Seasonal forecasting at ECMWF

L. Ferranti

The operational forecasting system

- High resolution forecast: twice per day
  16 km 91-level, to 10 days ahead

- Ensemble: twice daily
  51 members, 30/60 km 91levels, to 15 days ahead

- Extended range forecasts /ENS extension: twice a week (Mon/Thursdays)
  51 members, 30/60 km 91 levels, to 1 month ahead

- **Long range forecasts: once a month (coupled to ocean model) members, ~80 km 91 levels, to 7 months ahead**

Long range forecasts provide information about atmospheric and oceanic conditions averaged over the next few months.

Despite the chaotic nature of the atmosphere, long term predictions rely on a number of components which themselves show variations on long time scales (seasons and years) and, to a certain extent, are predictable.

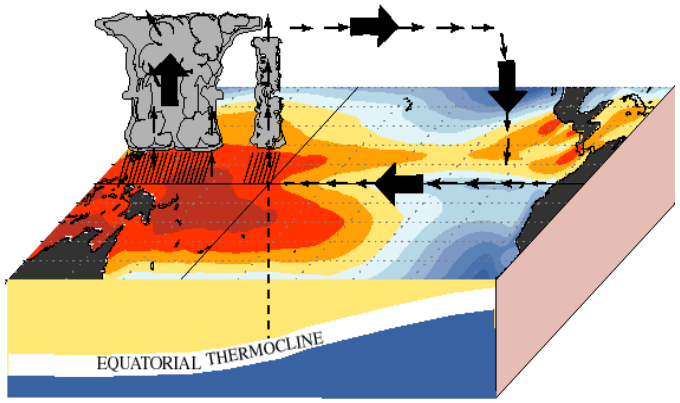
The most important of these components is the ENSO (El Nino Southern Oscillation) cycle. Although ENSO is a coupled ocean-atmosphere phenomenon centred over the tropical Pacific it affect atmospheric circulation over remote regions.

- **ENSO variability**

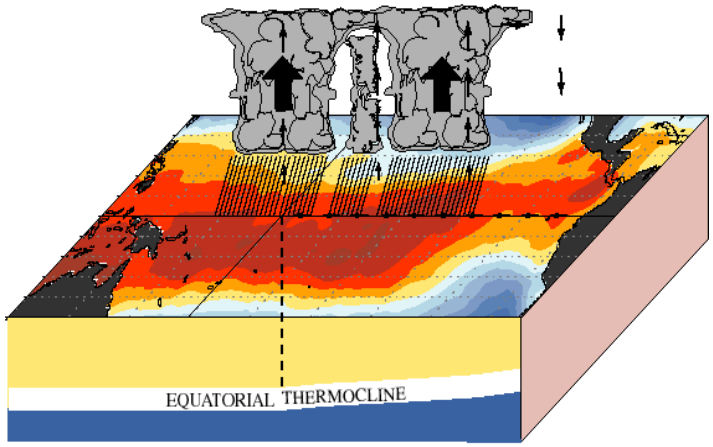
- **Other tropical ocean SST**
- **Climate change** - long term trends
- **Land surface conditions** - e.g. soil moisture in 2003, sea-ice

THE EL NIÑO/SOUTHERN OSCILLATION (ENSO) CYCLE

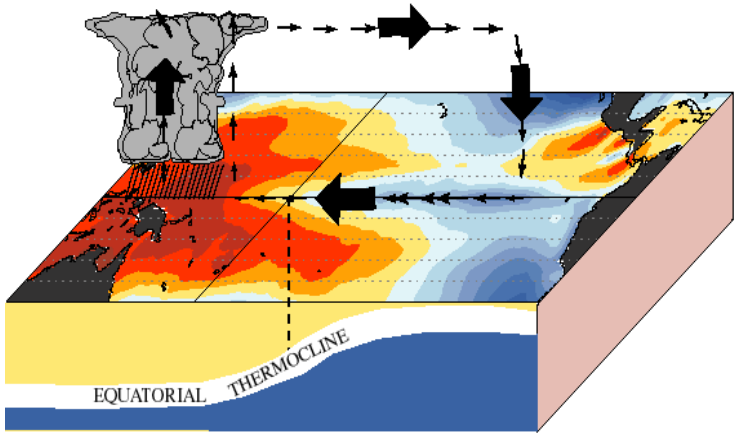
December - February Normal Conditions



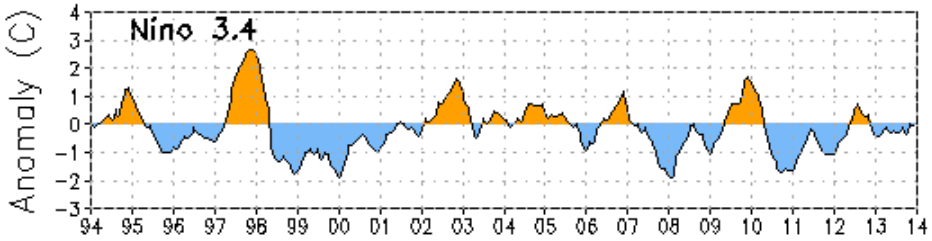
December - February El Niño Conditions



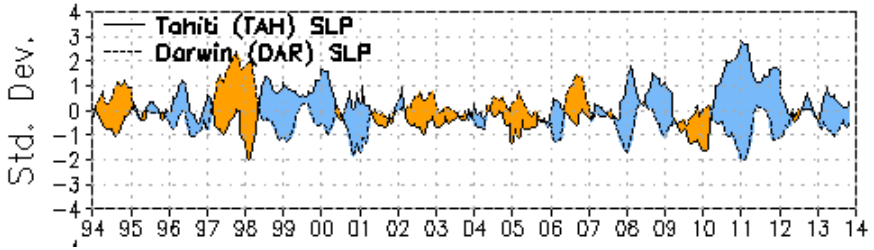
December - February La Niña Conditions



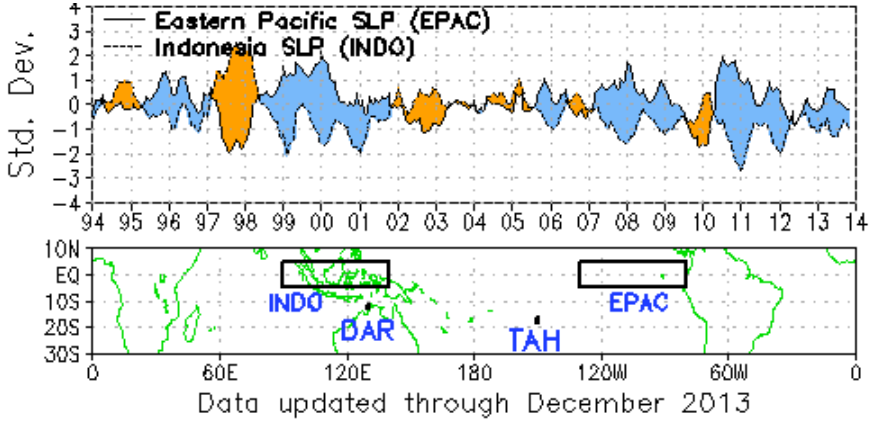
Sea Surface Temperature (SST) anomalies over the Equatorial Pacific:



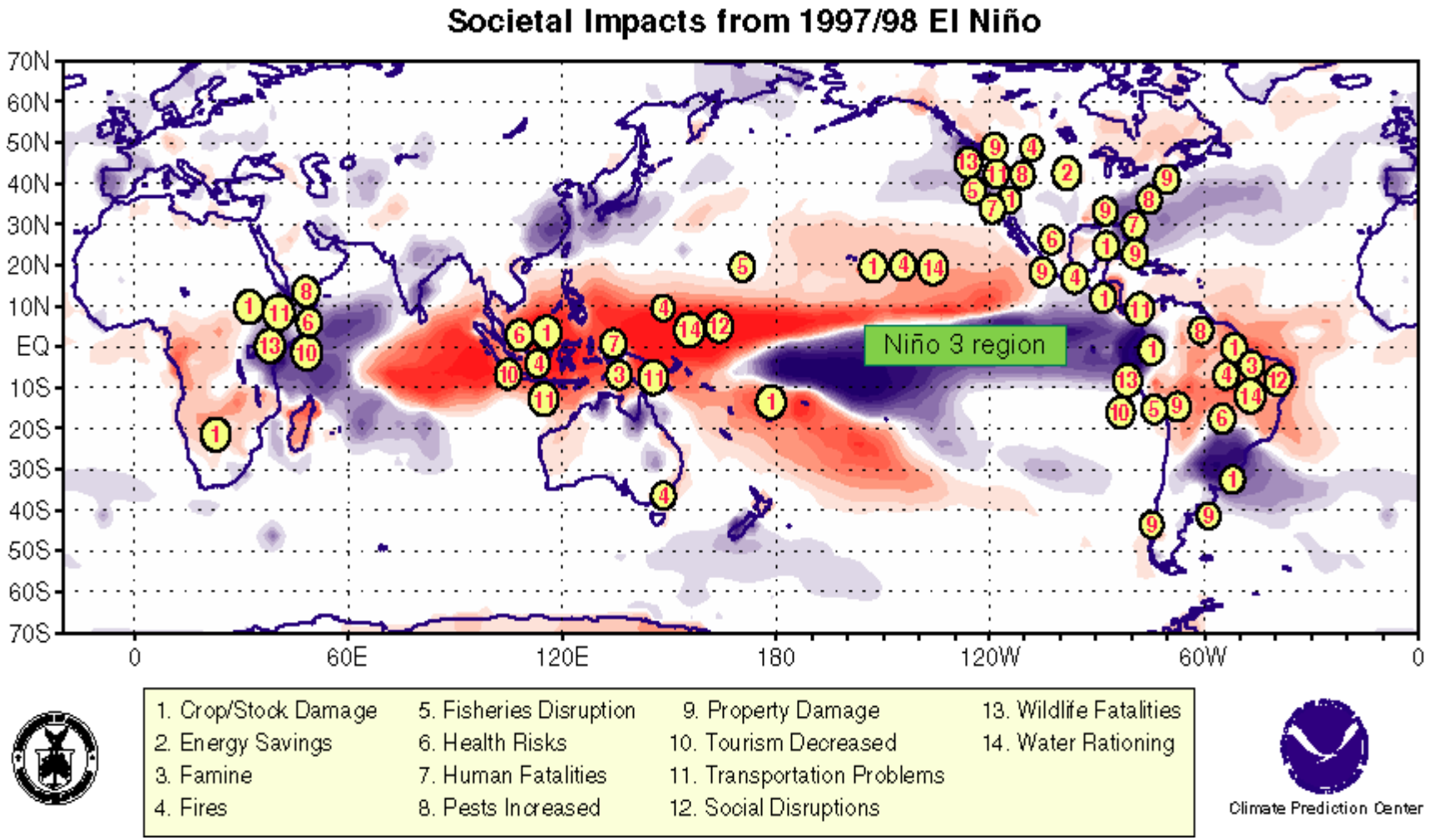
Southern Oscillation Index (SOI):



Equatorial Southern Oscillation Index (SOI):

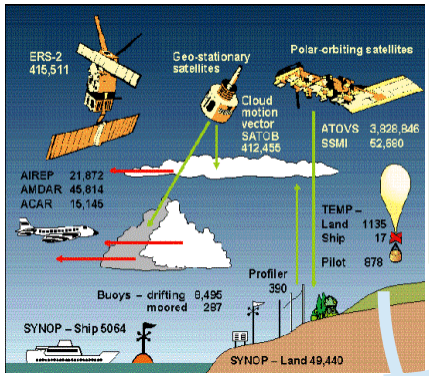


Weather-related natural disasters



ECMWF Seasonal Forecasting System

Observations



Data Assimilation

Current state of the atmosphere

Current state of the ocean

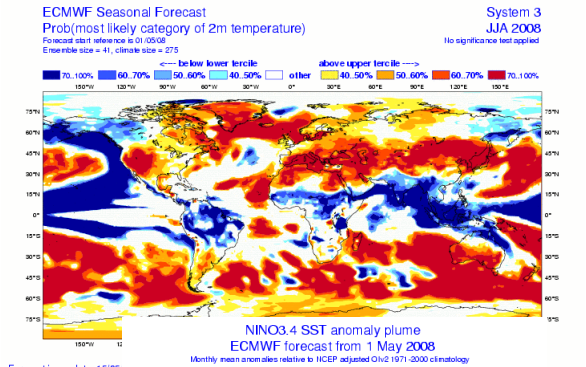
Coupled model

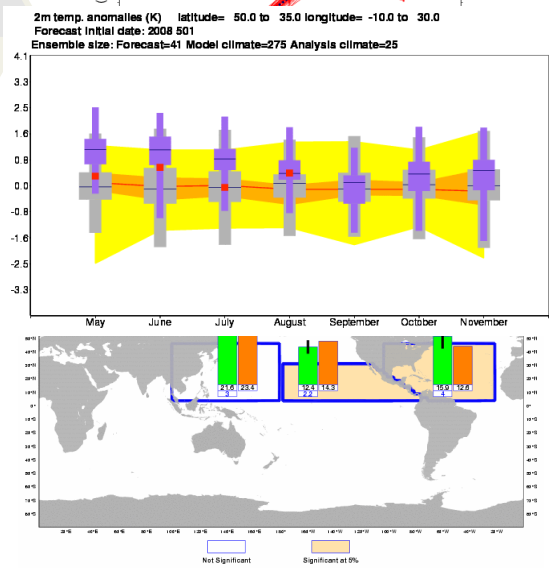
Atmospheric model

Coupler

Ocean Model

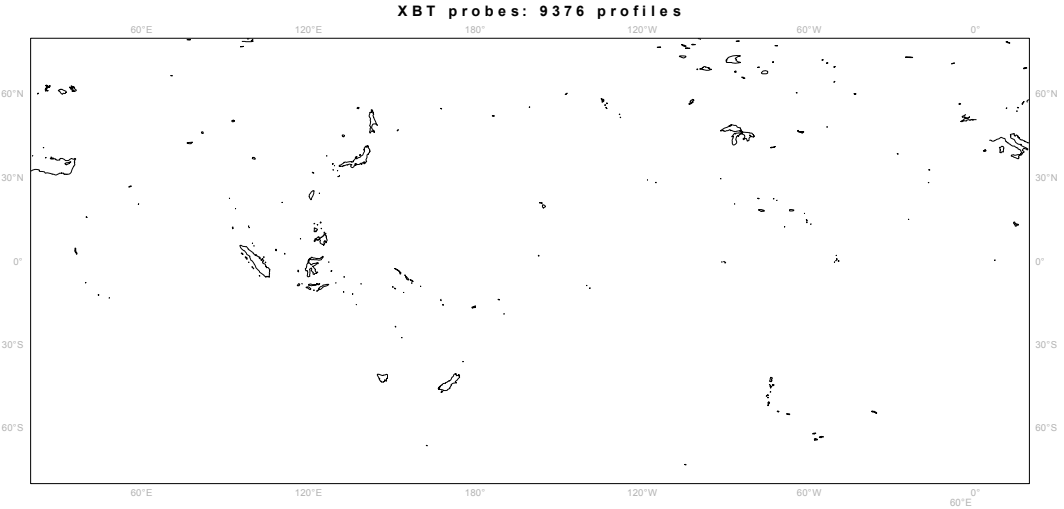
Forecast Products





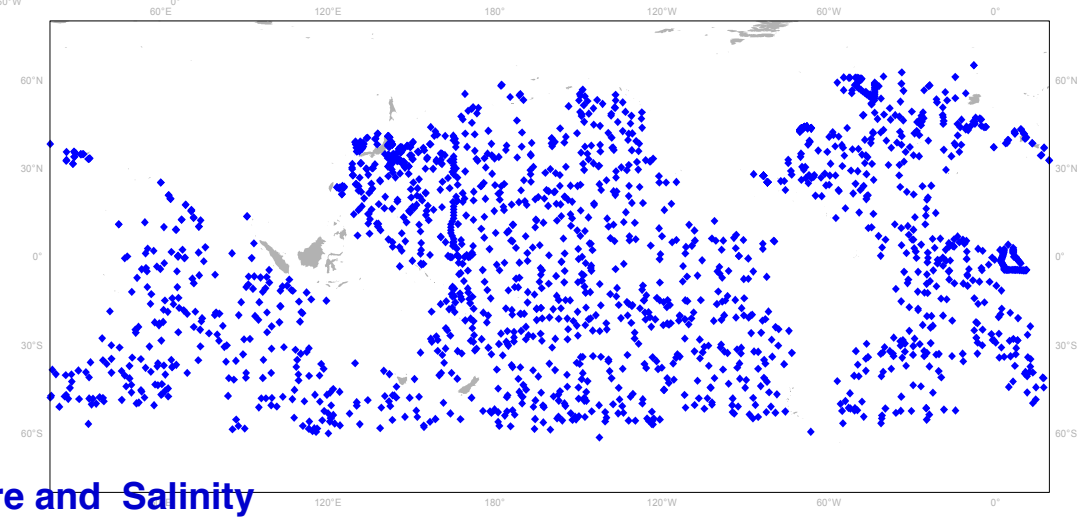
Ocean Observing System

Data coverage for June 1982



Changing observing system is a challenge for consistent reanalysis

Data coverage for Nov 2005



Today's Observations will be used in years to come

▲**Moorings: Subsurface Temperature**

◊ **ARGO floats: Subsurface Temperature and Salinity**

+ XBT : Subsurface Temperature

ECMWF System 4: main features

- **Operational forecasts**
  - **51-member ensemble from 1st day of the month**
  - **released on the 8th**
  - **7-month integration**

- **Re-forecast set**
  - **30 years, start dates from 1 Jan 1981 to 1 Dec 2010**
  - **15-member ensembles, 7-month integrations**
  - **13-month extension from 1st Feb/May/Aug/Nov**

- **Experimental ENSO outlook**
  - **13-month extension from 1st Feb/May/Aug/Nov**
  - **15-member ensemble**

Products :

- Ocean Analysis

- Seasonal outlook: (up to 7 months ahead)

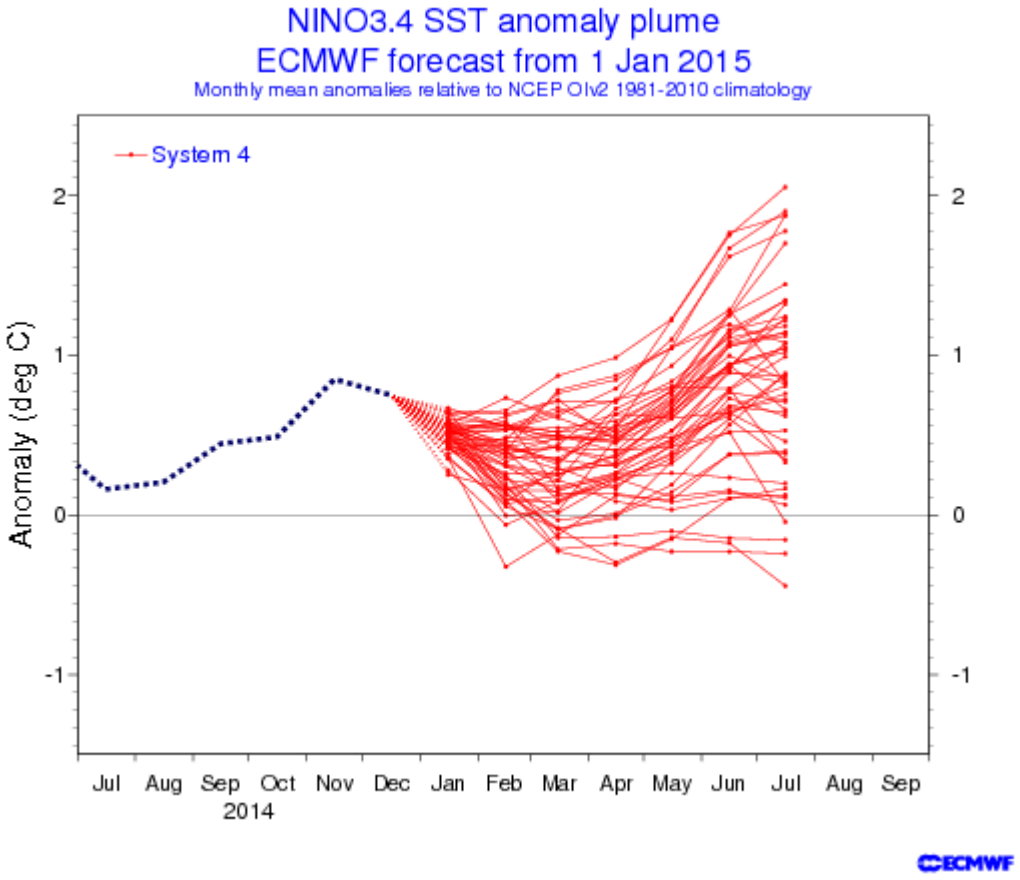
  - Forecasts for Nino3, Nino3.4 and Nino4

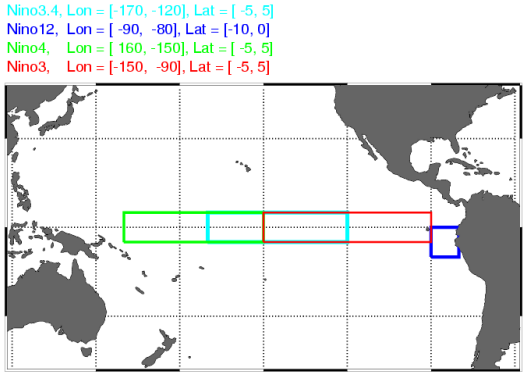
  - Spatial plots (ens.mean anomaly, terciles ..)

