE NOVEMBRE 2014

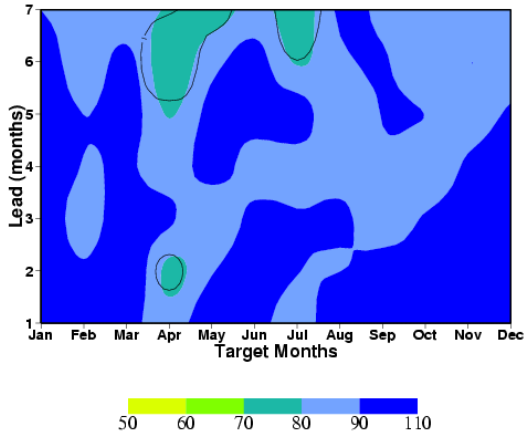


PROBABILITE (%) DE LA CATEGORIE LA PLUS PROBABLE

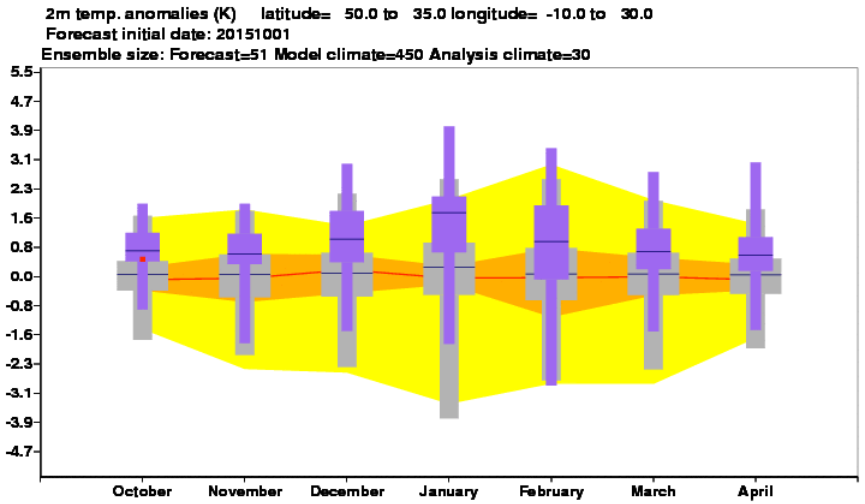
Make the best of GCM (1): look at scores to put forecasts into perspective

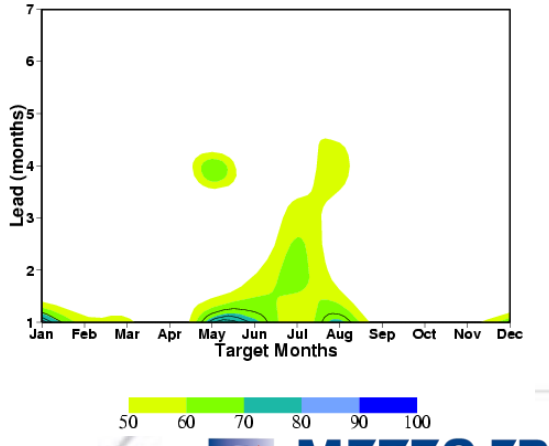
SST Nino3.4





T2m Southern Europe





http://www.ecmwf.int/

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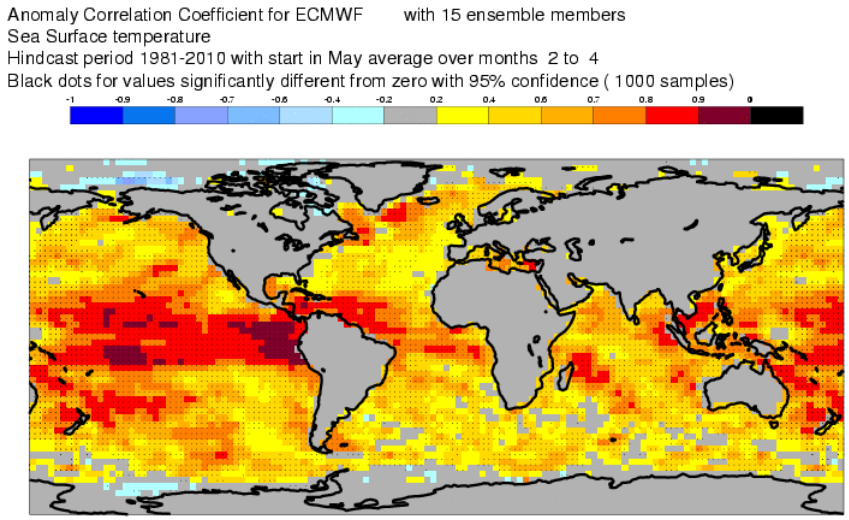
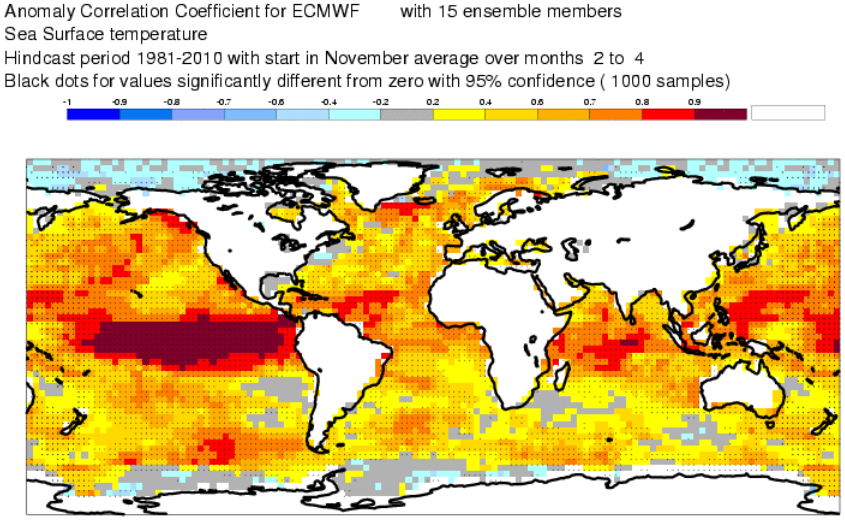
Make the best of GCM (2): Return to roots…

Number 1 forcing (and the best forecasted parameter) : tropical SST !