  - Climagrams (similar to Epsgrams, teleconenction patterns)

  - Tropical storms

NINO3.4 plumes



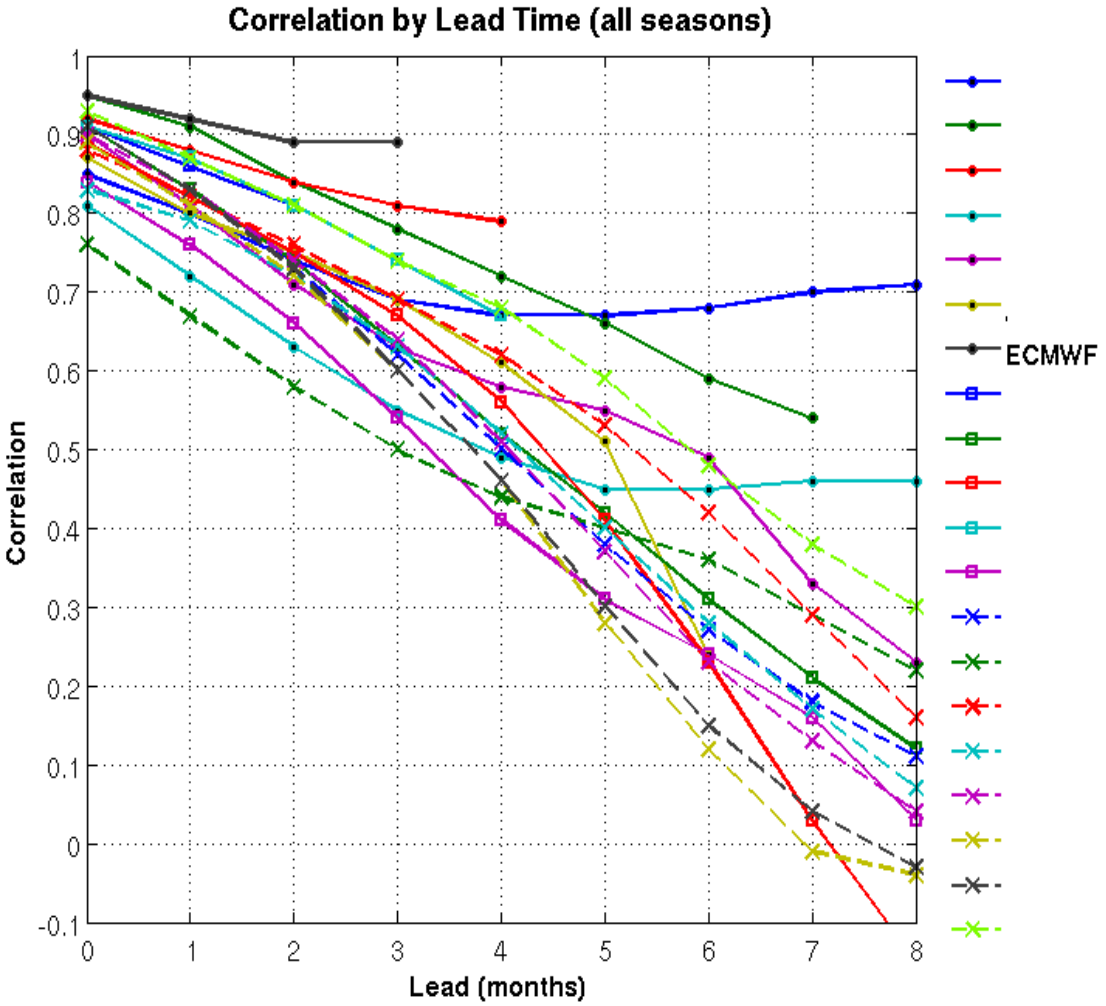


Forecast is made available on the 8h of each month.

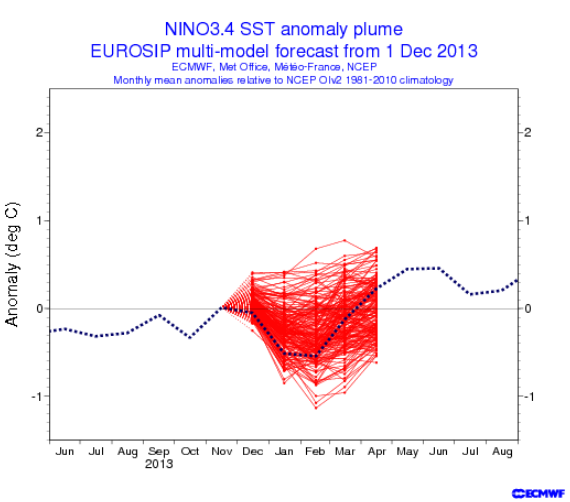
ENSO skill: comparison with other seasonal fc. systems

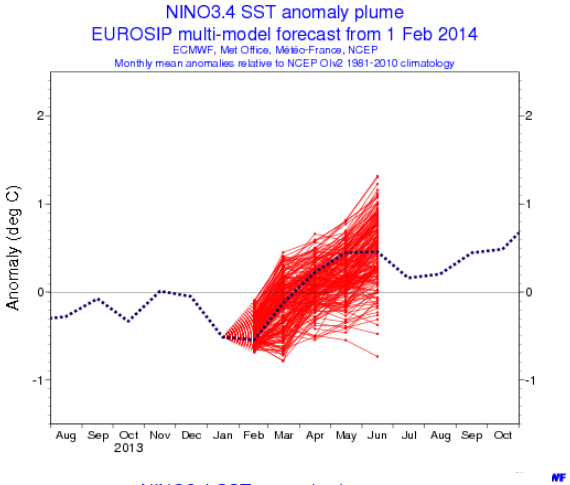
NINO3.4
Anomaly
Correlation

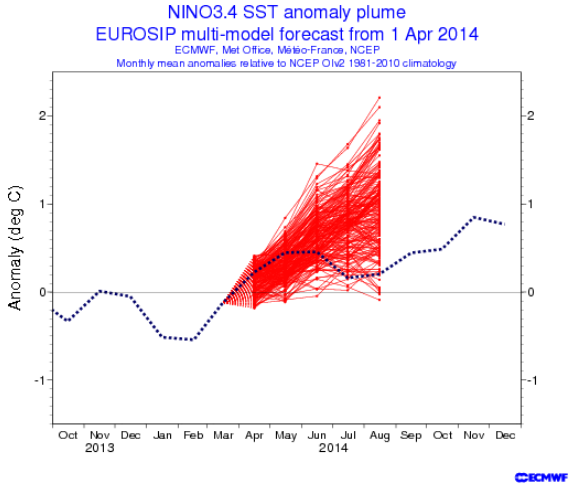
3-month
running means

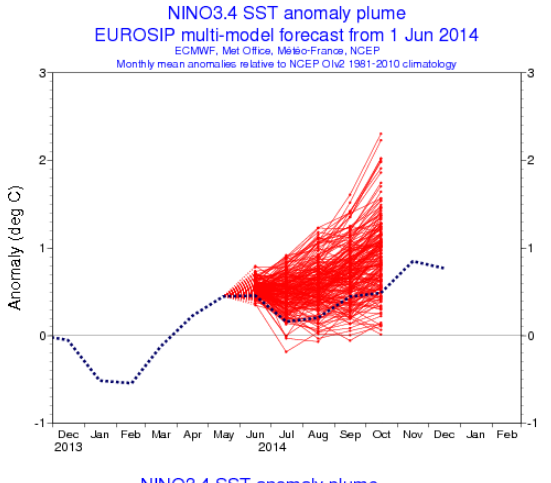


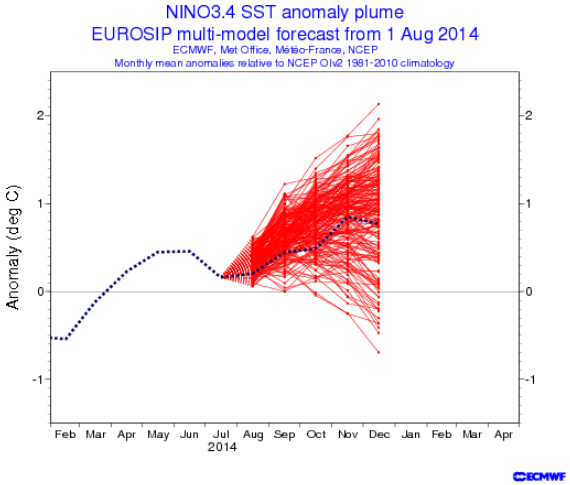
From: Barnston et al. 2011: Skill of Real-time Seasonal ENSO Model Predictions during 2002-2011—Is Our Capability Increasing? BAMS

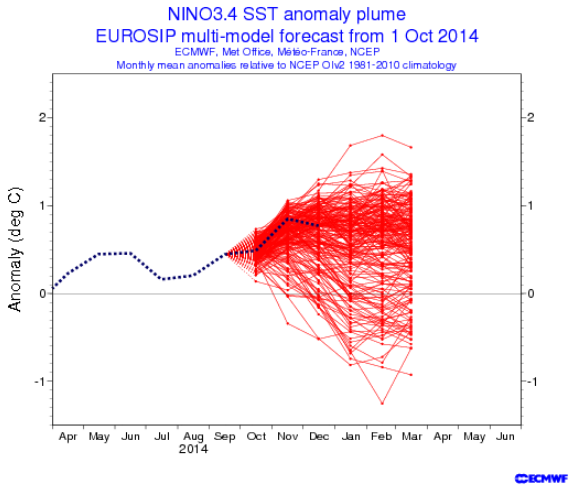

NINO3.4 SST anomaly plume
EUROSIP multi-model forecast from 1 Dec 2013
ECMWF, Met Office, Météo-France, NCEP
Monthly mean anomalies relative to NCEP OIv2 1981-2010 climatology
Anomaly (deg C)
Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug
2013
ECMWF

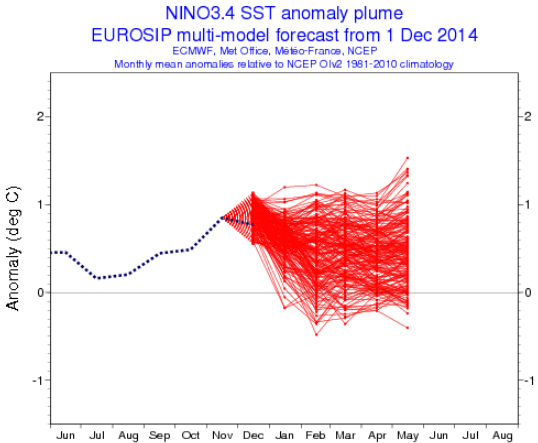

NINO3.4 SST anomaly plume
EUROSIP multi-model forecast from 1 Feb 2014
ECMWF, Met Office, Météo-France, NCEP
Monthly mean anomalies relative to NCEP OIv2 1981-2010 climatology
Anomaly (deg C)
Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct
2013


NINO3.4 SST anomaly plume
EUROSIP multi-model forecast from 1 Apr 2014
ECMWF, Met Office, Météo-France, NCEP
Monthly mean anomalies relative to NCEP OIv2 1981-2010 climatology
Anomaly (deg C)
Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
2013
2014
ECMWF


NINO3.4 SST anomaly plume
EUROSIP multi-model forecast from 1 Jun 2014
ECMWF, Met Office, Météo-France, NCEP
Monthly mean anomalies relative to NCEP OIv2 1981-2010 climatology
Anomaly (deg C)
Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb
2013
2014

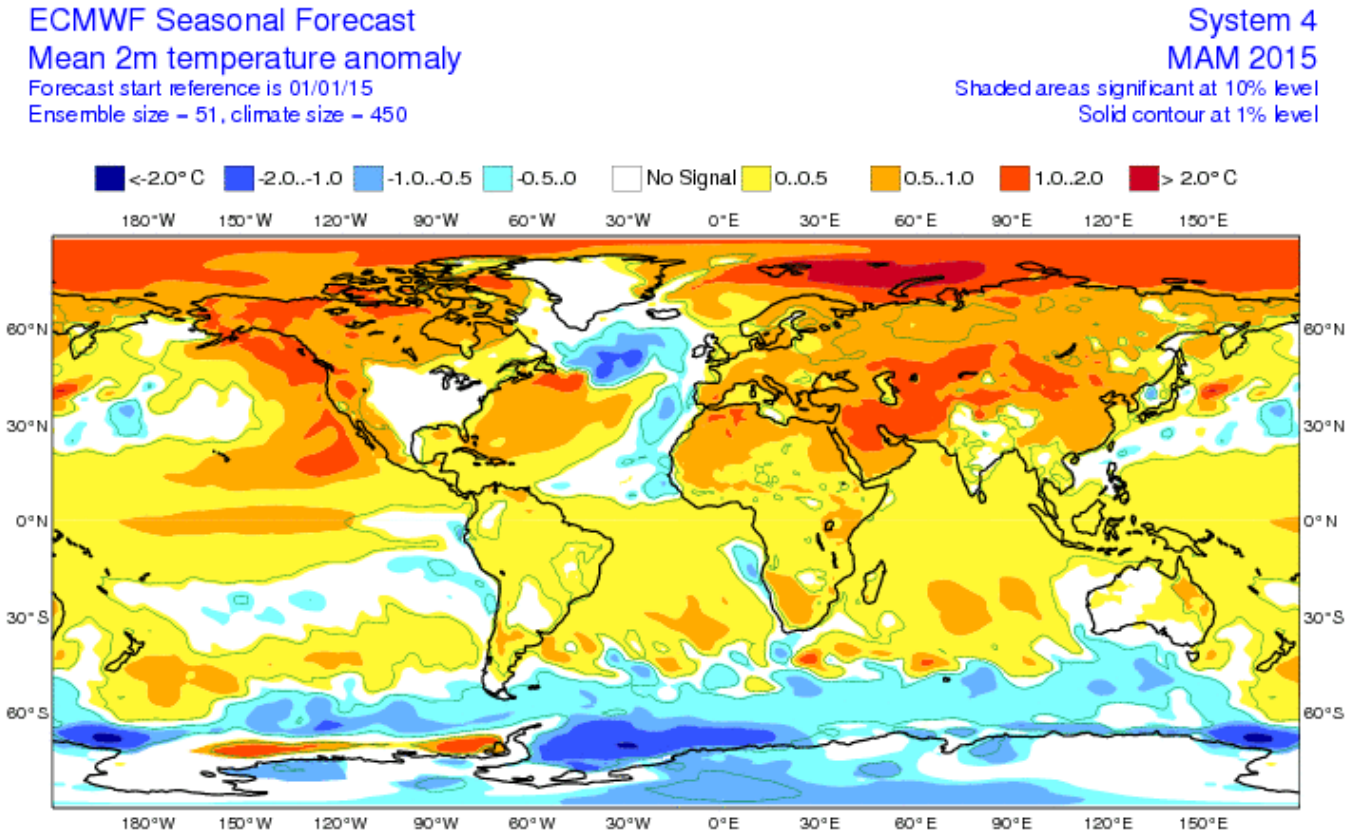

NINO3.4 SST anomaly plume
EUROSIP multi-model forecast from 1 Aug 2014
ECMWF, Met Office, Météo-France, NCEP
Monthly mean anomalies relative to NCEP OIv2 1981-2010 climatology
Anomaly (deg C)
Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr
2014
ECMWF


NINO3.4 SST anomaly plume
EUROSIP multi-model forecast from 1 Oct 2014
ECMWF, Met Office, Météo-France, NCEP
Monthly mean anomalies relative to NCEP OIv2 1981-2010 climatology
Anomaly (deg C)
Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun
2014
ECMWF


NINO3.4 SST anomaly plume
EUROSIP multi-model forecast from 1 Dec 2014
ECMWF, Met Office, Météo-France, NCEP
Monthly mean anomalies relative to NCEP OIv2 1981-2010 climatology
Anomaly (deg C)
Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug

Seasonal forecast charts :

Spatial maps representing the seasonal forecast in terms of model probabilities stratified by terciles.



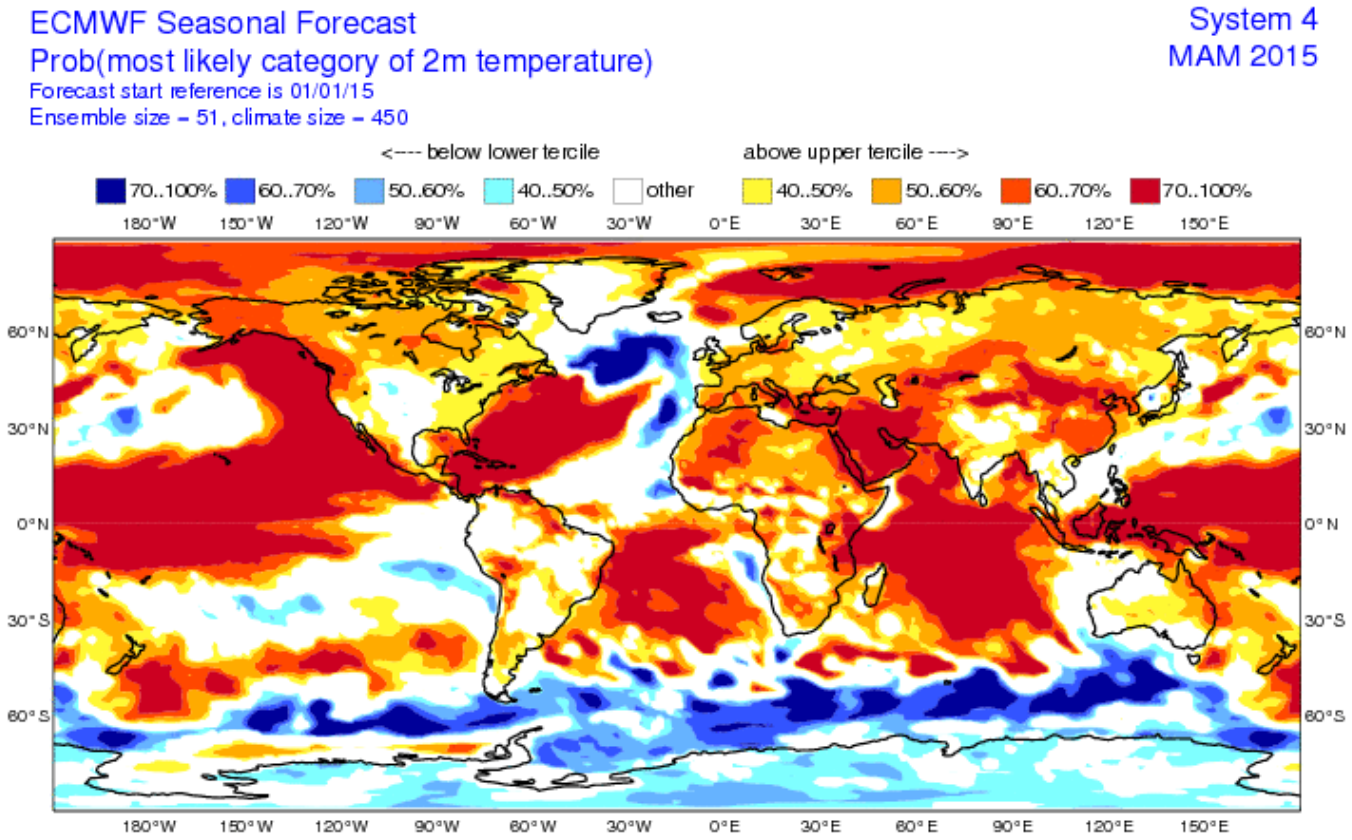
Available parameters are:

- 2m Temperature
- Mean sea level pressure
- Precipitation
- Sea surface temperature
- 850 hPa temperature
- 500 hPa geopotential

Forecast is made available on the 8th of each month.

Seasonal forecast charts :

Spatial maps representing the seasonal forecast in terms of model probabilities stratified by terciles.