JJA



DJF

http://www.ecmwf.int/

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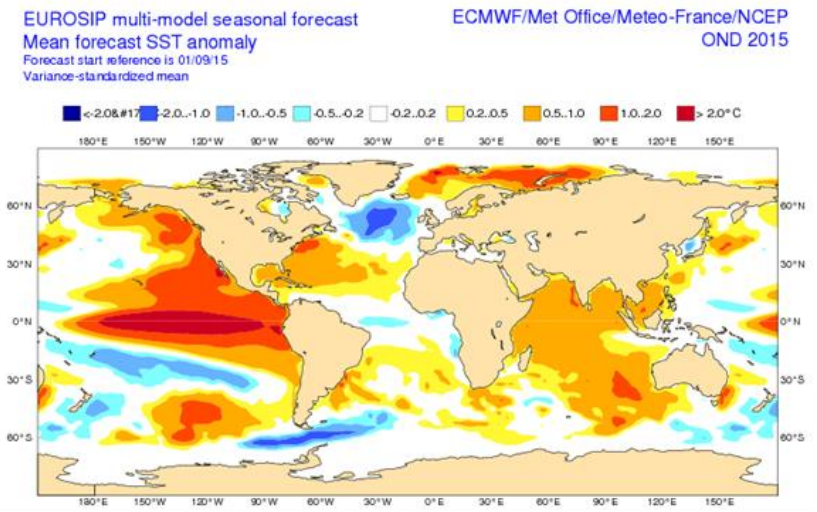
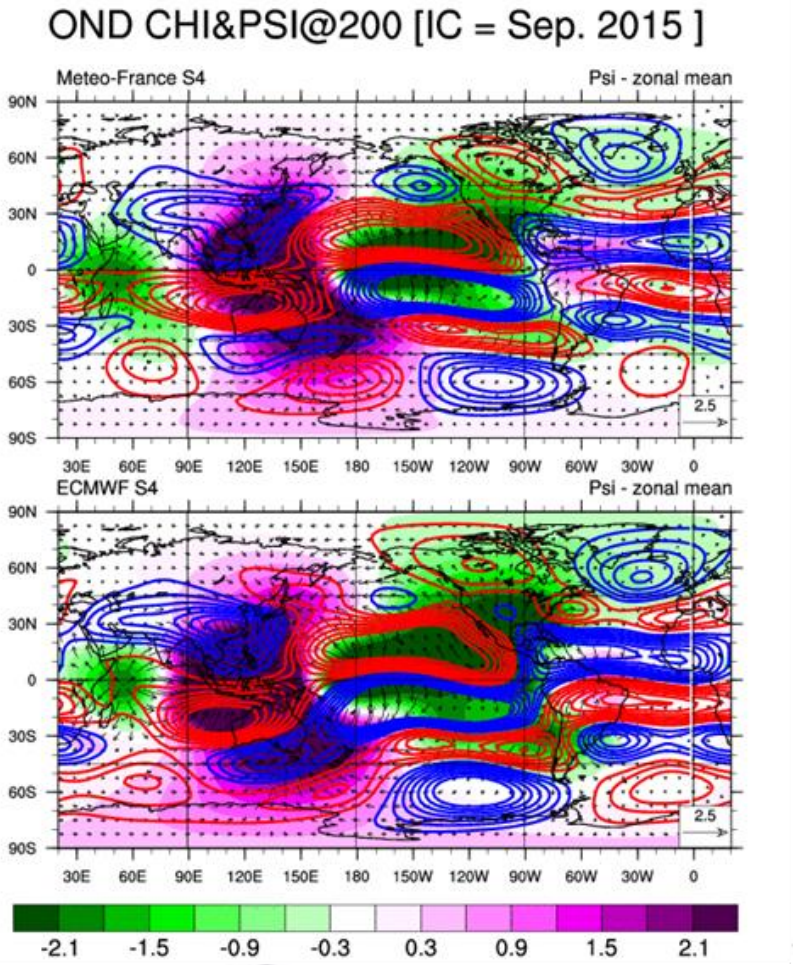
Make the best of GCM (3): general circulation products

From tropical SST to general circulation…



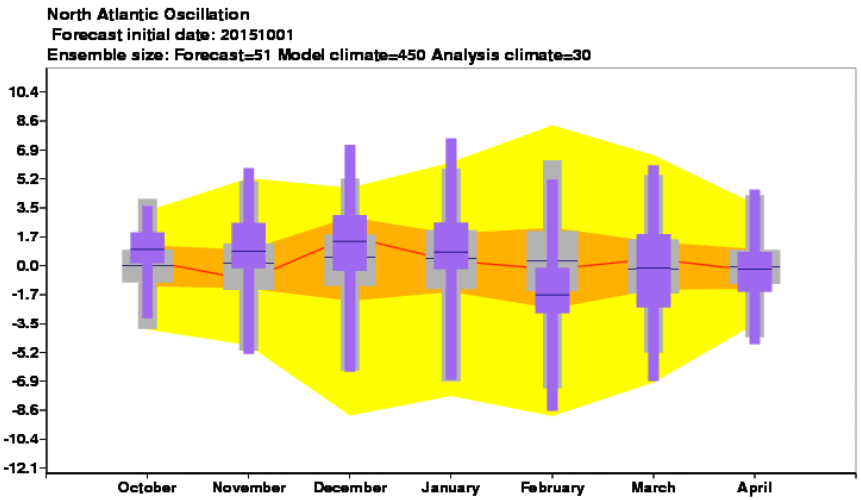


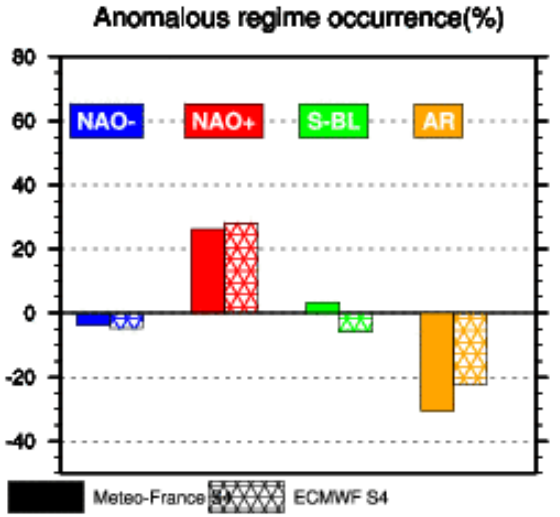
Velocity Potential (colour ranges) gives insight into the atmospheric response in terms of Hadley-Walker circulation anomalies

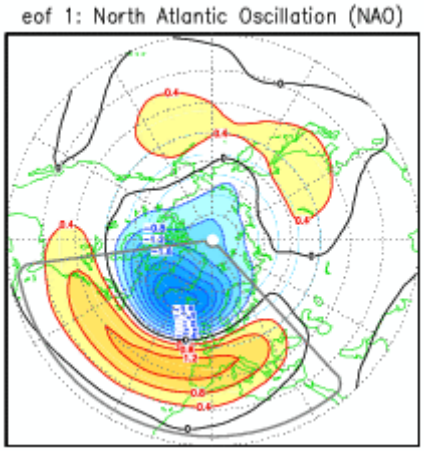
while Stream Function (red and blue contours) gives complementary insight into the atmospheric response to tropical forcing (especially in terms of teleconnections with mid-latitudes)