Available parameters are:

- 2m Temperature
- Mean sea level pressure
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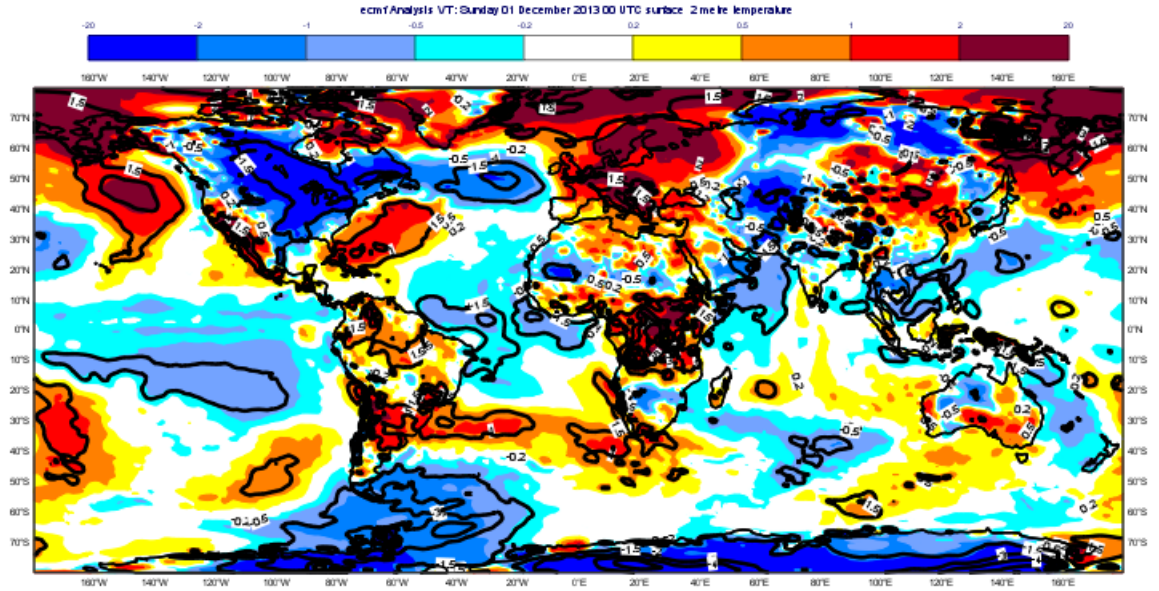
- Sea surface temperature
- 850 hPa temperature
- 500 hPa geopotential

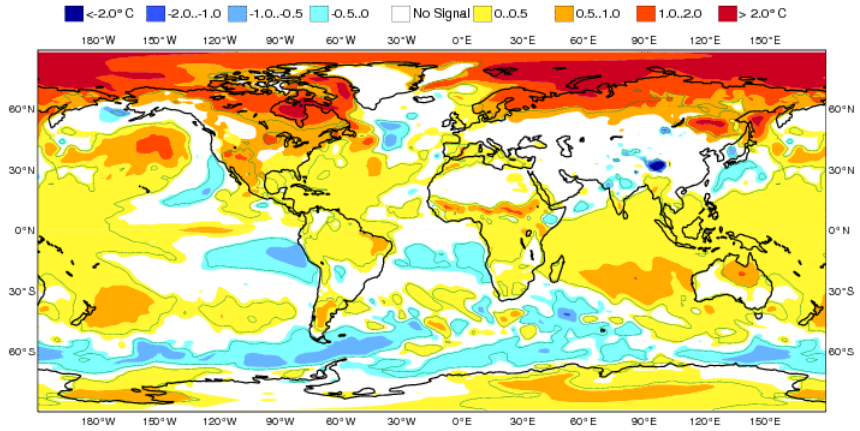
Forecast is made available on the 8h of each month

DJF 2014 : 2m temp anomalies



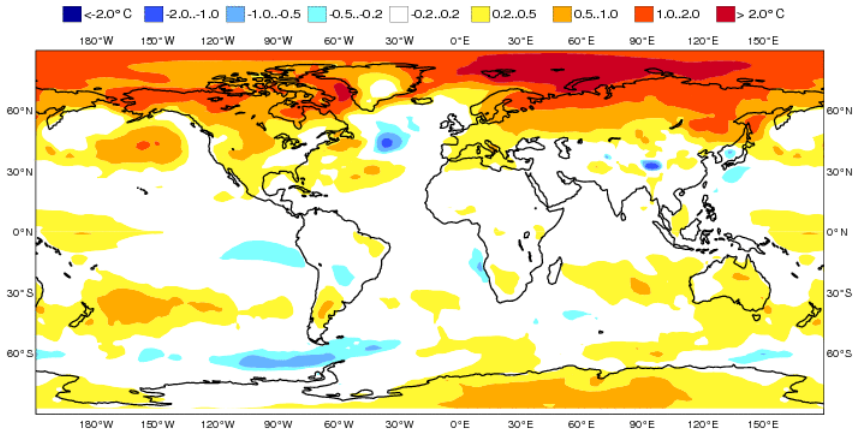
ECMWF Seasonal Forecast
Mean 2m temperature anomaly
Forecast start reference is 01/11/13
Ensemble size = 51, climate size = 450

System 4
DJF 2013/14
Shaded areas significant at 10% level
Solid contour at 1% level

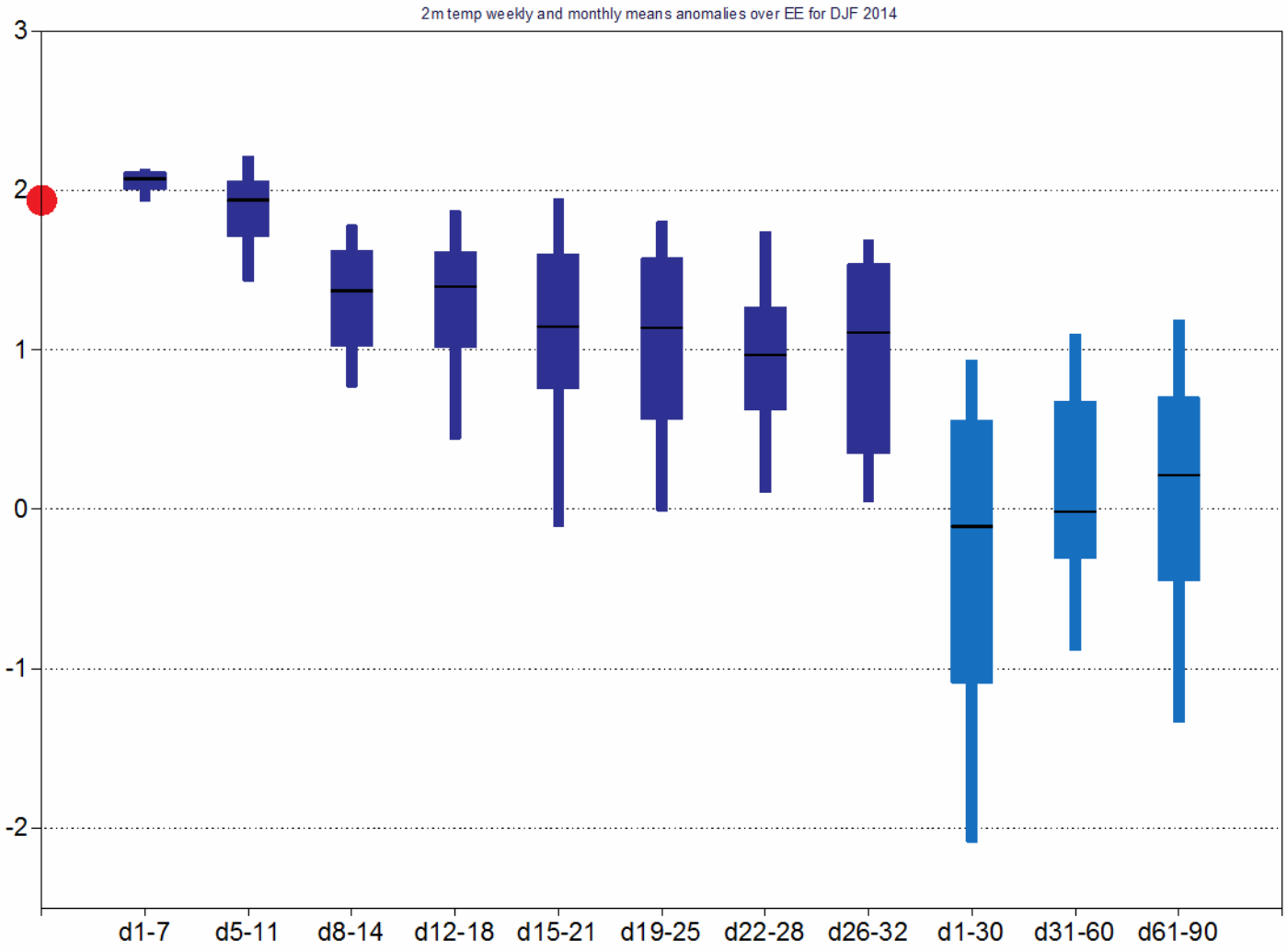


EUROSIP multi-model seasonal forecast
Mean 2m temperature anomaly
Forecast start reference is 01/11/13
Variance-standardized mean

ECMWF/Met Office/Meteo-France/NCEP
DJF 2013/14



Predictability of seasonal mean anomalies:
2m temp anomalies averaged over Eastern Europe fo

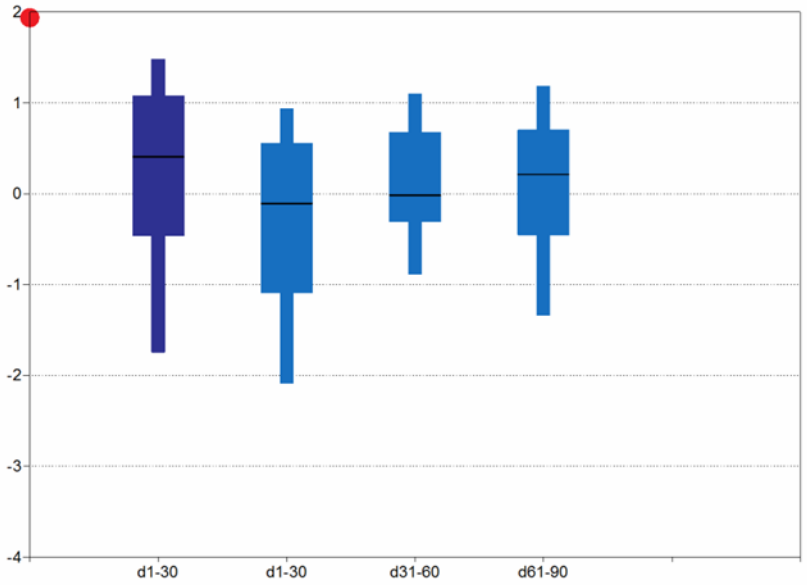


Predictability of seasonal mean anomalies:

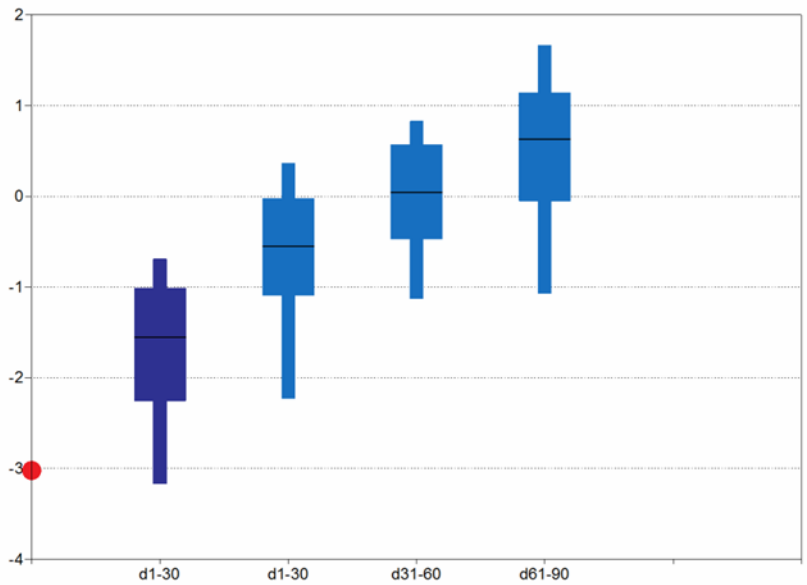
Monthly system versus Seasonal system

2m temp. anomalies for DJF 2014 averaged over:

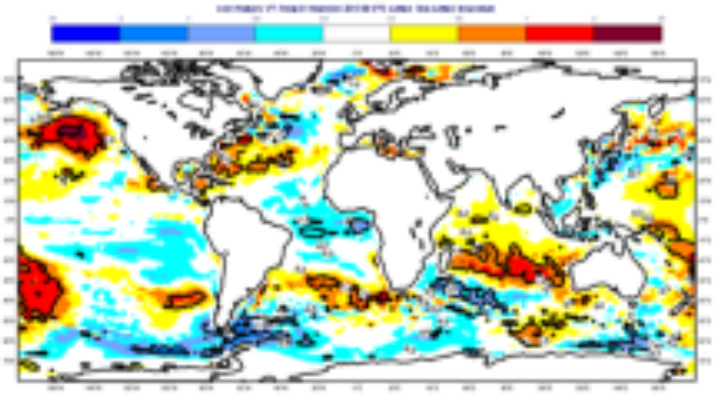
Eastern Europe

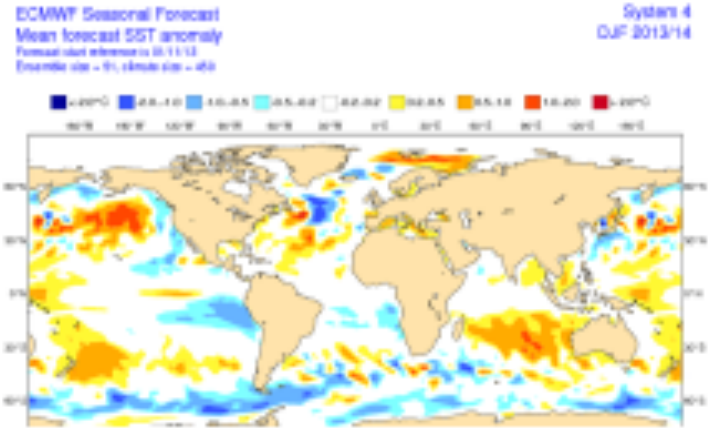


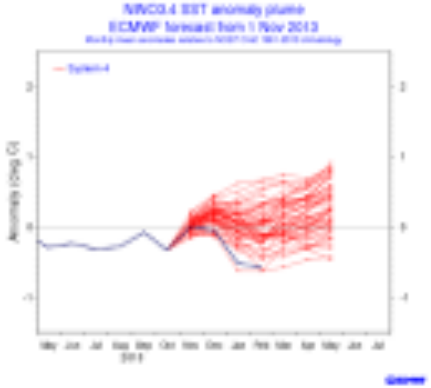
North America

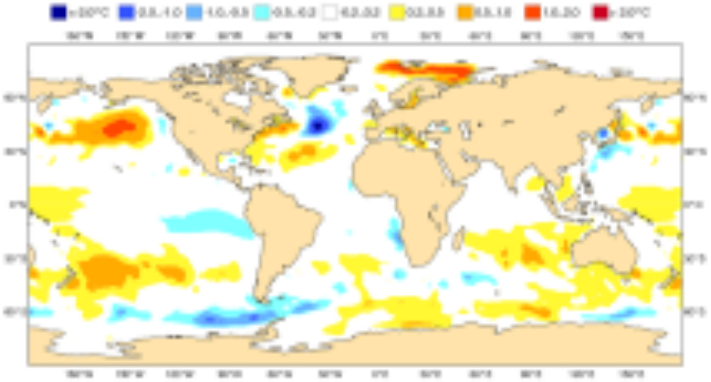


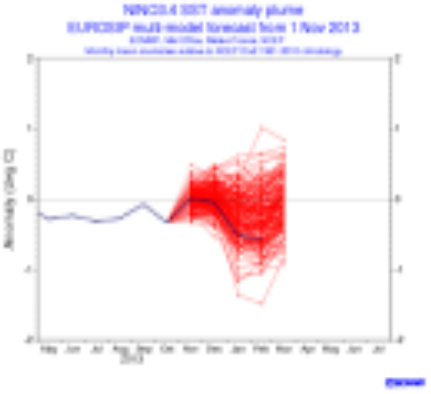
DJF 2014: SST anomalies







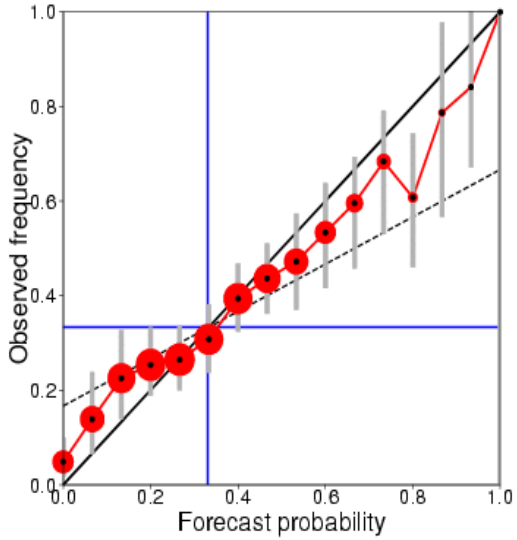




Reliability: 2m T > upper tercile over Europe, JJA

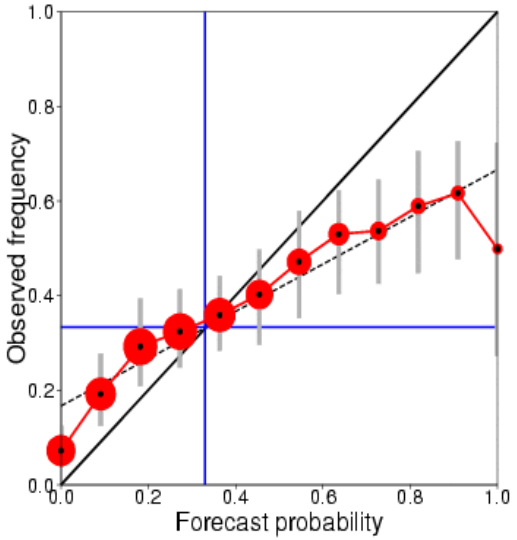
Sys 4

Reliability diagram for ECMWF with 15 ensemble members
Near-surface air temperature anomalies above the upper tercile
Accumulated over Europe (land and sea points)
Hindcast period 1981-2010 with start in May average over months 2 to 4
Skill scores and 95% conf. intervals (1000 samples)
Brier skill score: 0.092 (0.007, 0.162)
Reliability skill score: 0.986 (0.950, 0.994)
Resolution skill score: 0.106 (0.056, 0.173)



Sys 3

Reliability diagram for ECMWF with 11 ensemble members
Near-surface air temperature anomalies above the upper tercile
Accumulated over Europe (land and sea points)
Hindcast period 1981-2010 with start in May average over months 2 to 4
Skill scores and 95% conf. intervals (1000 samples)
Brier skill score: 0.031 (-0.045, 0.094)
Reliability skill score: 0.943 (0.891, 0.965)
Resolution skill score: 0.089 (0.056, 0.133)



Validation :

- Documentation of skill levels is provided to the users:

- The measure of skill conforms to a common standard defined by the WMO

- The verification sampling for seasonal forecast is limited, importance of significance levels in the verification statistics

ECMWF

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2m temperature

Parameter

2m temperature
mean sea level pressure
rain
sea surface temperature
850 hPa temperature
500 hPa geopotential

Lead time | **Area** | **Forecast type and skill measures**

two months lead time | Global | tercile summary

Month

Jan 2014

Jan 2014
Dec 2013
Nov 2013
Oct 2013
Sep 2013
Aug 2013
...

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Lead time
Area
Month
Forecast type and skill measures

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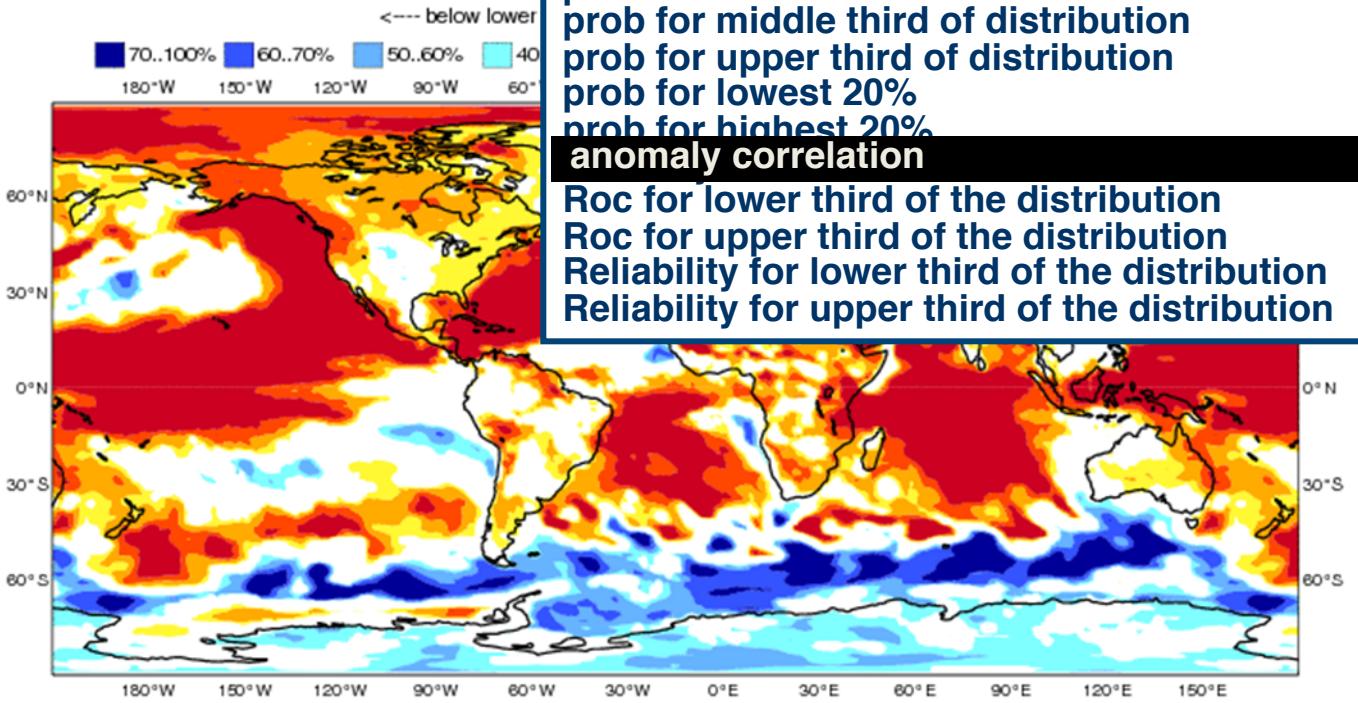
Postscript (1.2 Mbytes)

ECMWF Seasonal Forecast
Prob(most likely category of 2m temp
Forecast start reference is 01/01/15
Ensemble size = 51, climate size = 450



- tercile summary
- ensemble mean
- prob exceeding median
- prob for lower third of distribution
- prob for middle third of distribution
- prob for upper third of distribution
- prob for lowest 20%
- prob for highest 20%
- **anomaly correlation**
- Roc for lower third of the distribution
- Roc for upper third of the distribution
- Reliability for lower third of the distribution
- Reliability for upper third of the distribution

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2m temperature

Parameter

- 2m temperature
- mean sea level pressure
- rain
- sea surface temperature
- 850 hPa temperature
- 500 hPa geopotential

Month

Jan 2014

- Jan 2014
- Dec 2013
- Nov 2013
- Oct 2013
- Sep 2013
- Aug 2013
- ...