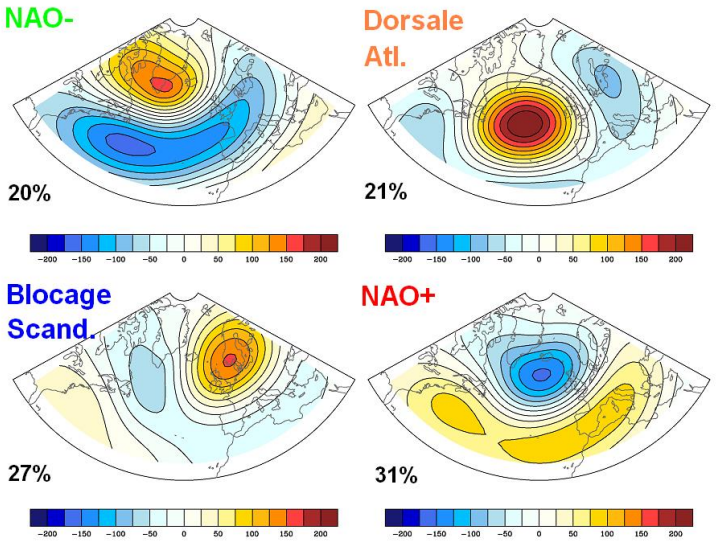
METEO FRANCE
Toujours un temps d'avance

Make the best of GCM (4): general circulation products

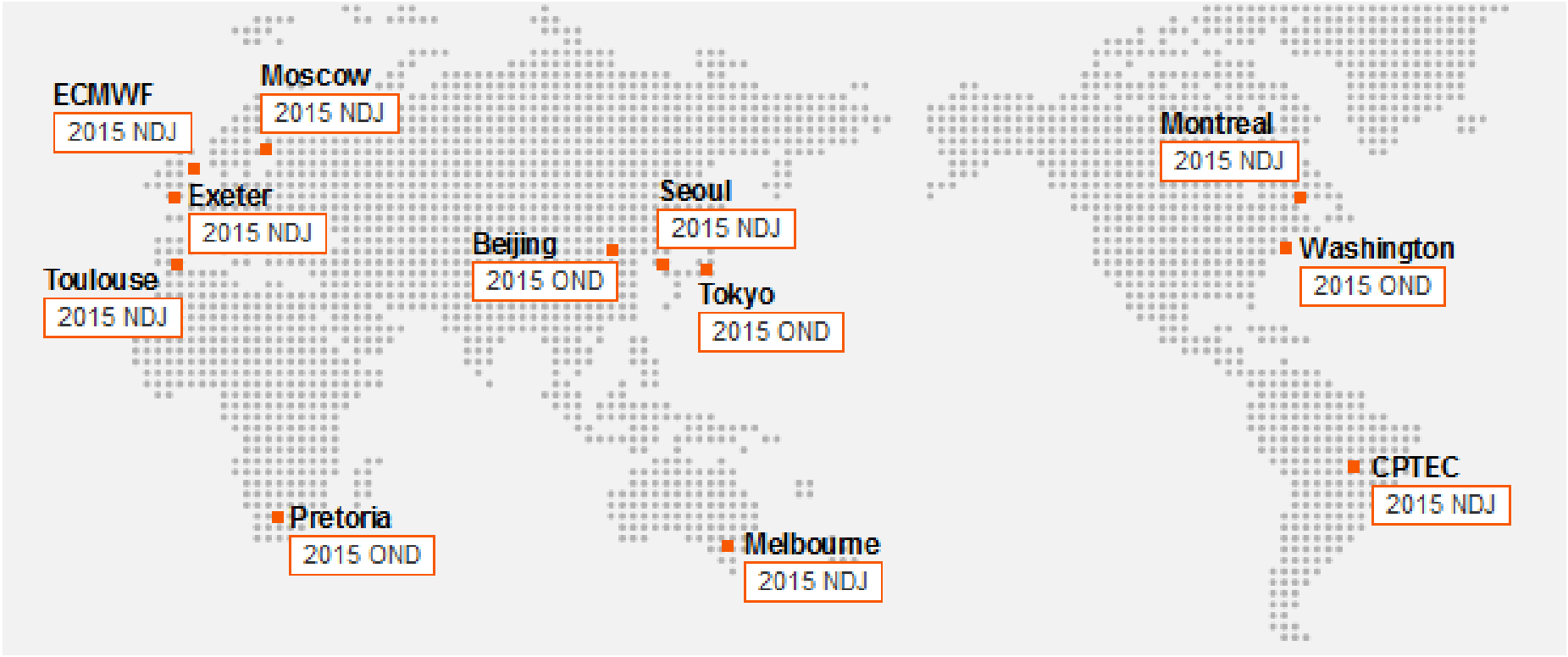






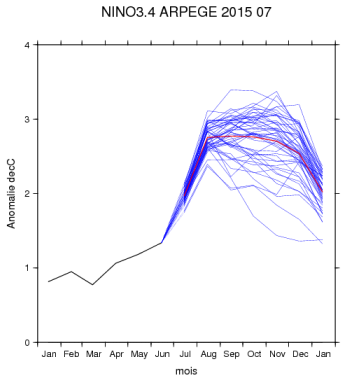


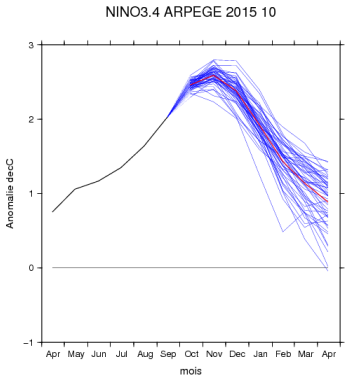
Make the best of GCM (5): benefit “biodiversity” !