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Show overview

- Lead time
- Area
- Month
- Forecast type and skill measures

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Lead time | **Area** | **Forecast type and skill measures**

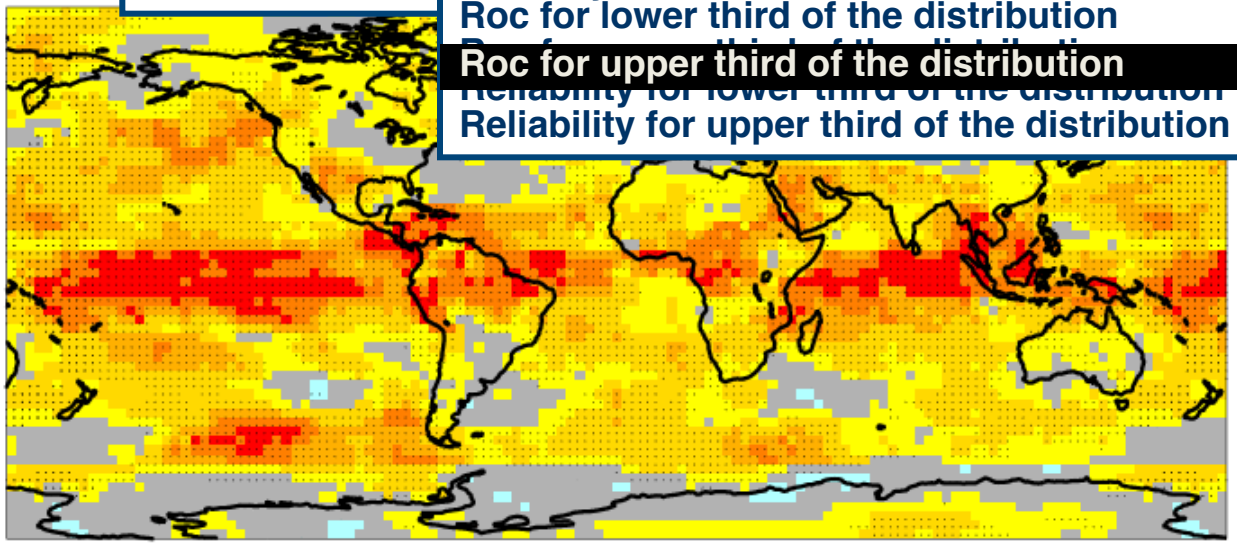
two months lead time | Global | anomaly correlation

Anomaly Co
Near-surfac
Hindcast pe
Black dots f

-1

Global
Tropics
Europe
Africa
East Asia
Asia
Australasia
North America
South America

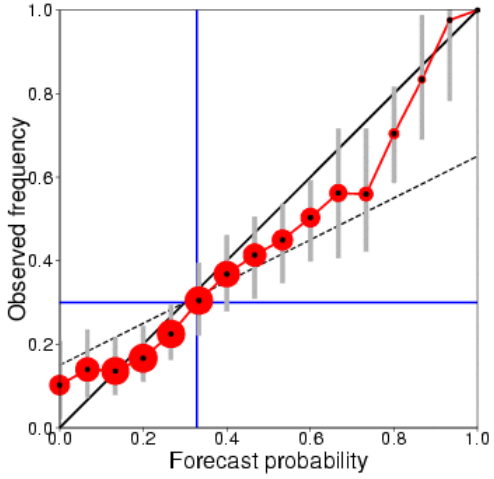
tercile summary
ensemble mean
prob exceeding median
prob for lower third of distribution
prob for middle third of distribution
prob for upper third of distribution
prob for lowest 20%
prob for highest 20%
anomaly correlation
Roc for lower third of the distribution
Roc for upper third of the distribution
Reliability for upper third of the distribution



Reliability for summer predictions: warm events

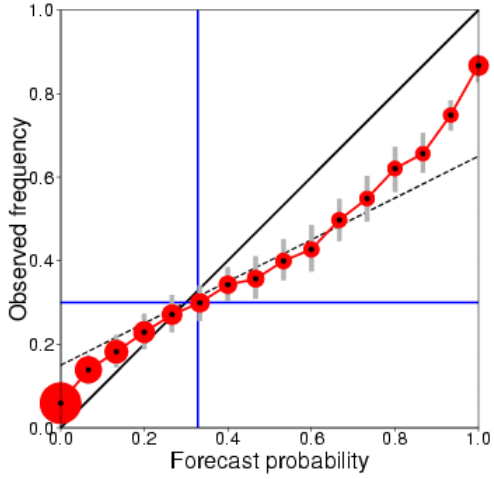
Europe

Reliability diagram for ECMWF with 15 ensemble members
Near-surface air temperature anomalies below the lower tercile
Accumulated over Europe (land and sea points)
Hindcast period 1981-2010 with start in May average over months 2 to 4
Skill scores and 95% conf. intervals (1000 samples)
Brier skill score: 0.108 (0.009, 0.183)
Reliability skill score: 0.980 (0.921, 0.991)
Resolution skill score: 0.128 (0.072, 0.203)



Tropics

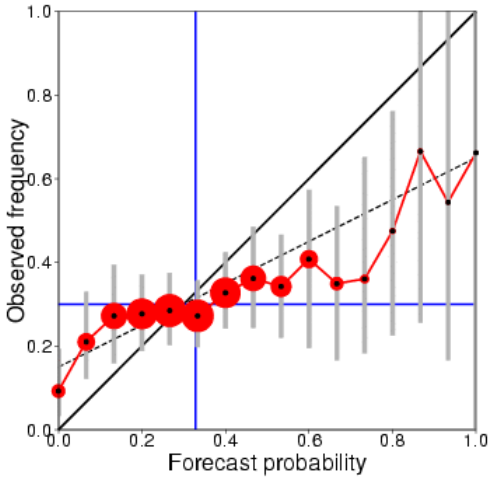
Reliability diagram for ECMWF with 15 ensemble members
Near-surface air temperature anomalies below the lower tercile
Accumulated over tropical band (land and sea points)
Hindcast period 1981-2010 with start in May average over months 2 to 4
Skill scores and 95% conf. intervals (1000 samples)
Brier skill score: 0.214 (0.146, 0.279)
Reliability skill score: 0.949 (0.925, 0.965)
Resolution skill score: 0.266 (0.211, 0.322)



Reliability for winter predictions : cold event

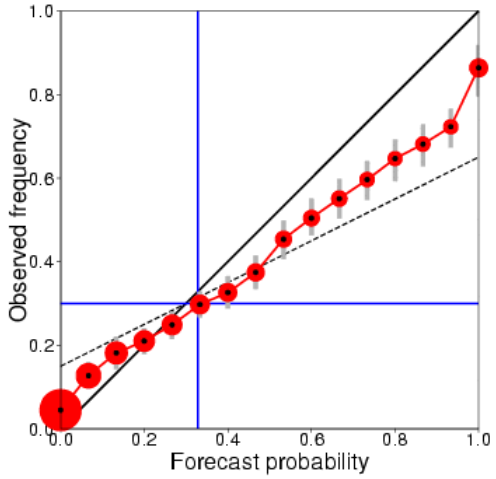
|Europe

Reliability diagram for ECMWF with 15 ensemble members
Near-surface air temperature anomalies below the lower tercile
Accumulated over Europe (land and sea points)
Hindcast period 1981-2010 with start in November average over months 2 to 4
Skill scores and 95% conf. intervals (1000 samples)
Brier skill score: -0.053 (-0.177, 0.032)
Reliability skill score: 0.929 (0.810, 0.969)
Resolution skill score: 0.018 (0.008, 0.068)



Tropics

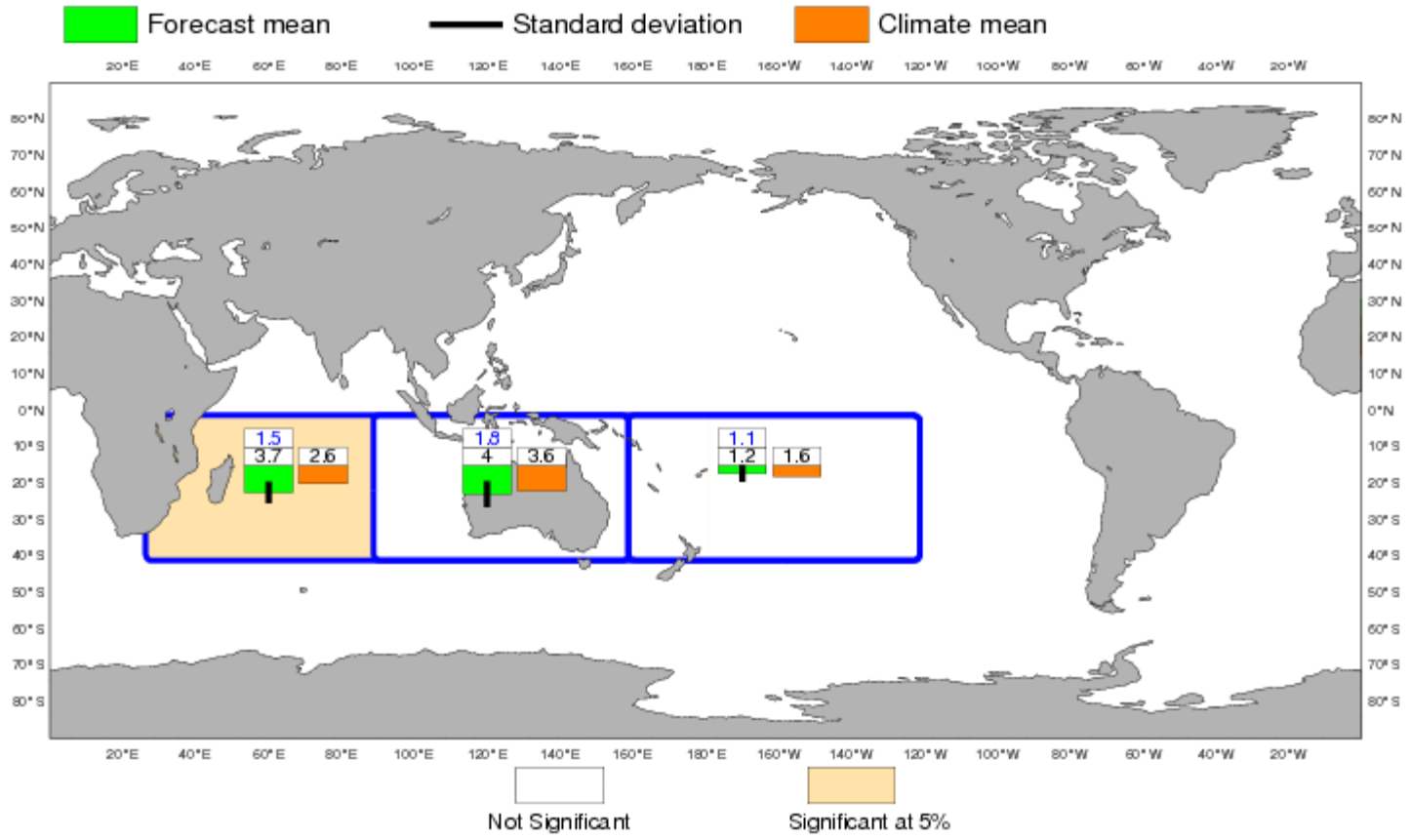
Reliability diagram for ECMWF with 15 ensemble members
Near-surface air temperature anomalies below the lower tercile
Accumulated over tropical band (land and sea points)
Hindcast period 1981-2010 with start in November average over months 2 to
Skill scores and 95% conf. intervals (1000 samples)
Brier skill score: 0.248 (0.175, 0.311)
Reliability skill score: 0.964 (0.942, 0.978)
Resolution skill score: 0.284 (0.225, 0.338)



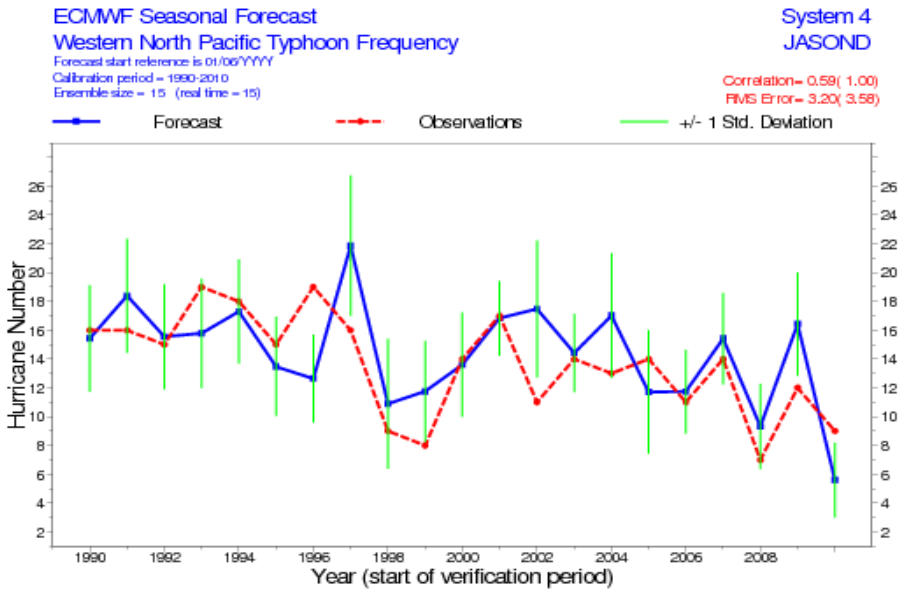
ECMWF Seasonal Forecast
Hurricane or typhoon Frequency

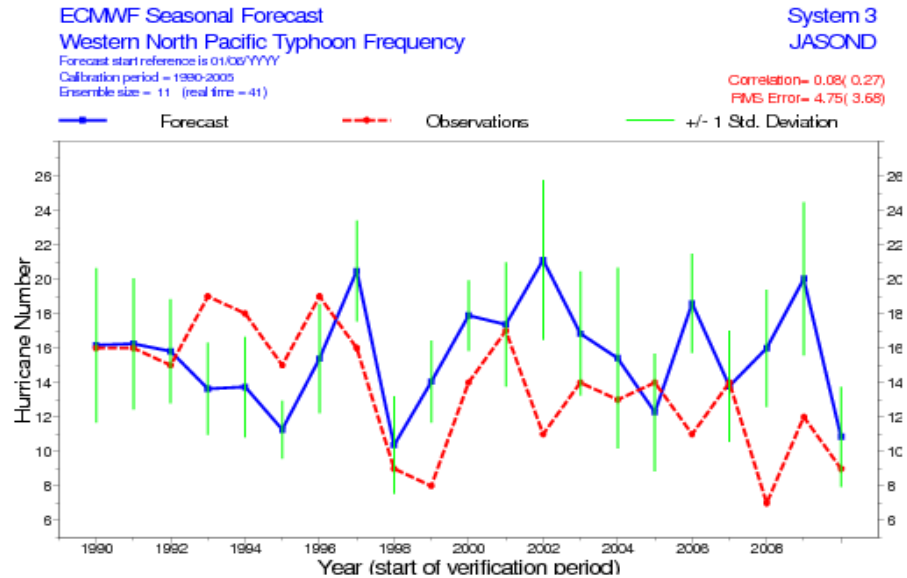
Forecast start reference is 01/01/2015
Ensemble size = 51,climate size =300

System 4
FMAMJJ 2015
Climate (initial dates) = 1990-2009



Prediction of tropical cyclone frequency: NW Pacific



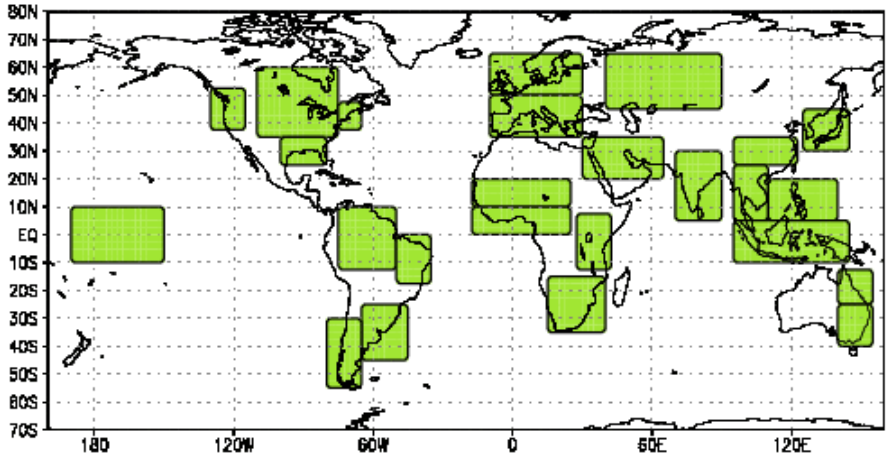


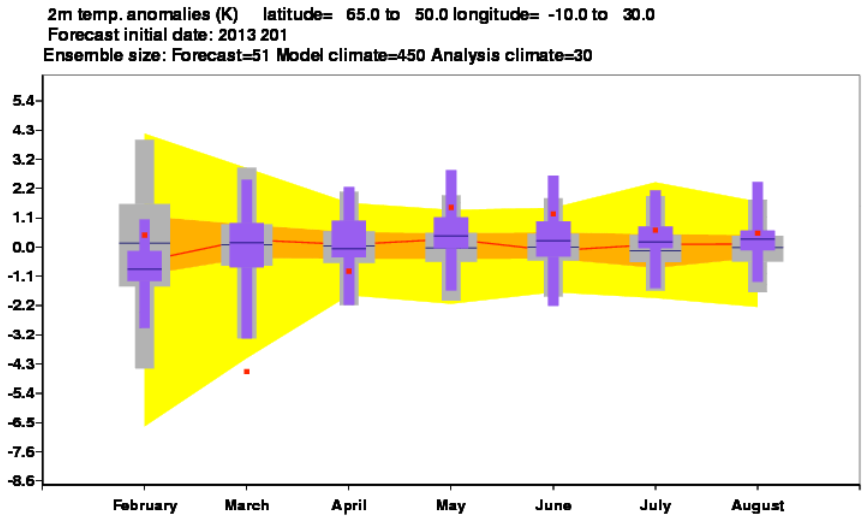
System 4
vs. ERA-Int.

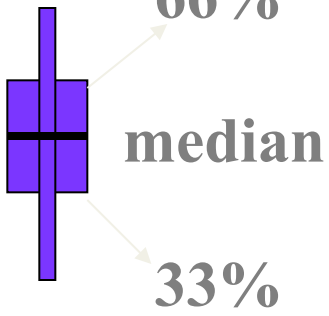
July-Dec.
1990-2010

System 3
vs. ERA-Int.

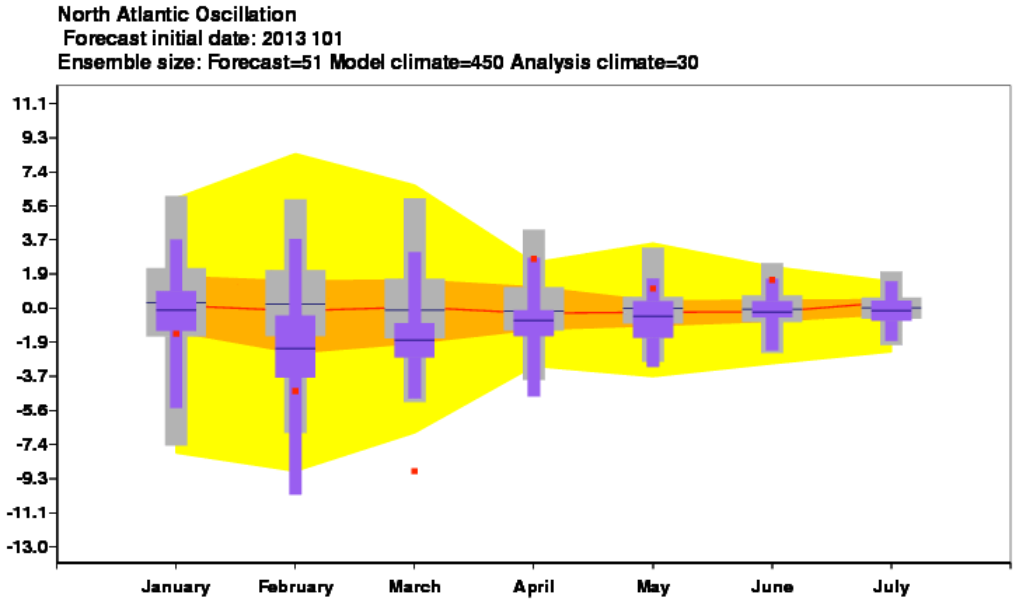
Climagrams : temp. area averages

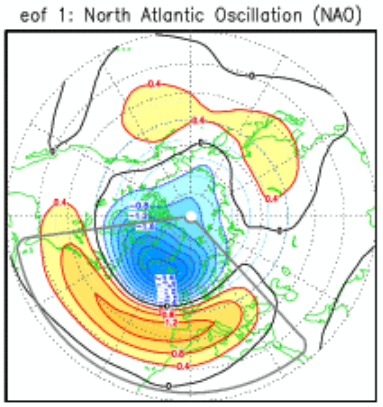


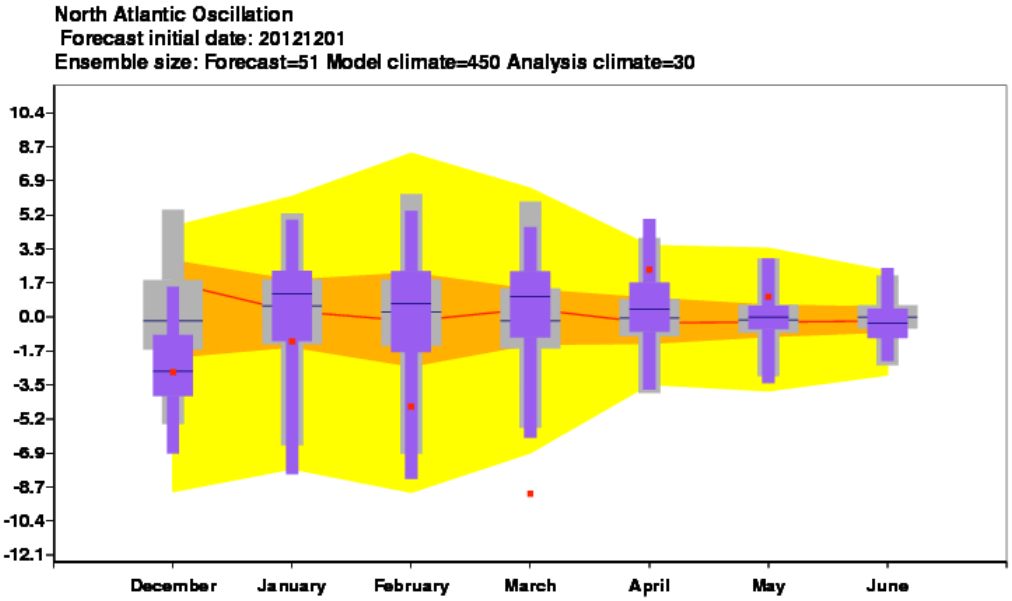


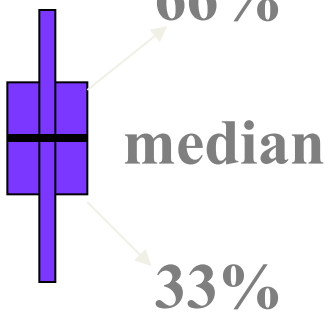


Climagrams : teleconnections indices NAO

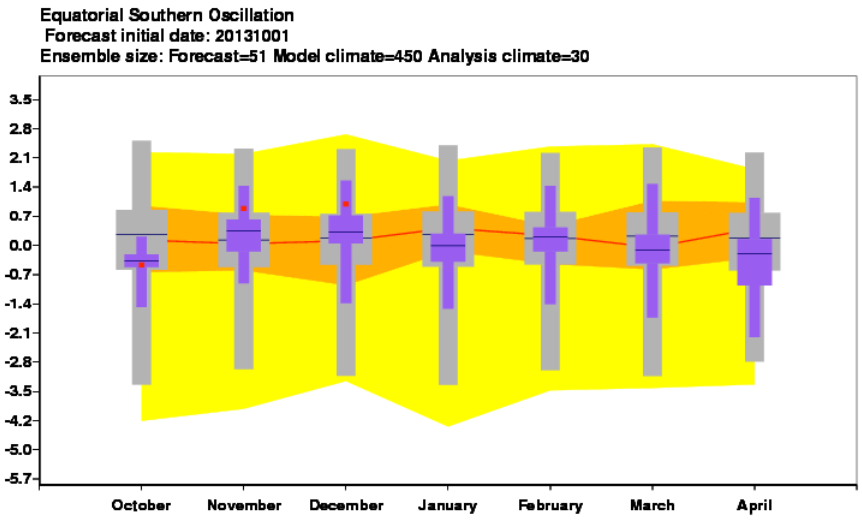


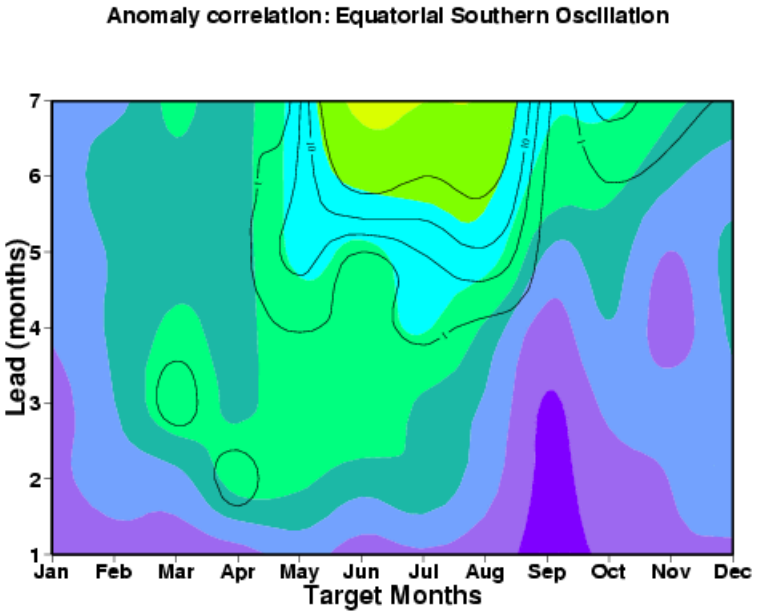


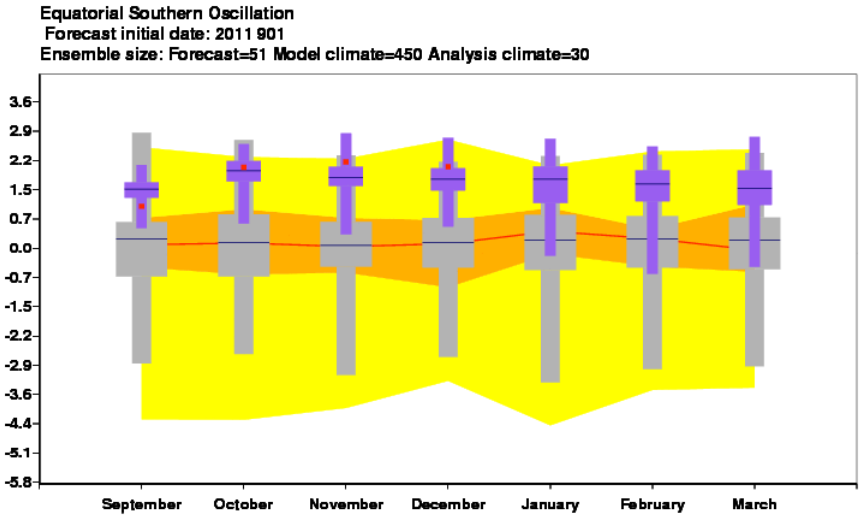


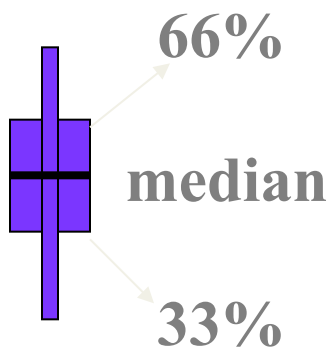


Climagrams : teleconnections indices SOI







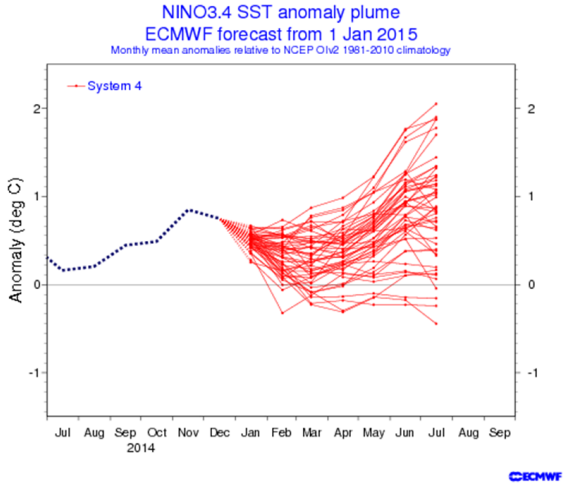


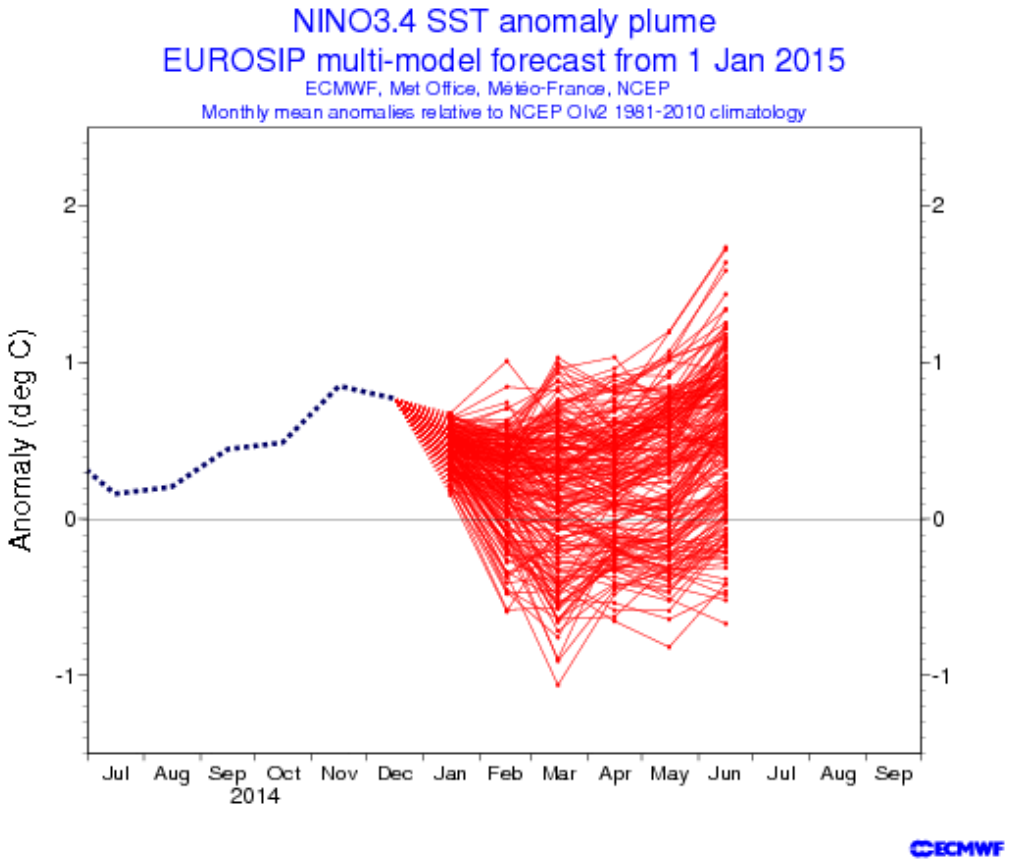
EUROSIP multi-model system:

4 Coupled Systems: ECMWF, Météo France, Met Office, NCEP

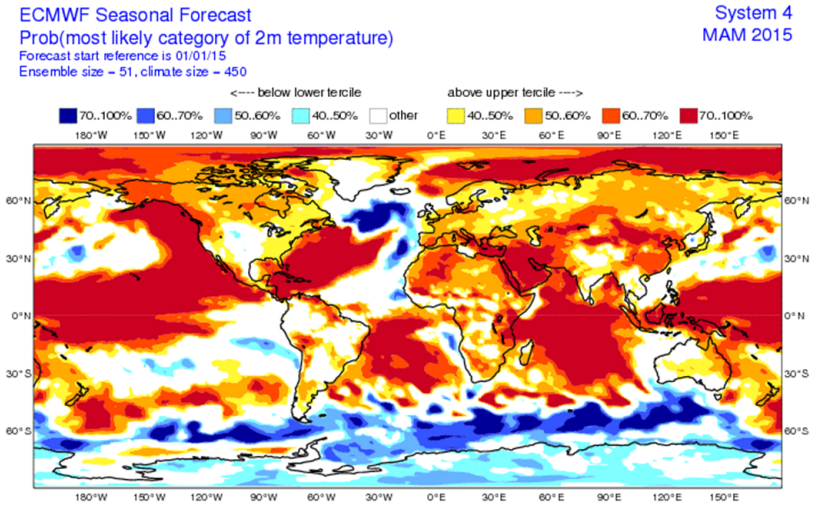
- **Ensemble generation for the 4 systems is different**
- **Development of multi-model products is ongoing**
- **EUROSIP products are available to WMO users**

EUROSIP multi-model system:

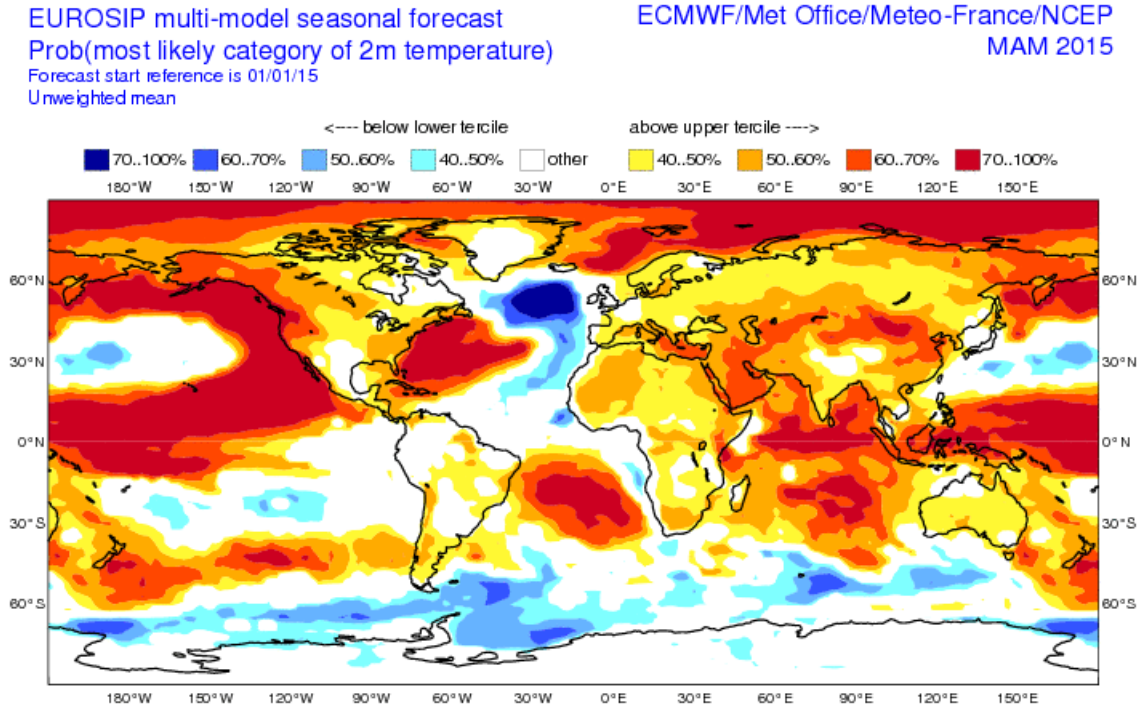




Eurosip is issued on the 15th of the month



EUROSIP 2mt predictions:



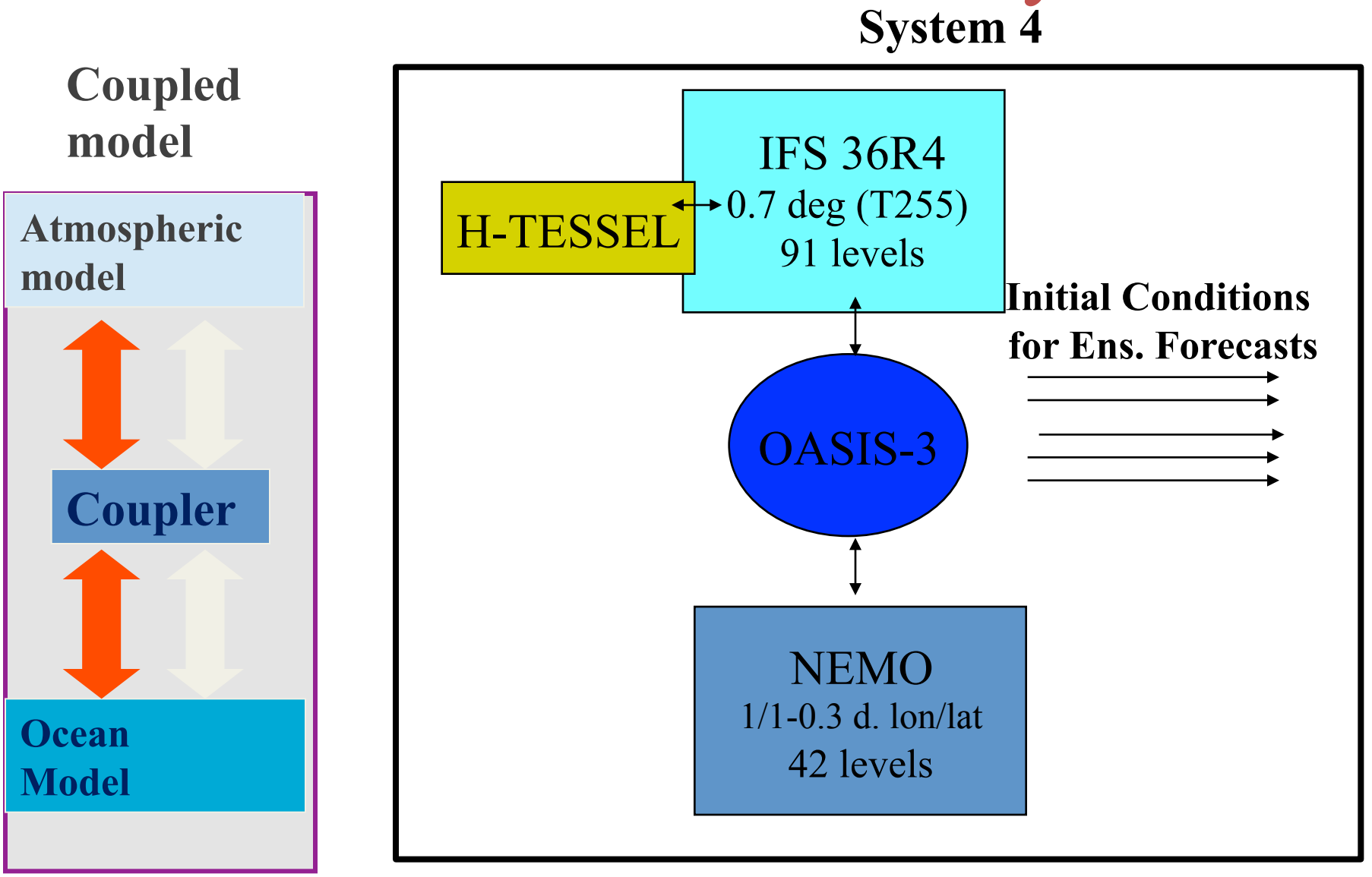
Summary (2)

- The current operational seasonal forecast system provides a set graphic products on the web and digital data set to the users.
- The ECMWF seasonal forecast is a good system for El Nino predictions.
- Seasonal forecast predictions, particularly over mid-latitudes, should be used in combination with some estimate of the forecast skill. Various skill estimates are available to the users.
- Multi-model approach: a way to deal with model error (model calibration) and to enhance forecast reliability.
- For further reading see ECMWF Tech Memo N.656, available at http:// www.ecmwf.int/publications

Summary (1):

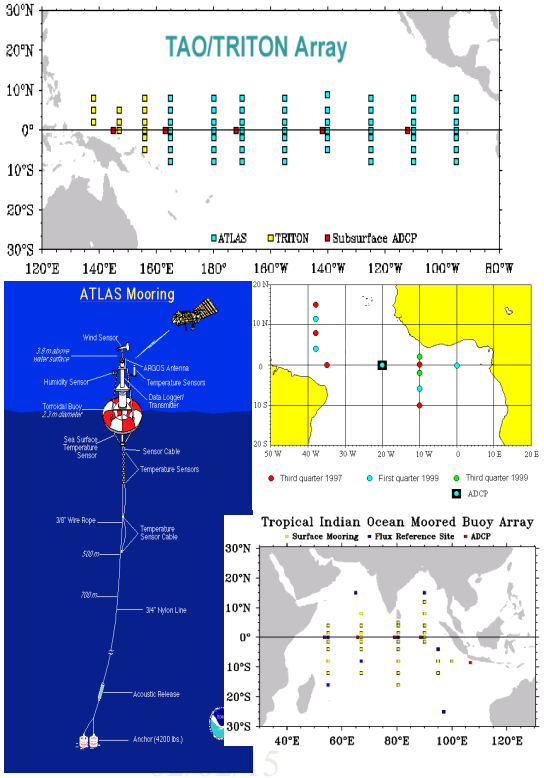
- **Seasonal fc. System-4 (S4):** IFS-NEMO coupled model, 3-D var. ocean data assimilation (NEMOVAR), higher atmos. spatial resolution than S3, larger ensemble size, extended re-forecast set.
- **Model biases**: much reduced extra-tropical biases, too strong trade winds and cold SST bias in the equatorial Pacific. ENSO SST variability is over-estimated.
- **SST forecast skill**: similar to S3 in the NINO regions (better in NINO3, slightly worse in NINO4), increased in the tropical and sub-trop. Atlantic.
- **Skill for atmospheric variables:** spatial averages of ensemble-mean scores are consistently higher than in S3 (NH summer better than winter).
- **Tropical atmospheric variability:** more realistic patterns of rainfall variability, better simulation of the interannual and decadal variation in tropical cyclone frequency.
- **Reliability:** the enhanced internal variability and better match between spread and error lead to more reliable seasonal forecasts w.r.t. S3 in both tropical and extra-tropical regions.