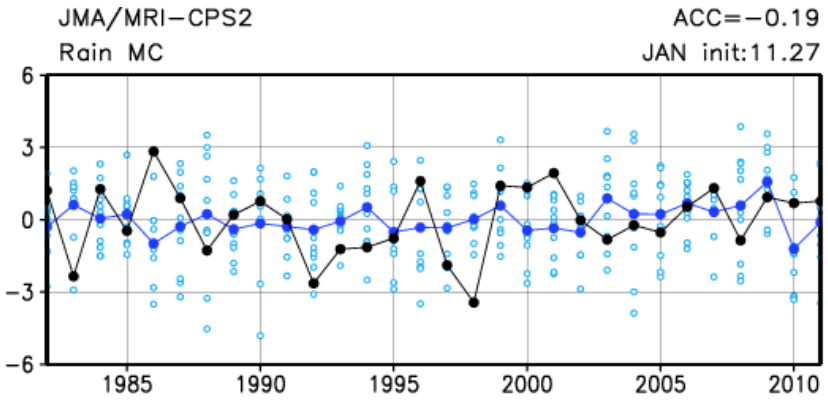
Make the best of GCM (6)

- GCMs produce probabilistic forecasts

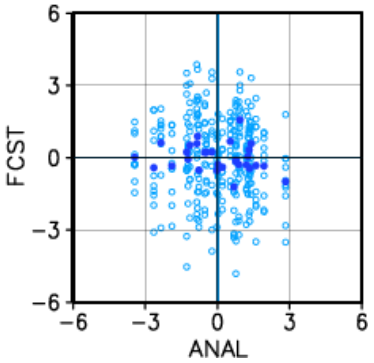




Precipitation
Maritime Continent



Black: analysis
Deep Blue: ensemble mean
Blue: each member(ensemble size=10)



Ensemble forecast spread

Forecast mean spread

Analysis spread

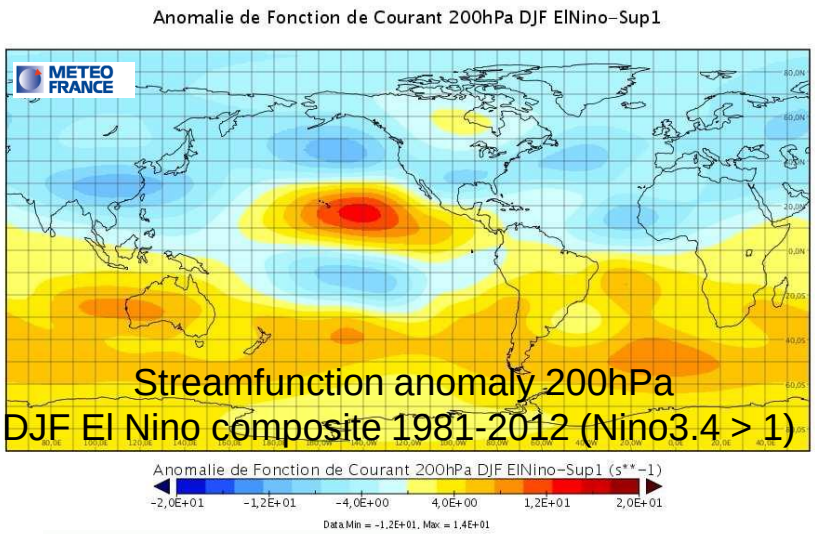
➔ **Don't summarize a SF to its ensemble mean**

http://ds.data.jma.go.jp/gmd/tcc/tcc/products/model/hindcast/CPS2/shisu/shisu.html

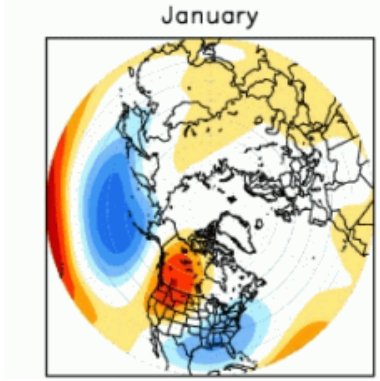
3. Other products : what else ?

Classical impacts of specific situations

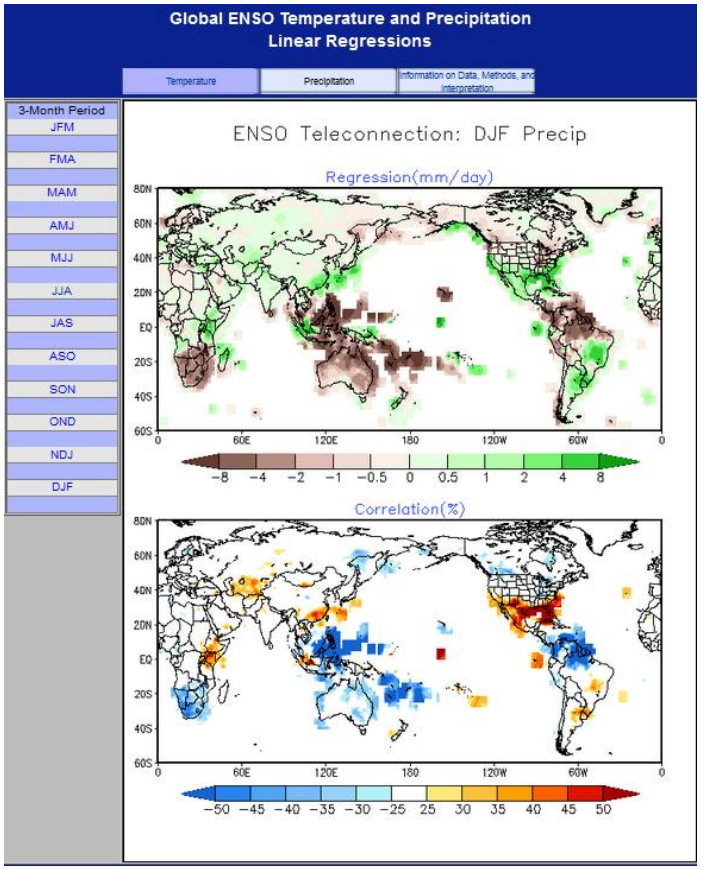
- Composites and regressions



Streamfunction anomaly 200hPa
DJF El Nino composite 1981-2012 (Nino3.4 > 1)



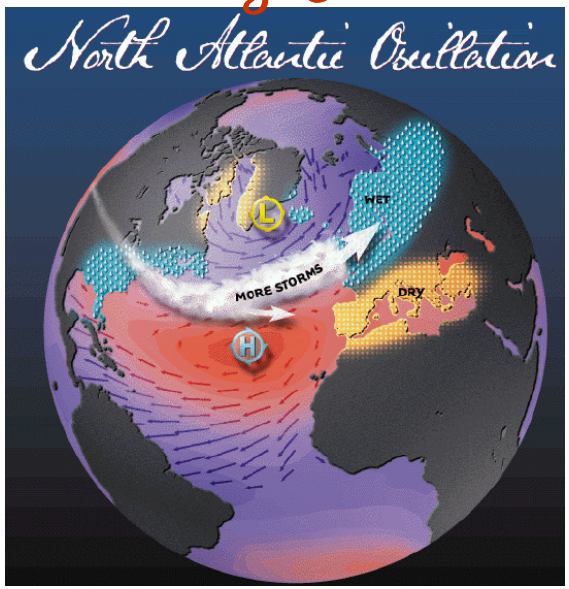
Pacific - North American Pattern (PNA)



http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ENSO/regressions/geplr.shtml