The ECMWF Seasonal fc. system

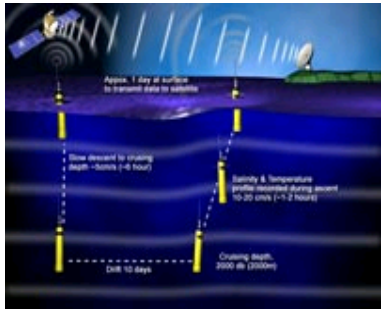


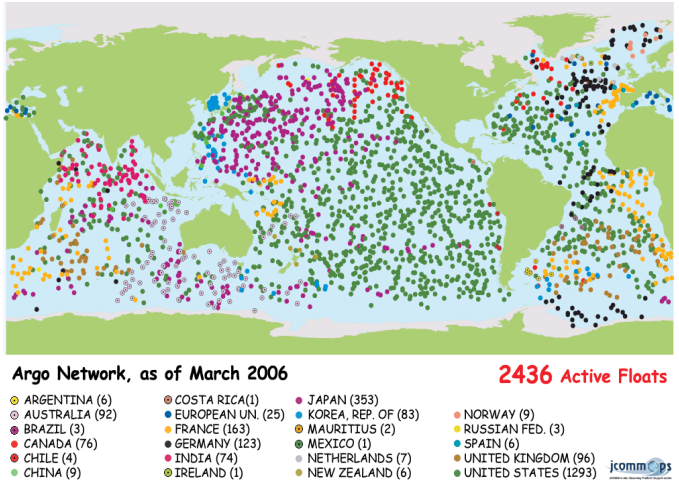
Real Time Ocean Observations

Moorings

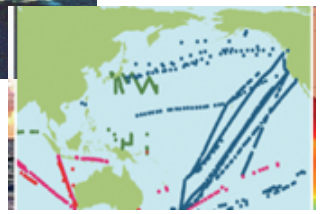


ARGO floats

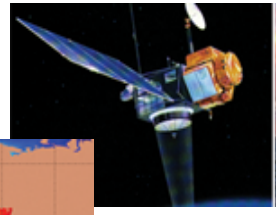


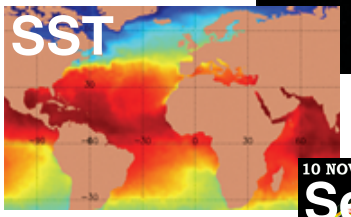


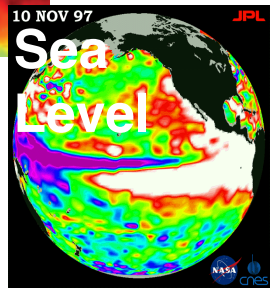
XBT (eXpendable BathiThermograh)



Satellite







Can the weather be predicted months in advance?

- Predictions may be possible a few months in advance based on the fact that irregular weather variations have been associated with El Niño - a warming of the Pacific Ocean near the equator- and La Niña, a similar event caused by the cooling of equatorial Pacific waters.

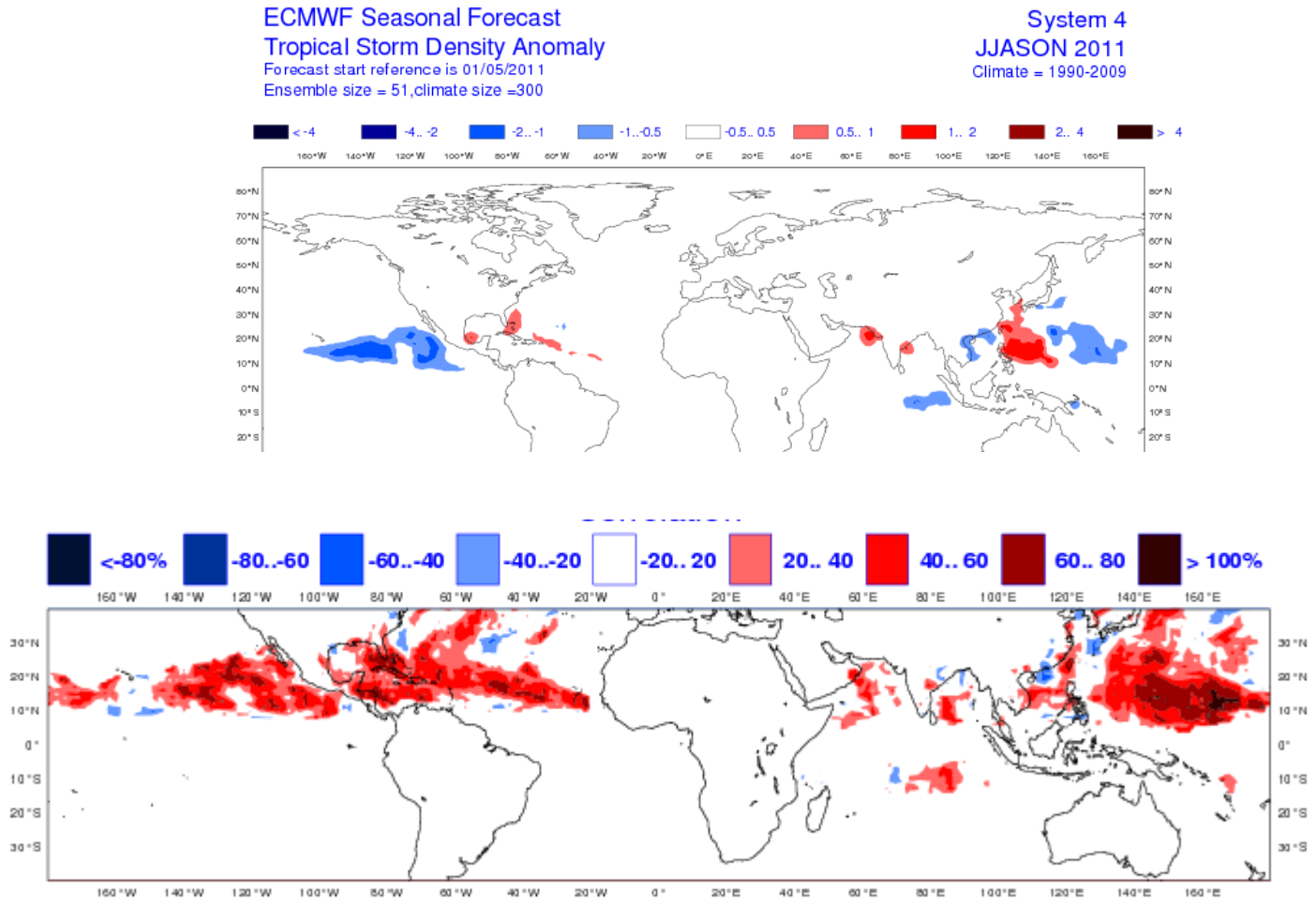
- The slow changes in the surface temperatures of the oceans are thought to impart a degree of predictability.

Seasonal Forecasting at ECMWF

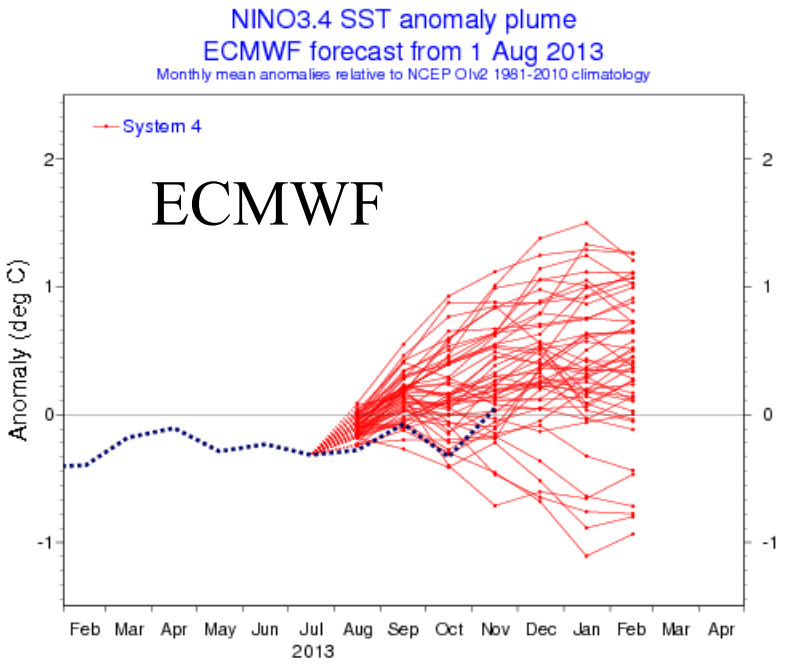
In 1995 ECMWF started an experimental programme in seasonal forecasting. Successful predictions of the exceptional El Nino event of 1997 encouraged the Council to support the seasonal forecast activity.

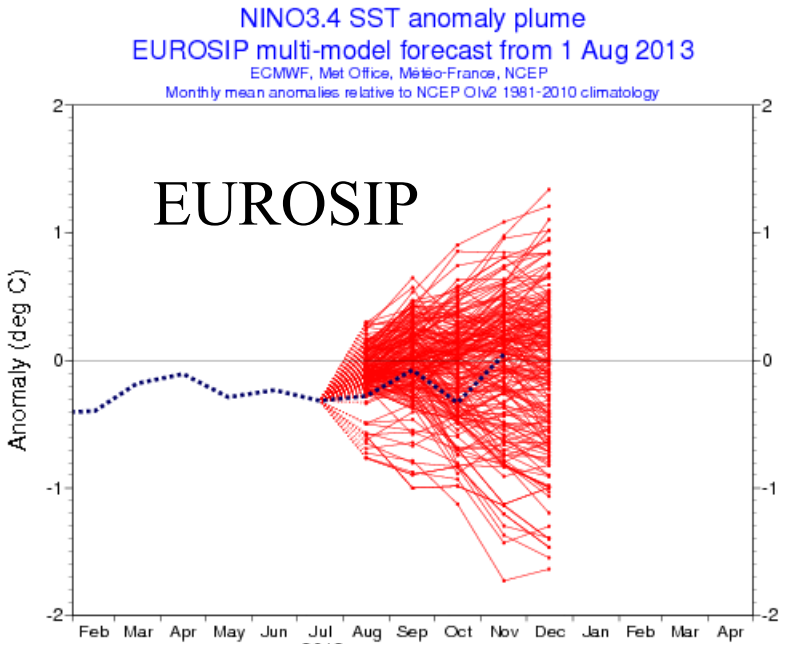
A range of seasonal products are issued routinely on http://www.ecmwf.int/products/forecasts/seasonal

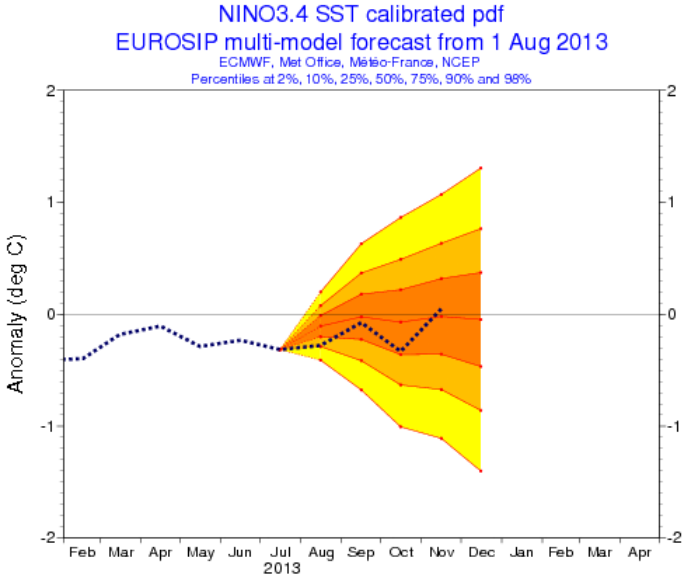
Cyclone track density new product from S4 and its verification



Track density for the July-Dec. period from fc. started on 1 May 1990-2010


NINO3.4 SST anomaly plume
ECMWF forecast from 1 Aug 2013
Monthly mean anomalies relative to NCEP OIv2 1981-2010 climatology
System 4
ECMWF
Anomaly (deg C)
Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr
2013

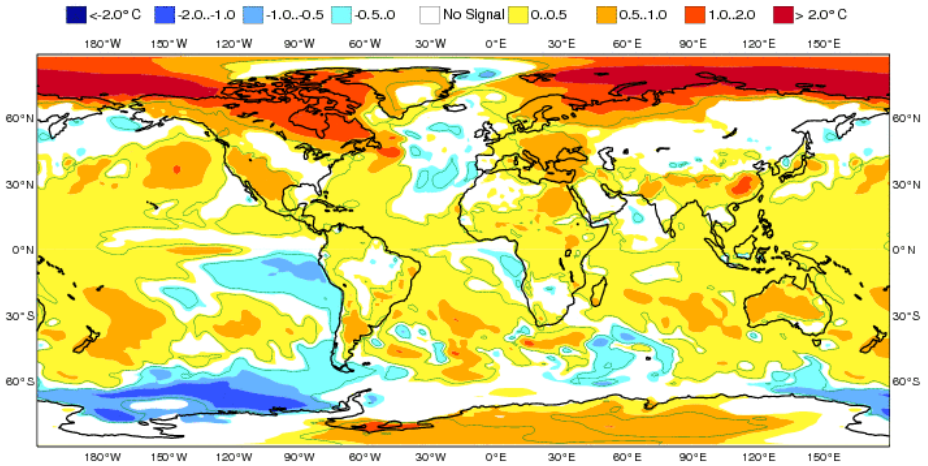

NINO3.4 SST anomaly plume
EUROSIP multi-model forecast from 1 Aug 2013
ECMWF, Met Office, Météo-France, NCEP
Monthly mean anomalies relative to NCEP OIv2 1981-2010 climatology
EUROSIP
Anomaly (deg C)
Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr


NINO3.4 SST calibrated pdf
EUROSIP multi-model forecast from 1 Aug 2013
ECMWF, Met Office, Météo-France, NCEP
Percentiles at 2%, 10%, 25%, 50%, 75%, 90% and 98%
Anomaly (deg C)
Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr
2013

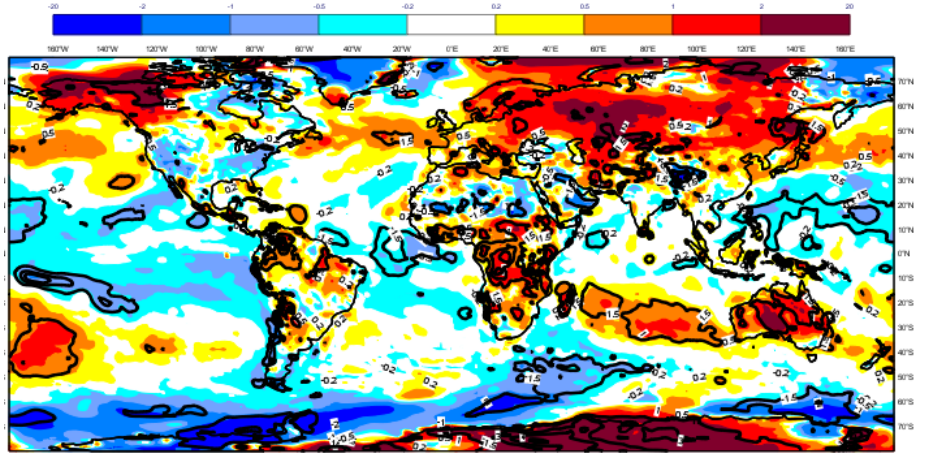
2m temperature anomalies SON 2013

ECMWF

System 4
SON 2013
Shaded areas significant at 10% level
Solid contour at 1% level

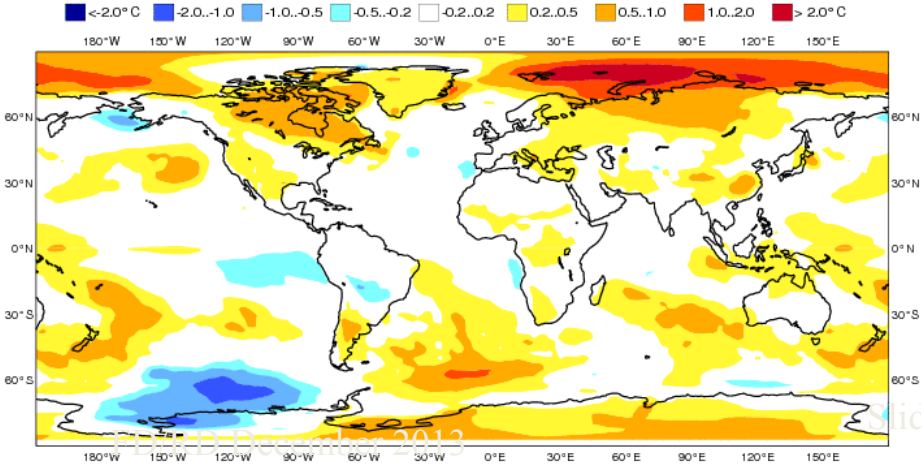


ANALYSIS



EUROSIP

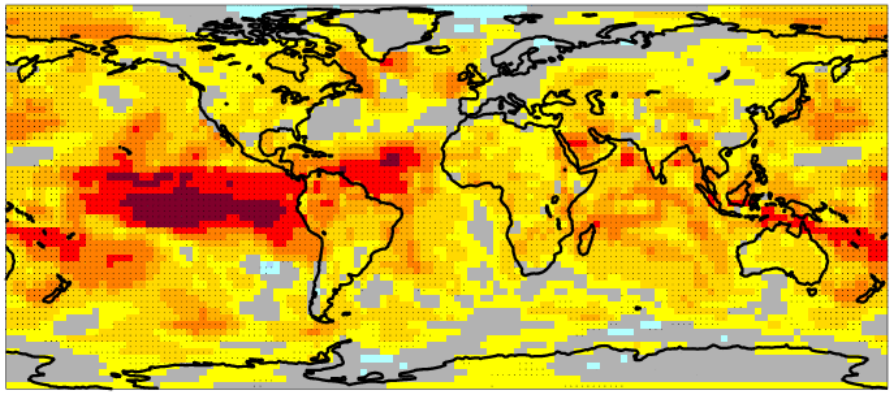
ECMWF/Met Office/Meteo-France/NCEP
SON 2013



ECMWF skill

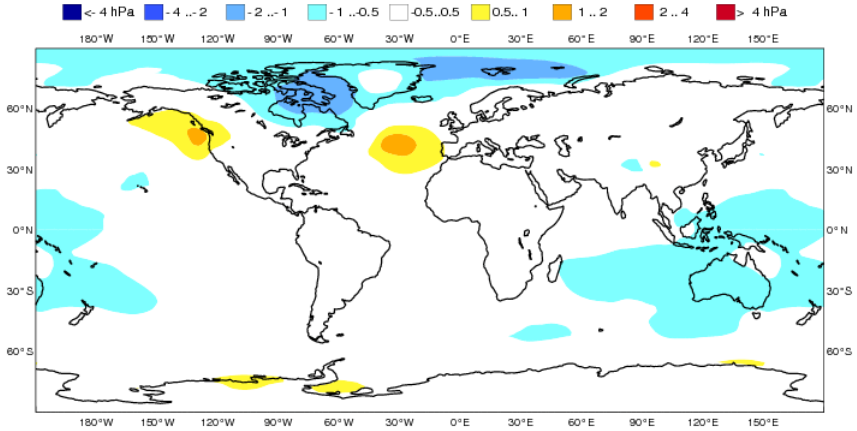
with 15 ensemble members

Black dots for values significantly different from zero with 95% confidence (1000 samples)



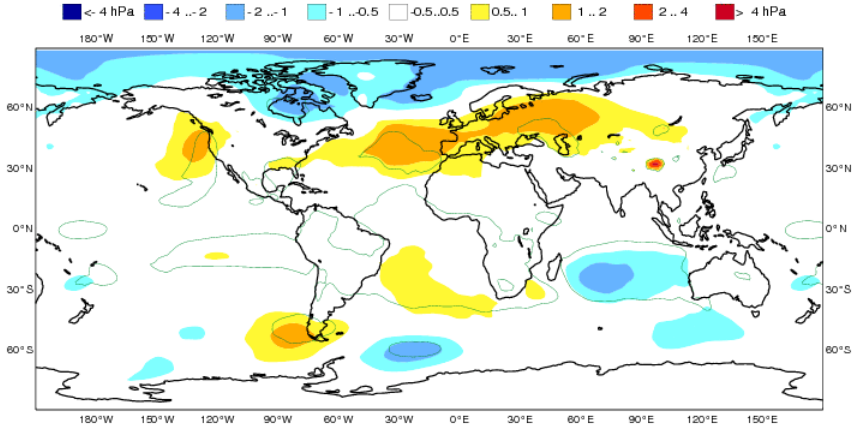
EUROSIP multi-model seasonal forecast
Mean MSLP anomaly
Forecast start reference is 01/11/13
Variance-standardized mean

ECMWF/Met Office/Meteo-France/NCEP
DJF 2013/14



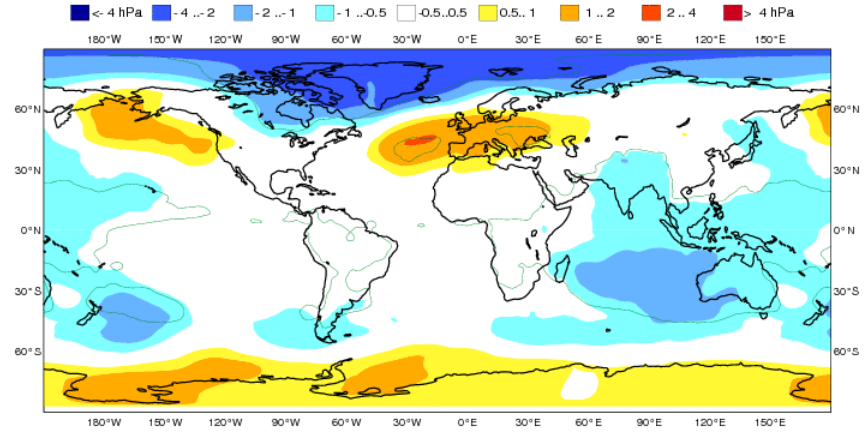
ECMWF Seasonal Forecast
Mean MSLP anomaly
Forecast start reference is 01/11/13
Ensemble size = 51, climate size = 450

System 4
DJF 2013/14
Solid contour at 1% significance level

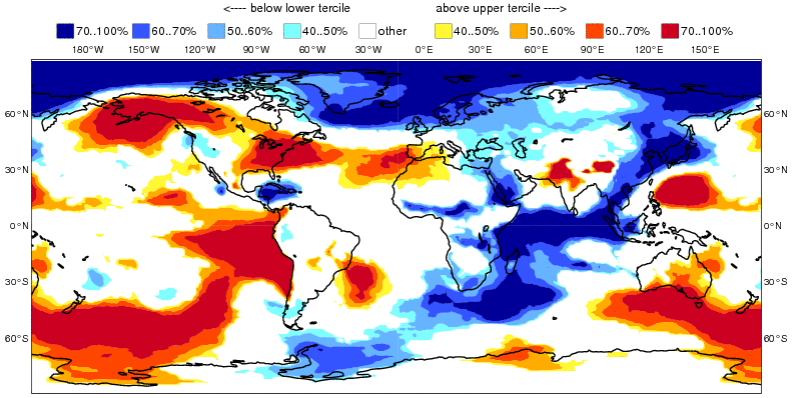


EUROSIP: Met Office contribution
Mean MSLP anomaly
Forecast start reference is 01/11/13
Ensemble size = 40, climate size = 168