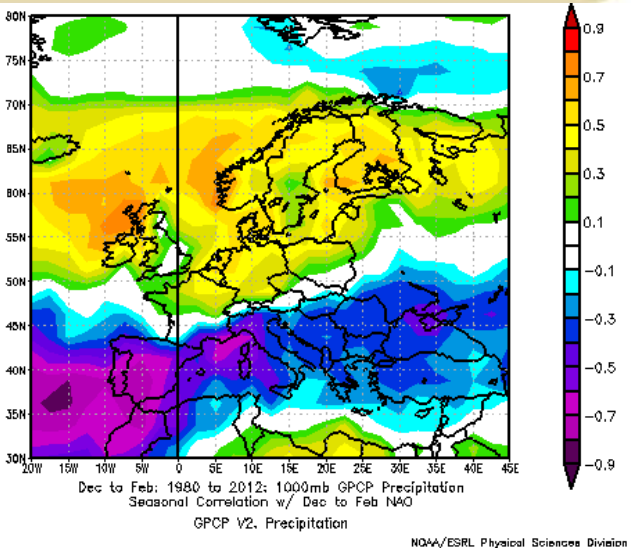
Classical impacts of specific situations

Large Scale



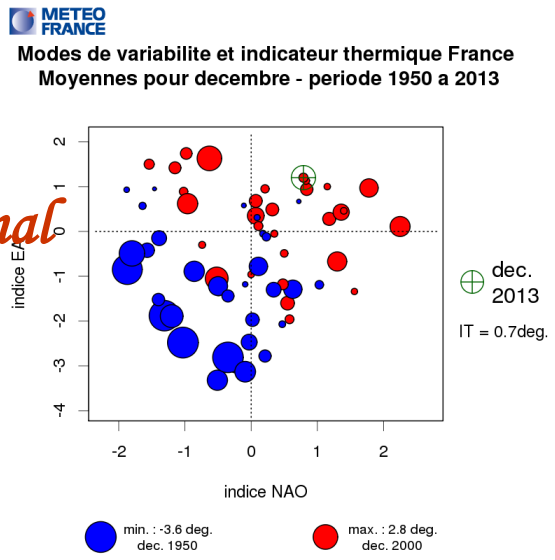
http://www.ldeo.columbia.edu/res/pi/NAO/

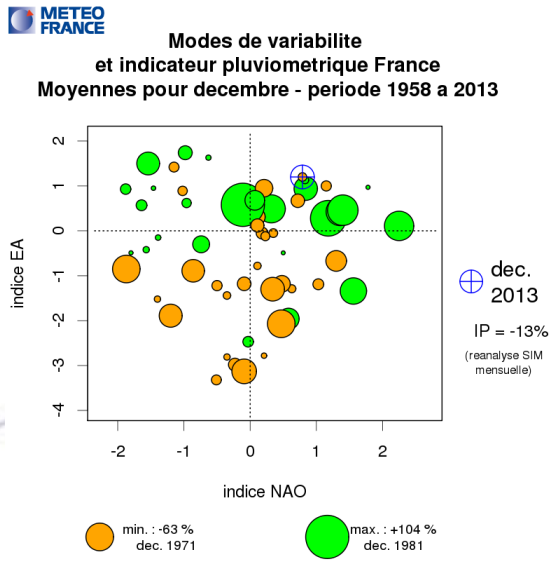
Regional Scale



http://www.esrl.noaa.gov/psd/data/correlation/

National Scale





Statistical Downscaling

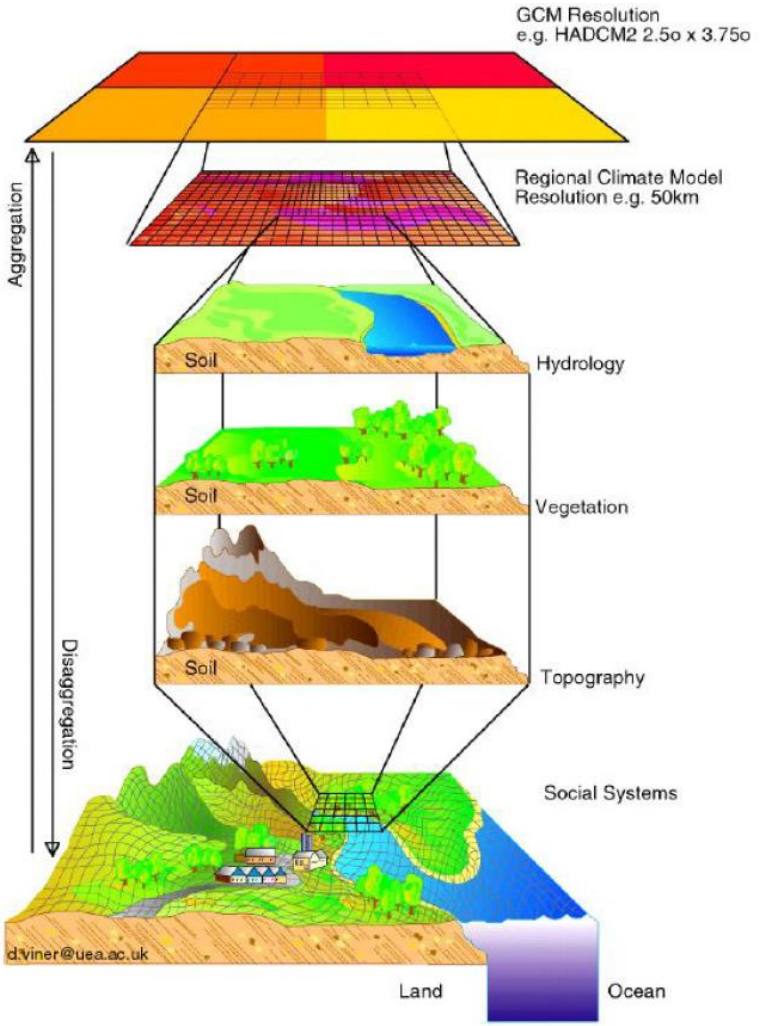
$$X_{large} \Leftrightarrow$$

$$\downarrow$$

$$Y_{local} \approx \mathcal{F}(X_{large}, \sigma)$$

$$\downarrow$$

$$Y_{local} \Leftrightarrow$$



...Downscaling consists in searching for valuable F.

METEO FRANCE
Toujours un temps d'avance

Forces and limits

- Composites and regressions :
  - 0 correlation means “no systematic effect”, it doesn’t mean “no effect”…
  - … and significant correlation doesn’t mean “100% sure”
    ➔ don’t forget the probabilistic nature of SF
    ➔ to be confirmed by analysis
  - climate trends could create “artificial” correlation

- Downscaling products (also relevant for RCM):
  - Don’t forget large scale forcings !
    ➔ predictability comes from large scale, should be taken into account when looking at downscaled products

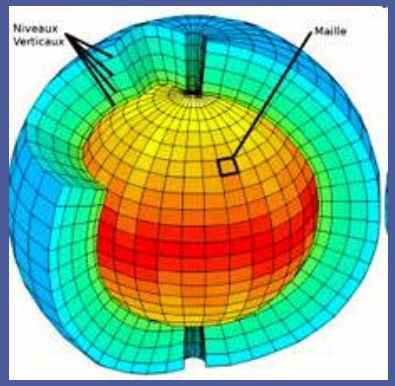
4. Conclusion

Conclusion : data and tools for SF production

- GCM : mainly able to predict **large scale features**
- Interpretation of GCM impact parameter forecasts (T, RR) :
  - to cross-check with circulation and knowledge on the impact of this circulation.
  - to interpret relatively to their skill : scores should help
- Seasonal forecast: basically **Probabilistic forecast**,
- **Forecast of the temporal Mean State** and not of the Weather,
- Confidence in the forecast depending of the place, the year and the parameter,

  - better in tropical regions than in the mid-latitudes regions
  - generally better for temperatures than for precipitations
  - better in the case of a strong forcing (El Niño)

Questions ?



HARTMANNSWILLER

Prévisions météo : la théorie des oignons de Noël

Rémy Gullung est passionné par la météo et les traditions paysannes d'autrefois. Cette année, la nuit de Noël, il n'a pas dérogé à ses habitudes : il a observé les oignons pour avoir un aperçu de la météo de 2015.

Le 30/12/2014 05:00

http://www.lalsace.fr/haut-rhin/2014/12/30/previsions-meteo-la-theorie-des-oignons-de-noel