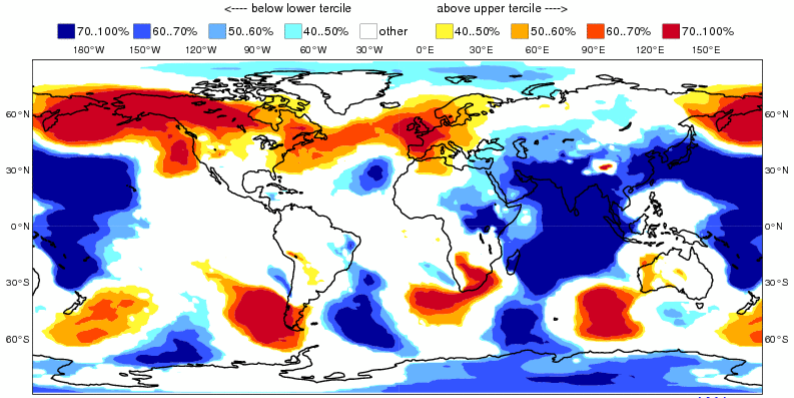
System 9
DJF 2013/14
Solid contour at 1% significance level



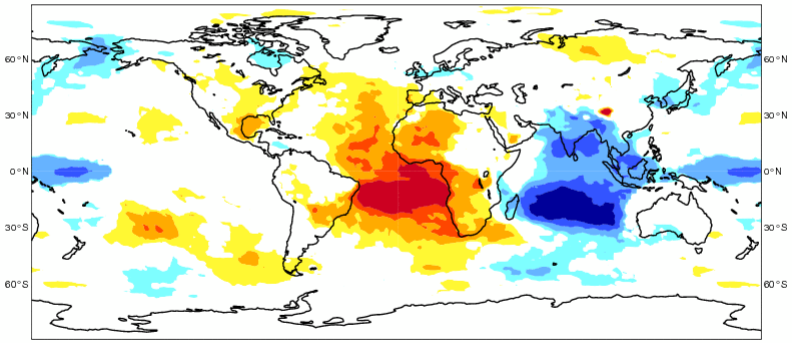
ECMWF Seasonal Forecast
Prob(most likely category of MSLP)
Forecast start reference is 01/11/13
Ensemble size = 51, climate size = 450
System 4
NOV 2013



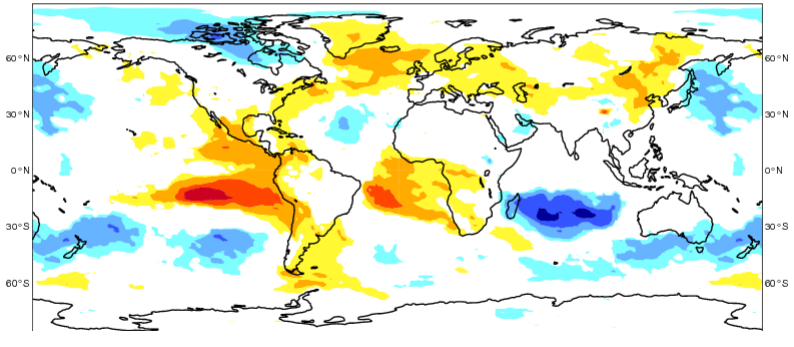
ECMWF Seasonal Forecast
Prob(most likely category of MSLP)
Forecast start reference is 01/12/13
Ensemble size = 51, climate size = 450
System 4
DEC 2013



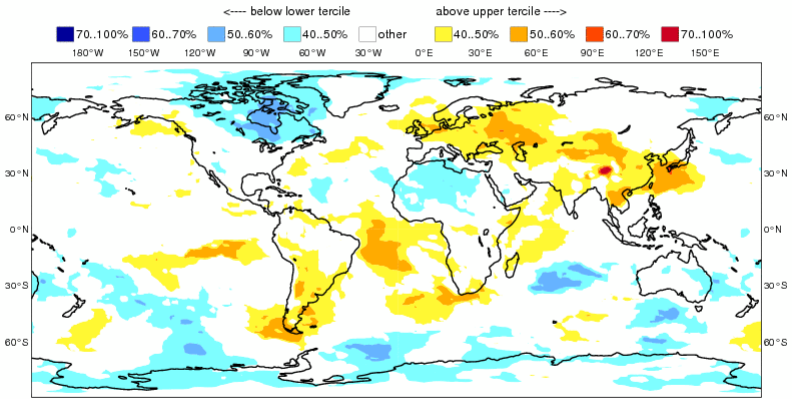
Prob(most likely category of MSLP)
Forecast start reference is 01/11/13
Ensemble size = 51, climate size = 450
DEC 2013



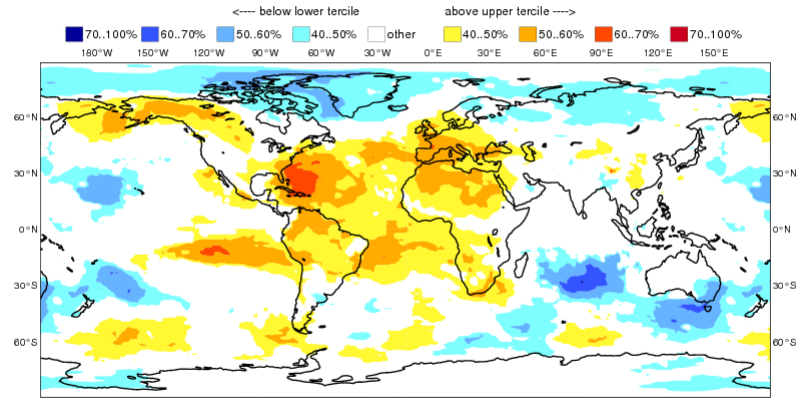
Prob(most likely category of MSLP)
Forecast start reference is 01/12/13
Ensemble size = 51, climate size = 450
JAN 2014



Prob(most likely category of MSLP)
Forecast start reference is 01/11/13
Ensemble size = 51, climate size = 450
JAN 2014

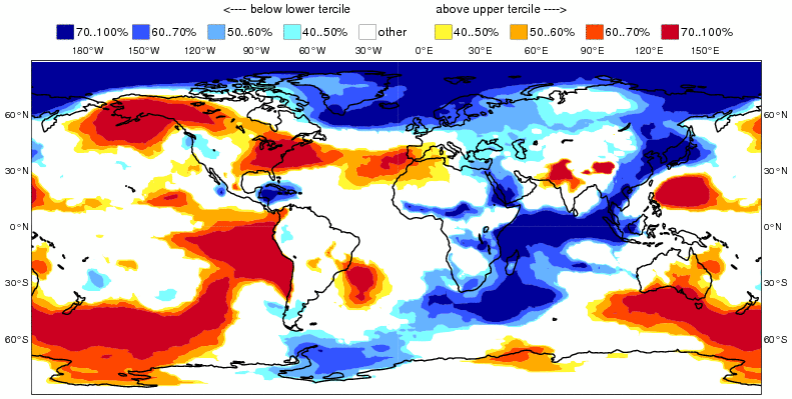


Prob(most likely category of MSLP)
Forecast start reference is 01/12/13
Ensemble size = 51, climate size = 450
FEB 2014



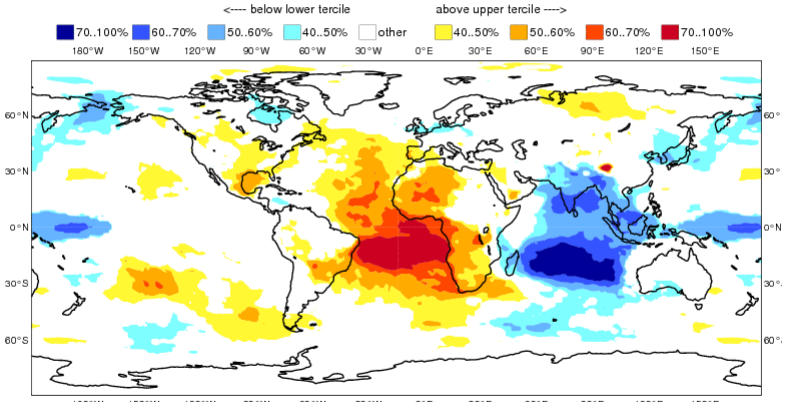
ECMWF Seasonal Forecast
Prob(most likely category of MSLP)
Forecast start reference is 01/11/13
Ensemble size = 51, climate size = 450

System 4
NOV 2013



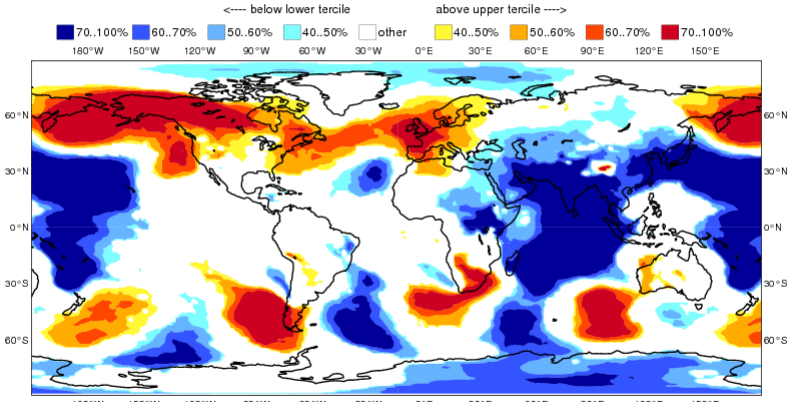
Prob(most likely category of MSLP)
Forecast start reference is 01/11/13
Ensemble size = 51, climate size = 450

DEC 2013

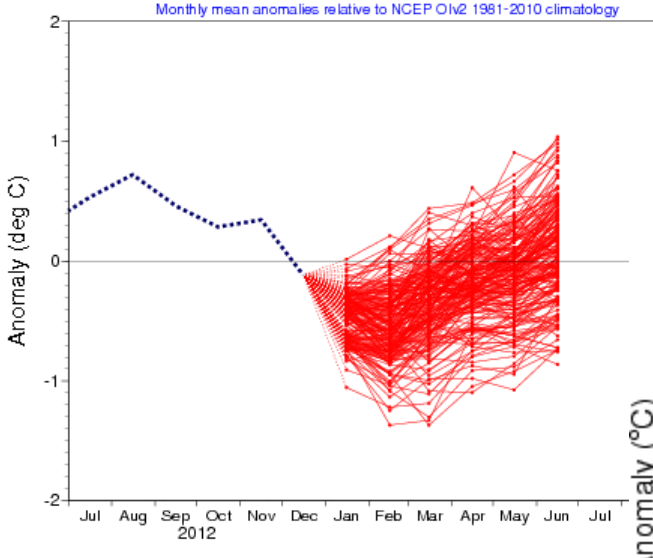


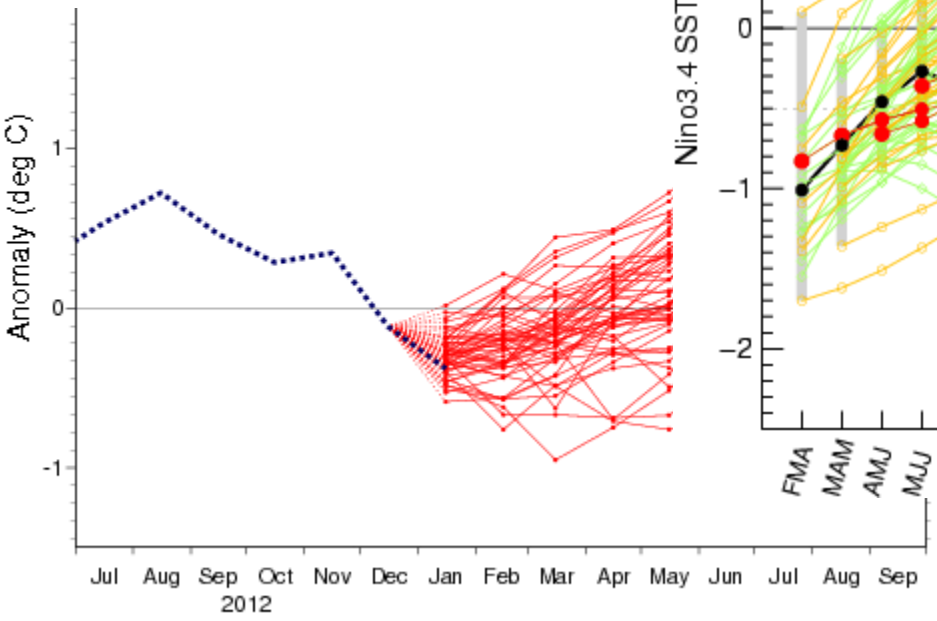
ECMWF Seasonal Forecast
Prob(most likely category of MSLP)
Forecast start reference is 01/12/13
Ensemble size = 51, climate size = 450

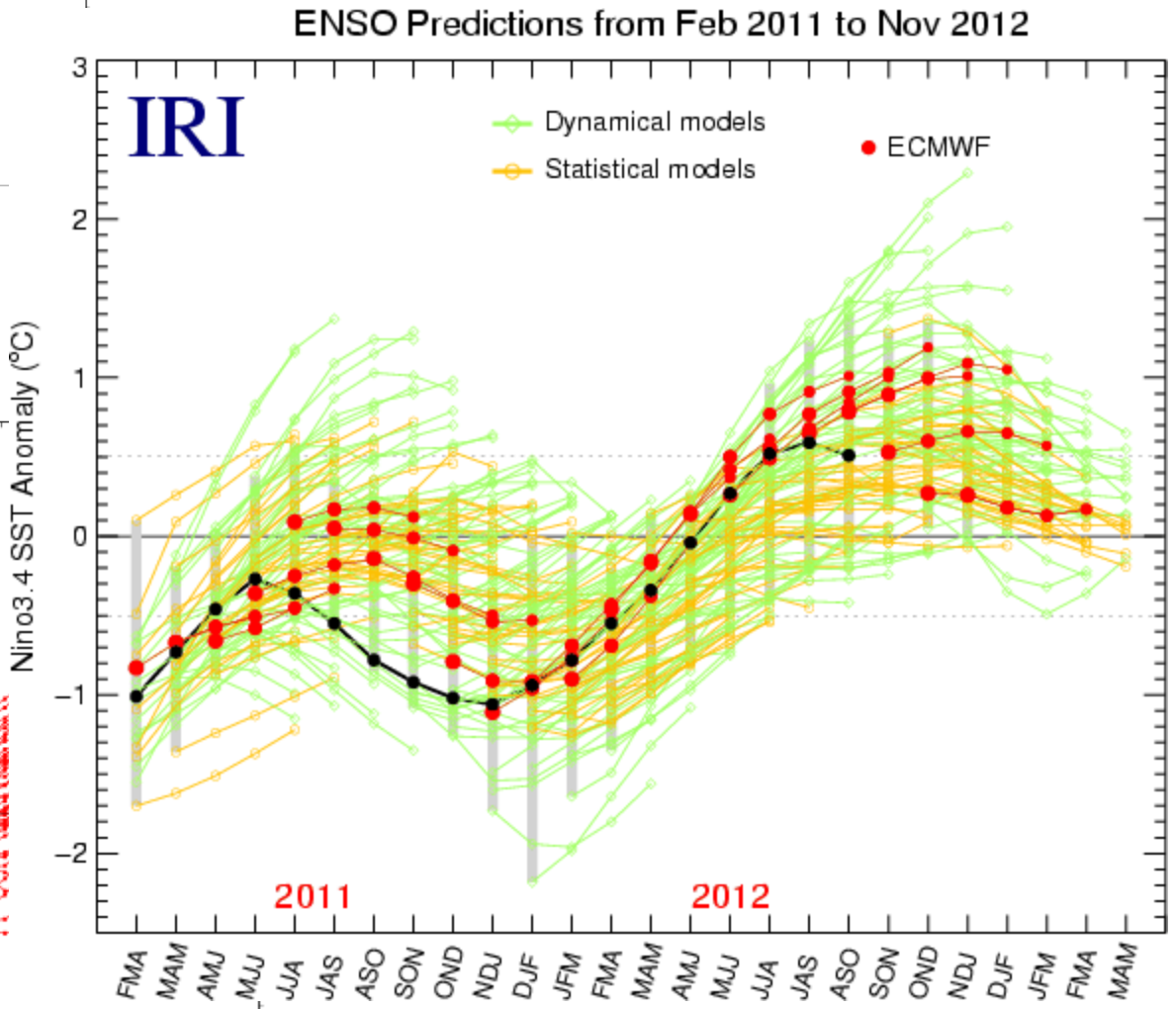
System 4
DEC 2013



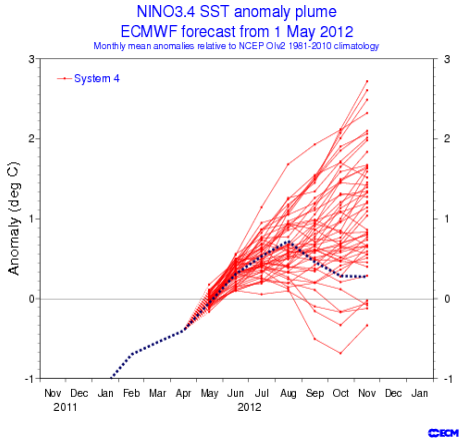
3.4 outlook

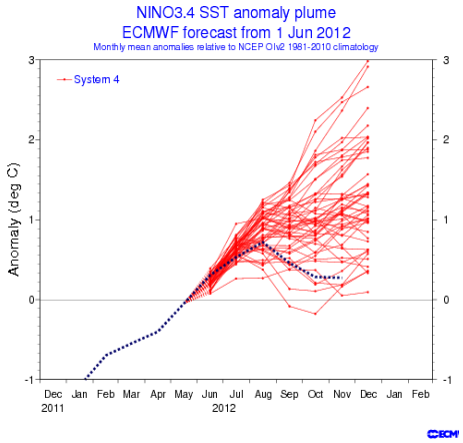

NINO3.4 SST anomaly plume
EUROSIP multi-model forecast from 1 Jan 2013
ECMWF, Met Office, Météo-France, NCEP
Monthly mean anomalies relative to NCEP OIv2 1981-2010 climatology
Anomaly (deg C)
Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul
2012

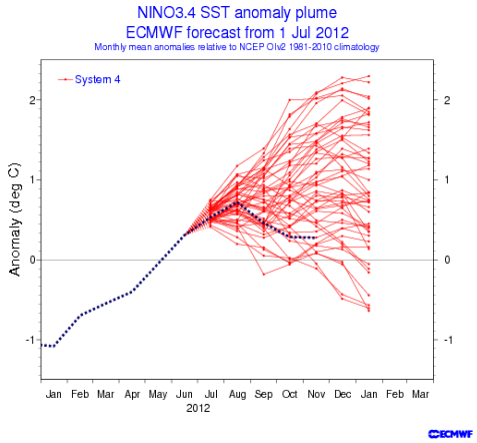

Anomaly (deg C)
Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep
2012

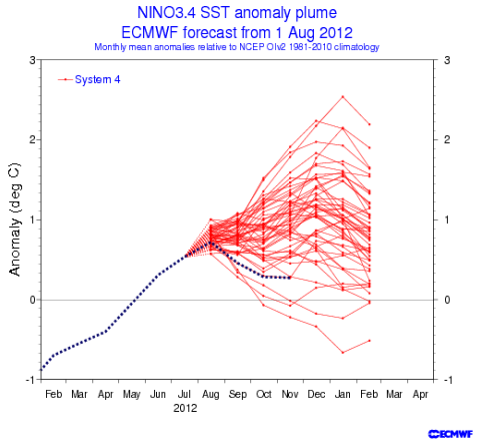

ENSO Predictions from Feb 2011 to Nov 2012
IRI
Dynamical models
Statistical models
ECMWF
Nino3.4 SST Anomaly (°C)
2011
2012
FMA MAM AMJ MJJ JJA JAS ASO SON OND NDJ DJF JFM FMA MAM AMJ MJJ JJA JAS ASO SON OND NDJ DJF JFM FMA MAM