Christian.viel@meteo.fr

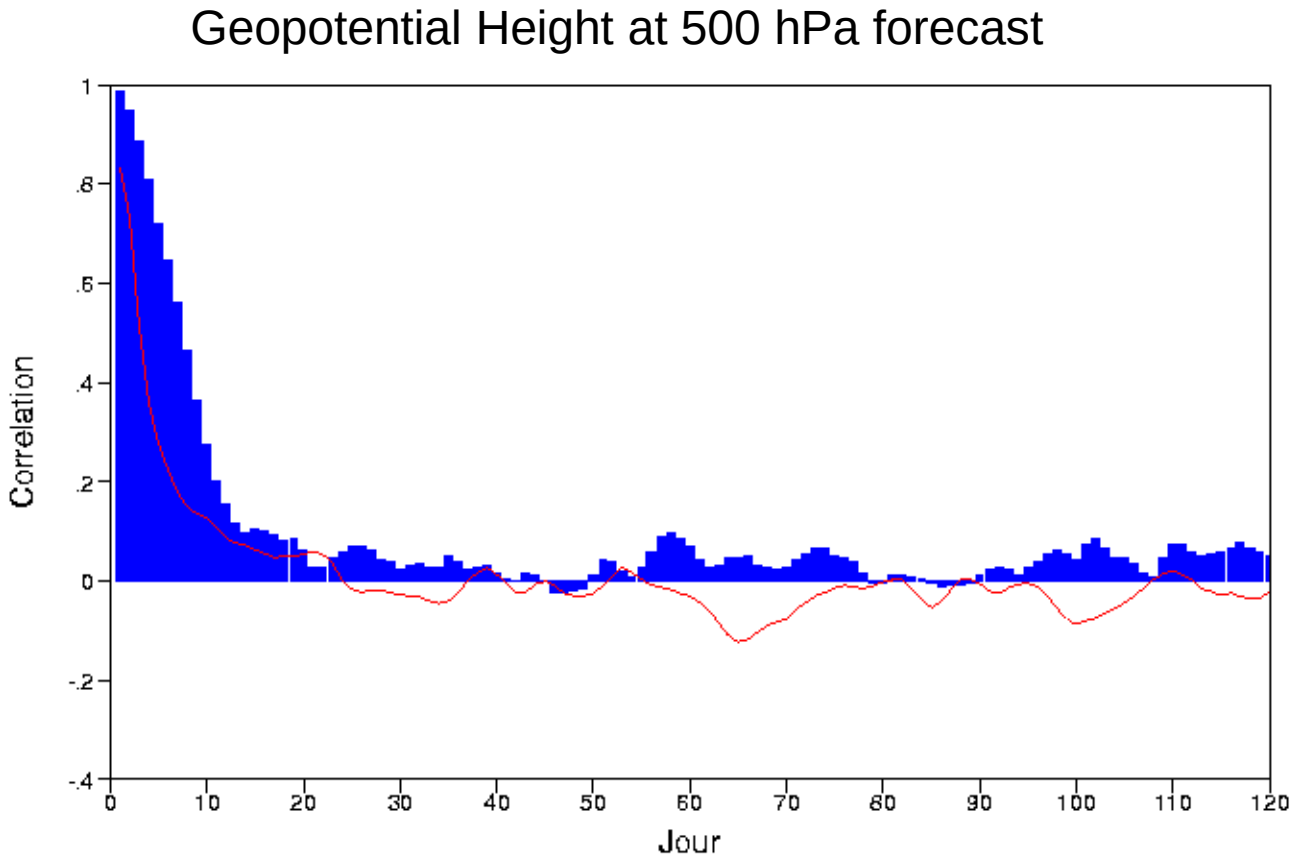
METEO FRANCE
Toujours un temps d'avance

Limitation of numerical forecast : Daily forecast

Daily Scores over Northern Hemisphere

+

Persistence Scores

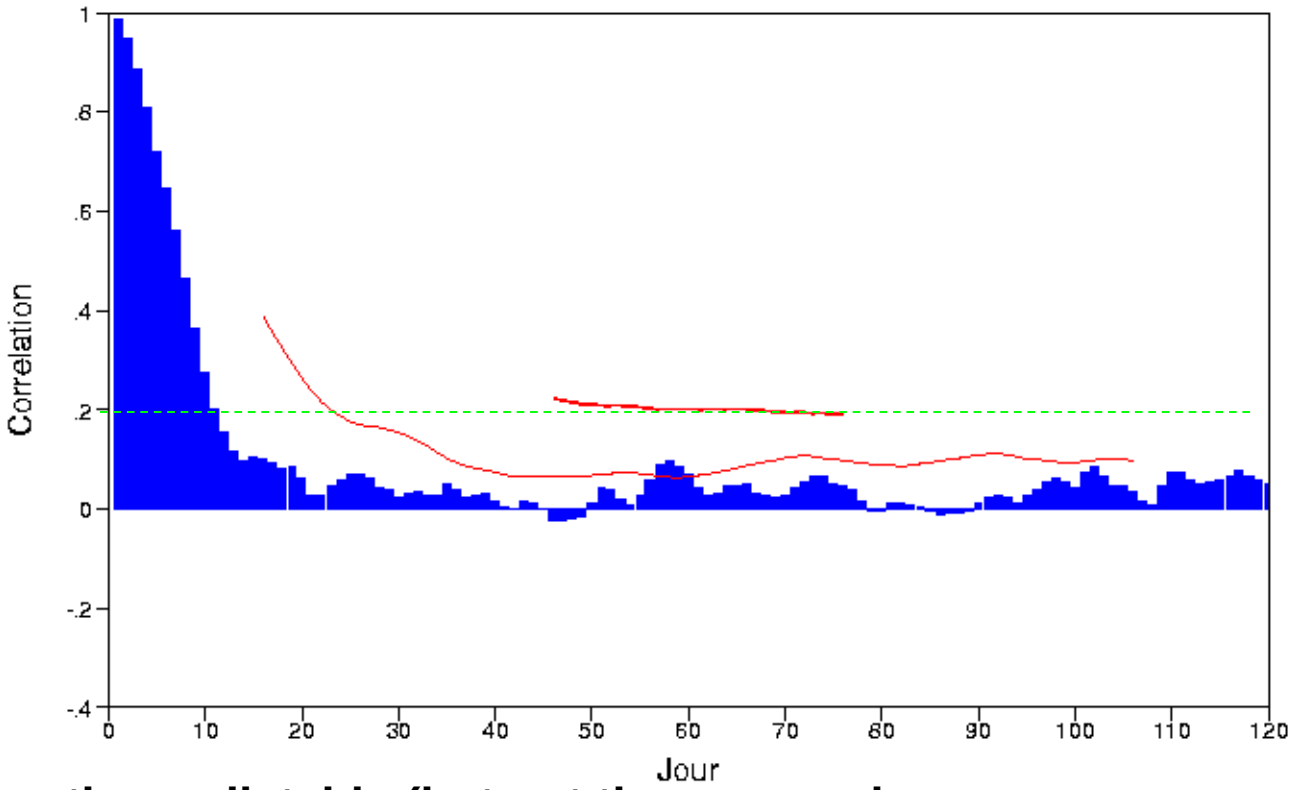


Limitation of numerical forecast : Seasonal forecast

Daily Scores over Northern Hemisphere

+

seasonal running mean Scores



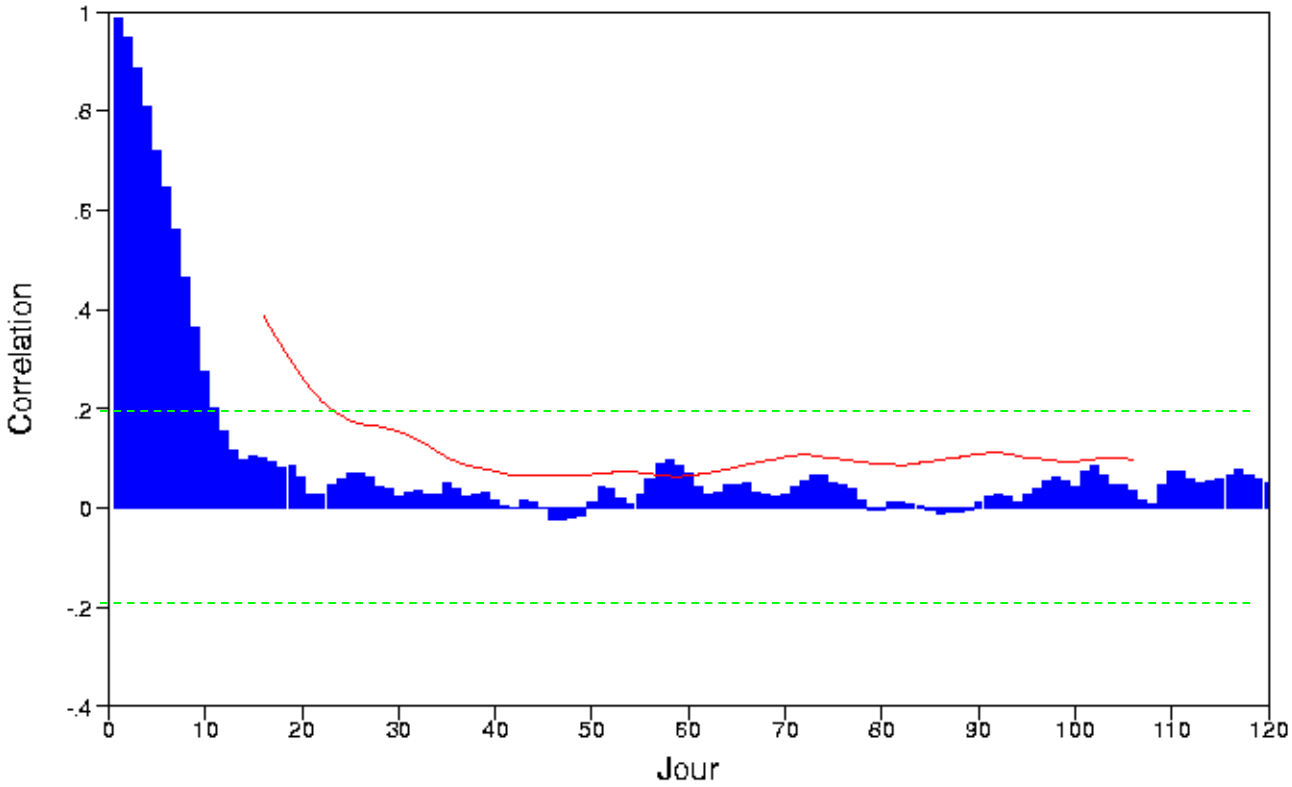
The mean state is partly predictable (but not the successive instantaneous states of the atmosphere)

Limitation of numerical forecast : Monthly forecast

Daily Scores over Northern Hemisphere

+

Monthly running mean Scores

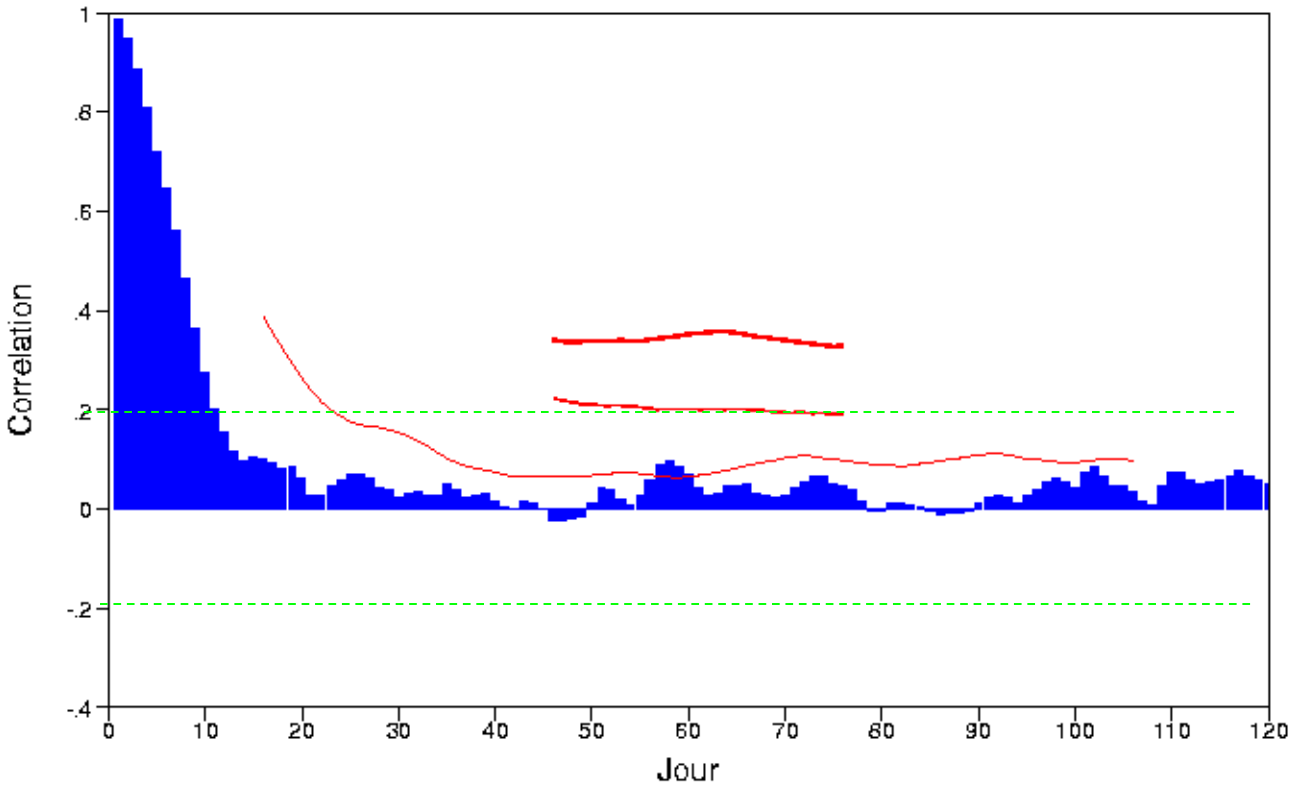


Limitation of numerical forecast : Seasonal forecast

Daily Scores over Northern Hemisphere

+

Ensemble forecast, seasonal running mean and SST forecast



The evolution of external forcing conditions

- **Evolution of Sea Surface temperature (SST)**
  - Interannual variability (like ENSO)
  - Decadal variability (like PDO)

- **Evolution of continental surface conditions**
  - Influence of continental surface conditions (snow, albedo, ..),
  - Intraseasonal variability (notably soil moisture)

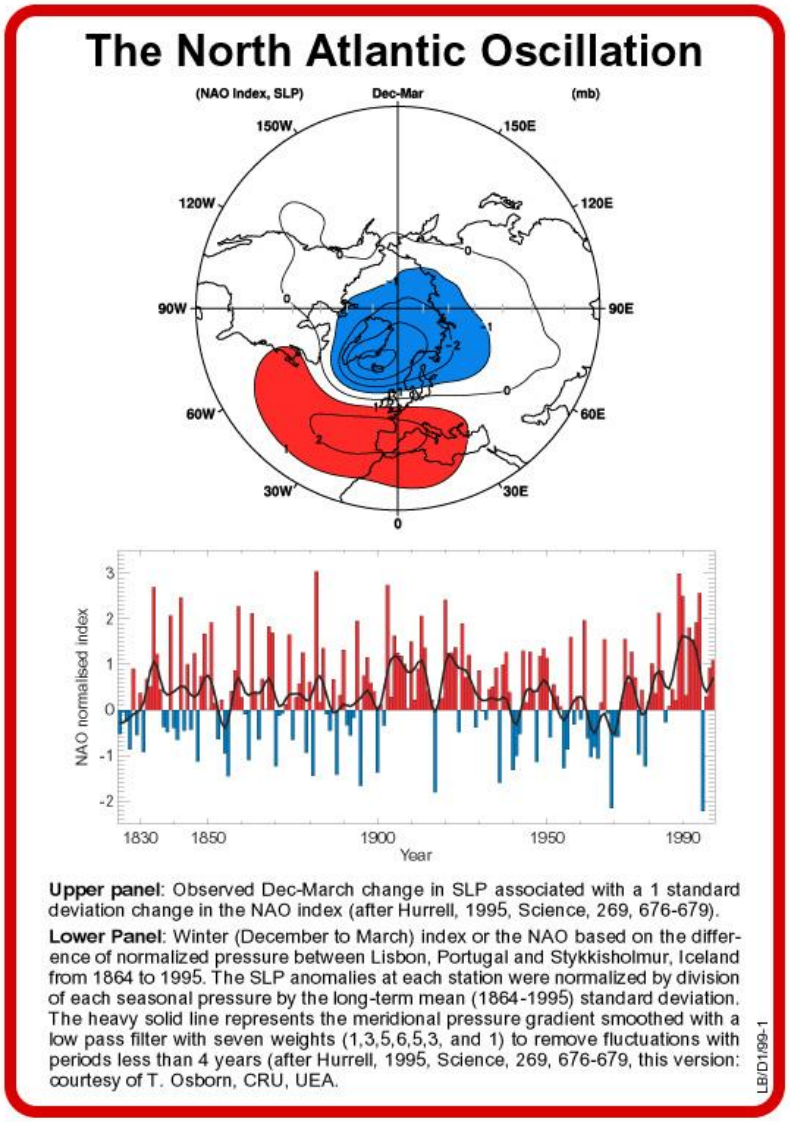
- **Mutual influences**
  - Decadal/ENSO
  - ENSO/Intraseasonal
  - Intraseasonal/Synoptic

The climatic variability

- The climatic variability : slow variation in the Atmosphere
  - NAO
  - PNA mode
  - PDO
  - QBO or TBO
  - http://www.cpc.ncep.noaa.gov/data/teledoc/telecontents.shtml

  and Barnston and Livezey 1987, Mon. Wea. Rev., 115, 1083-1126)

The « North Atlantic Oscillation »



NAO positive phase (NAO+)

- increase in the north-south gradient of pressure over the North Atlantic region

- acceleration of the circulation of perturbations

Winter Regimes and extremes