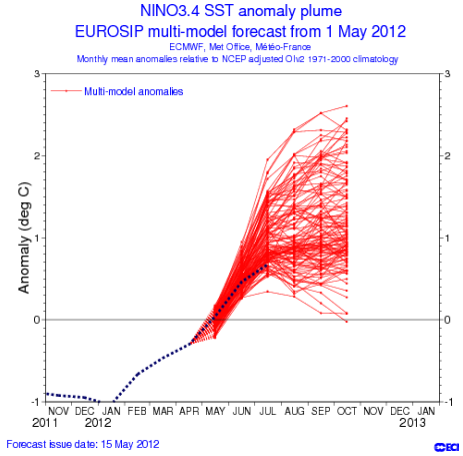
NINO 3.4 past predictions

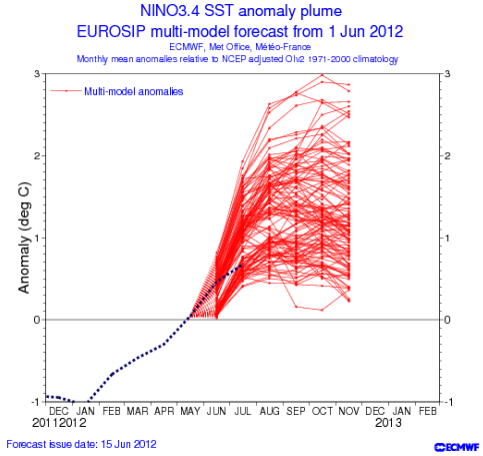


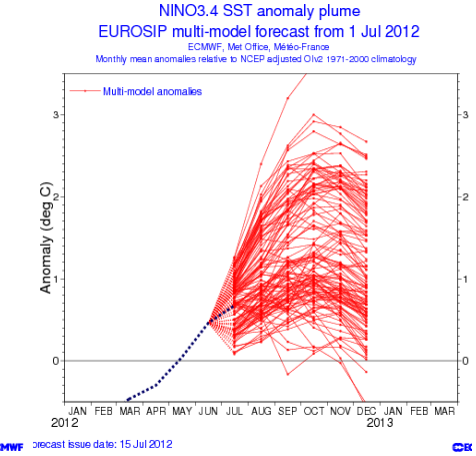


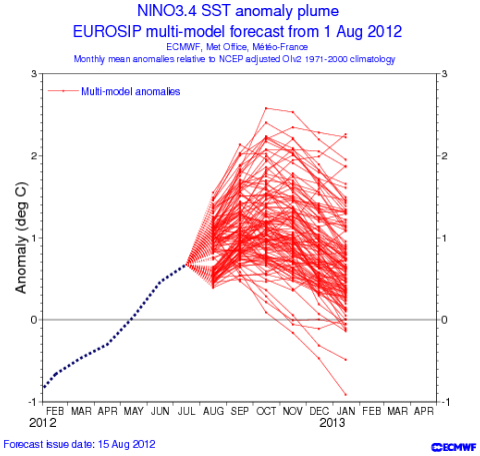








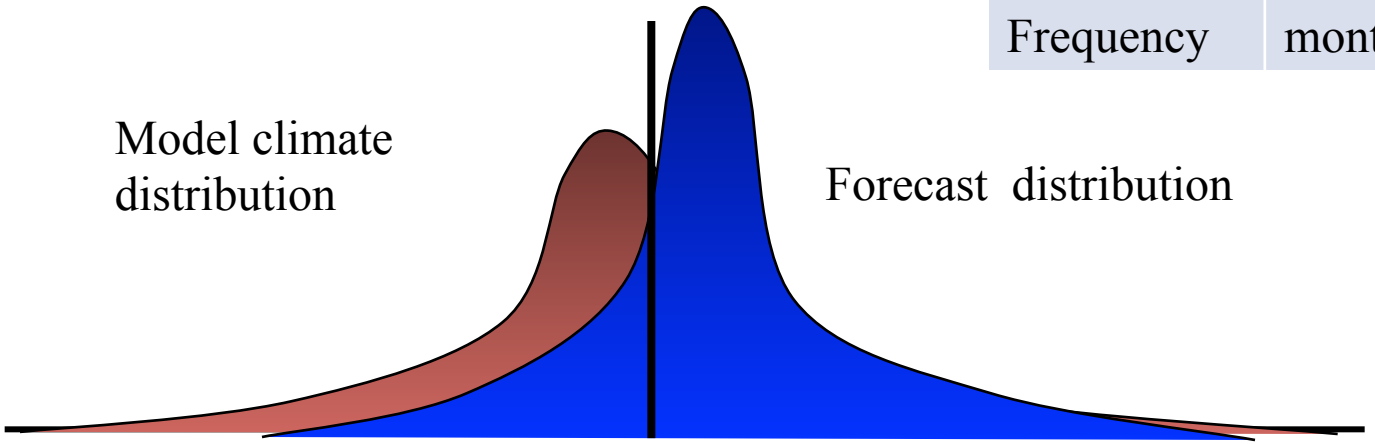




Extended range predictions

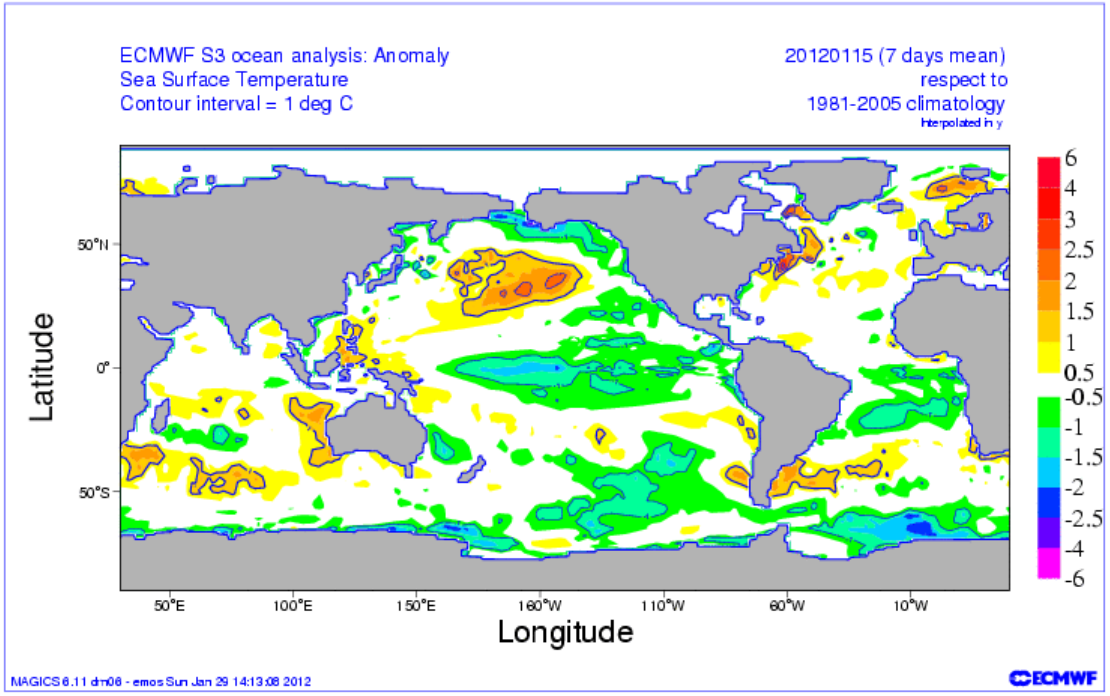
- Products from Extended range predictions are generally defined with reference to the model climate estimated by the re-forecast data.
- Post-processing/calibration of model data is indispensable for the extended range forecasts.

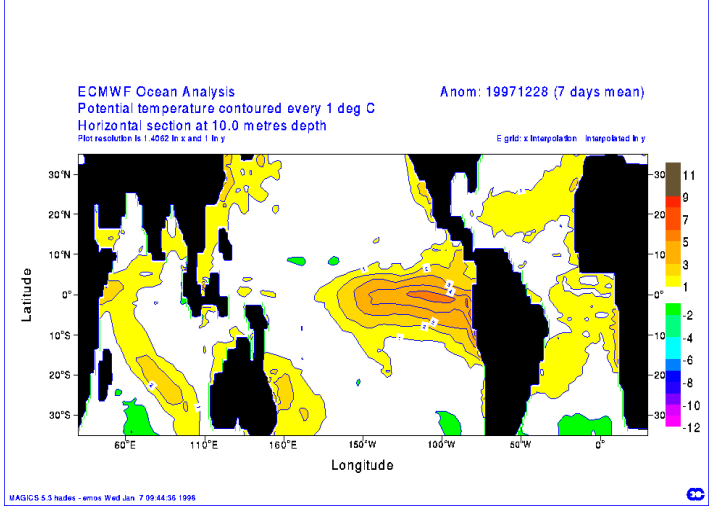
Re-forecast	Seasonal
Period	30 years
Ens. Size	15
Frequency	monthly

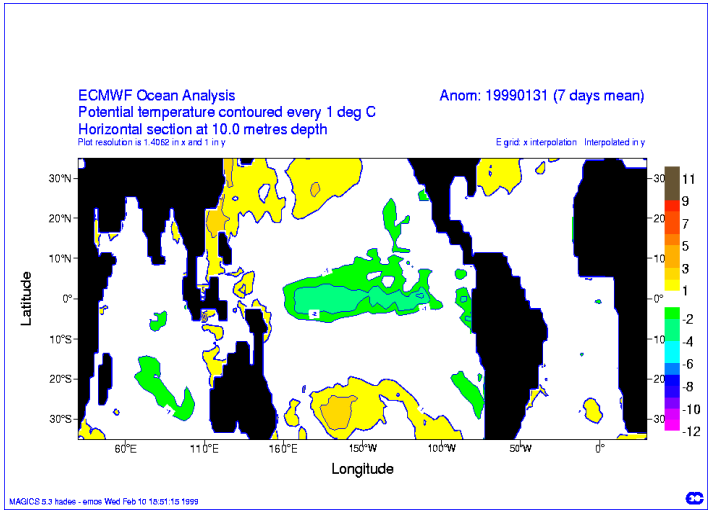


<L clim >: Model climate upper tercile

Ocean analysis:

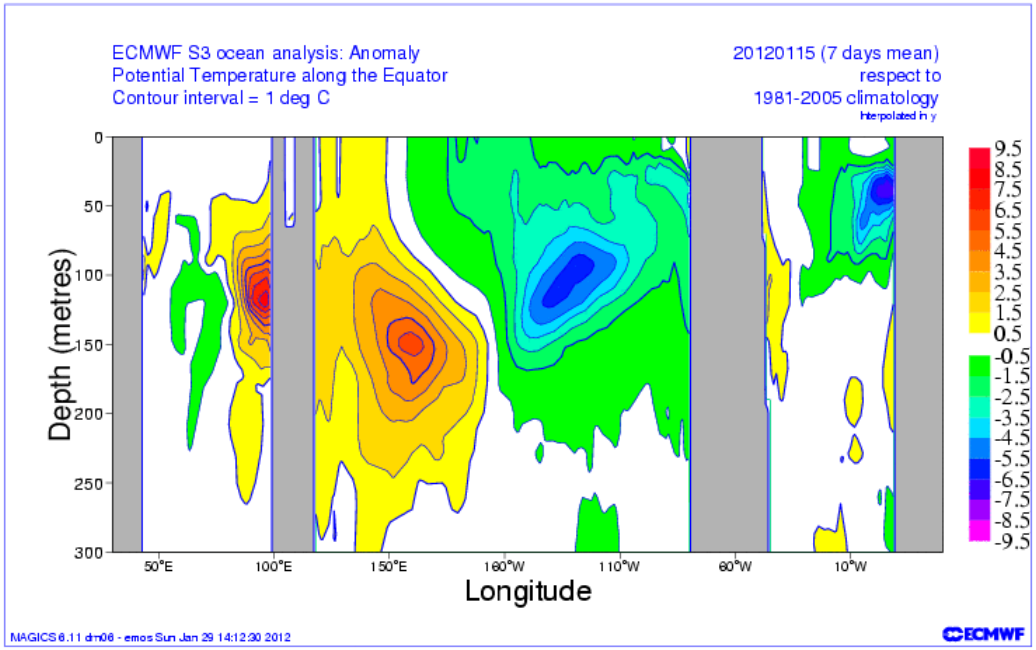


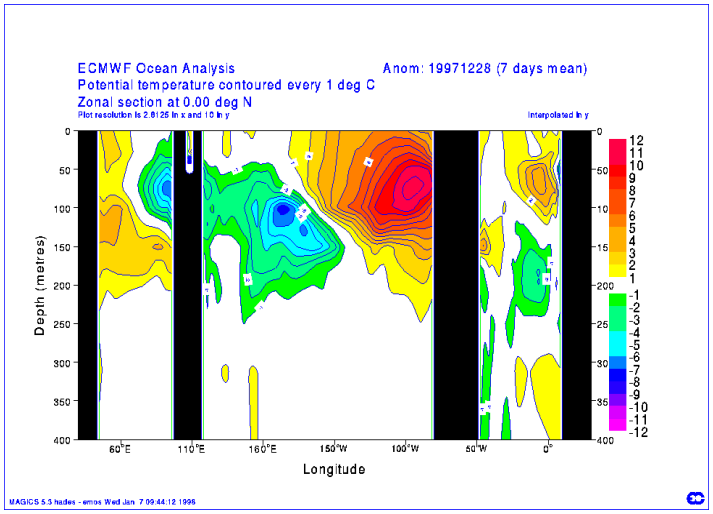


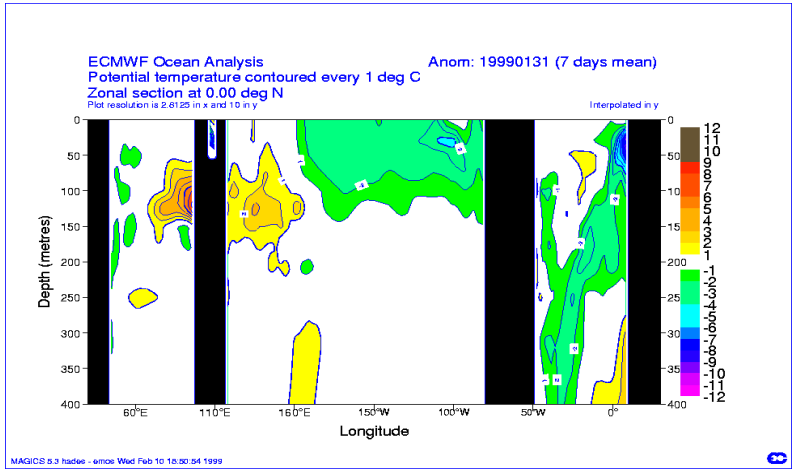


Daily weekly and monthly products are available on the web

Ocean analysis:





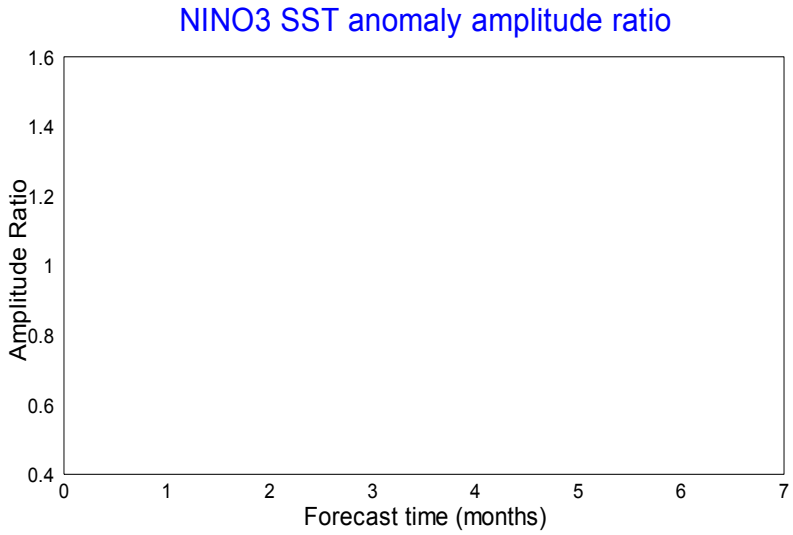


Chaotic nature of the atmosphere:

- To deal with the chaotic processes in the atmosphere we use an ensemble of simulations: on the 1st of the month 40 forecasts are run for 6 months. They have initial conditions from 5-member ensemble of ocean analyses (wind perturbations throughout analysis and SST perturbations at start of forecasts)

- Seasonal forecasting does not give exact predictions, but it may allow us to describe the probability that a certain weather event can happen.

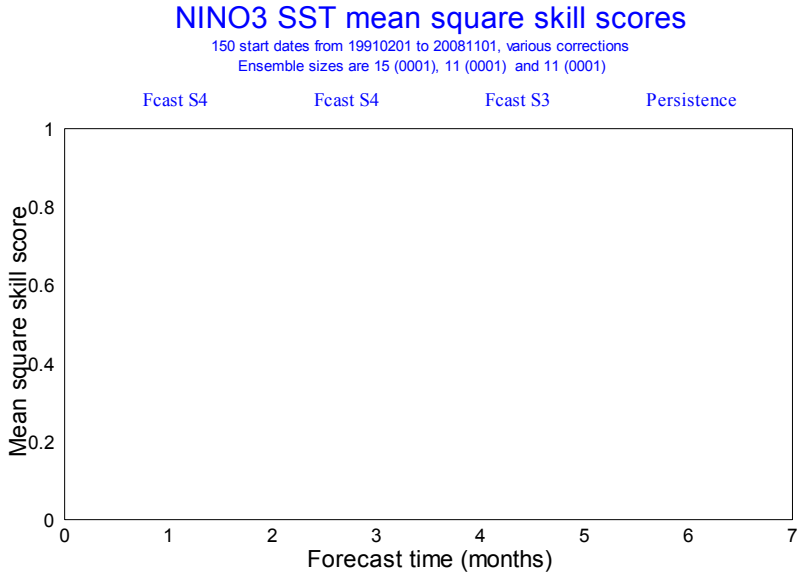
Calibration of ENSO SST indices



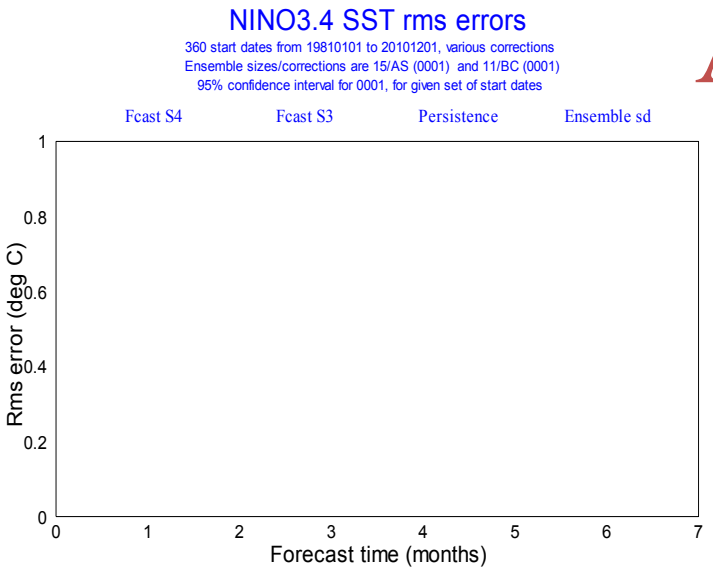
S4 non calib.

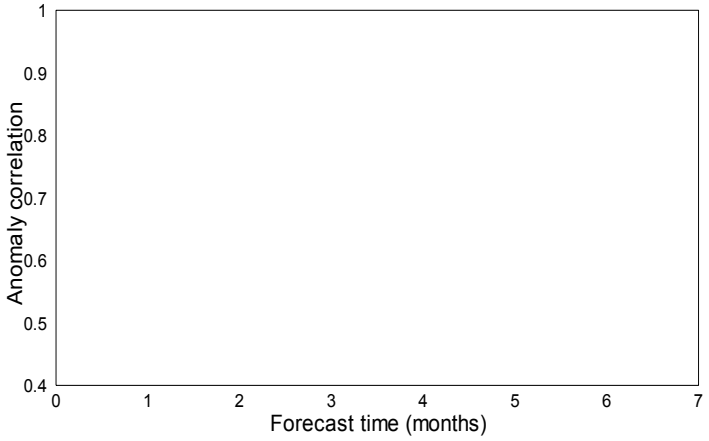
S4 calibrated

S3



SST scores: Nino 3.4 and Eq. Atlantic





Solid:

S4 error

S3 error

Dashed:

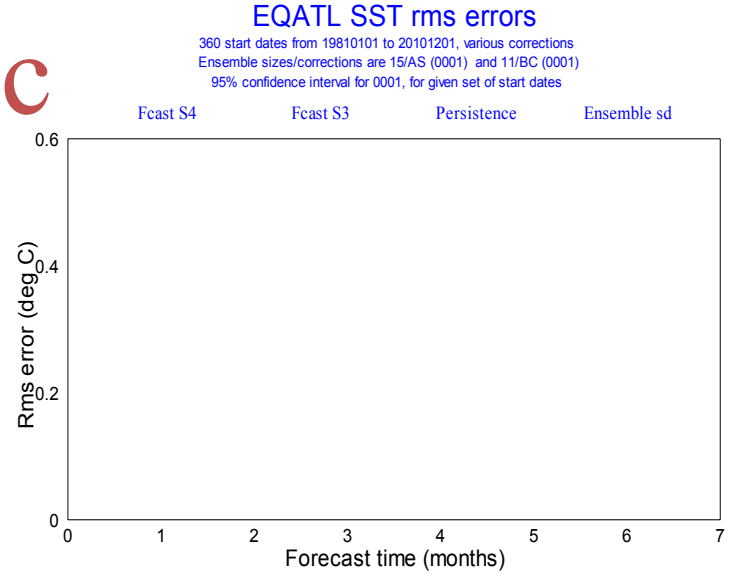
S4 spread

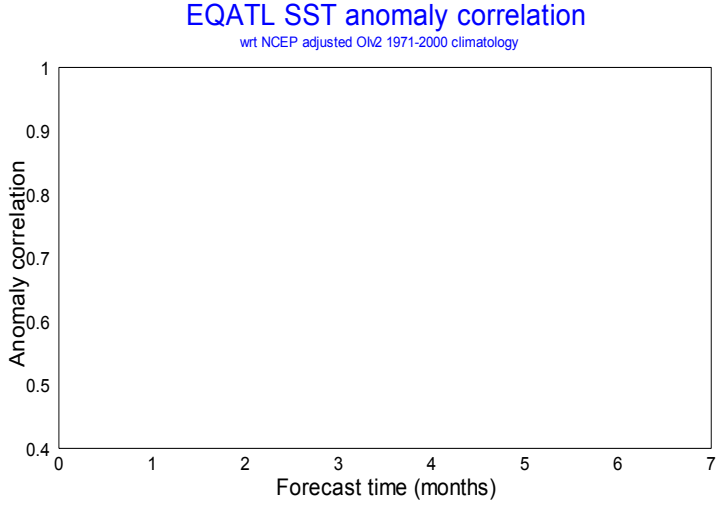
S3 spread

S4 ACC

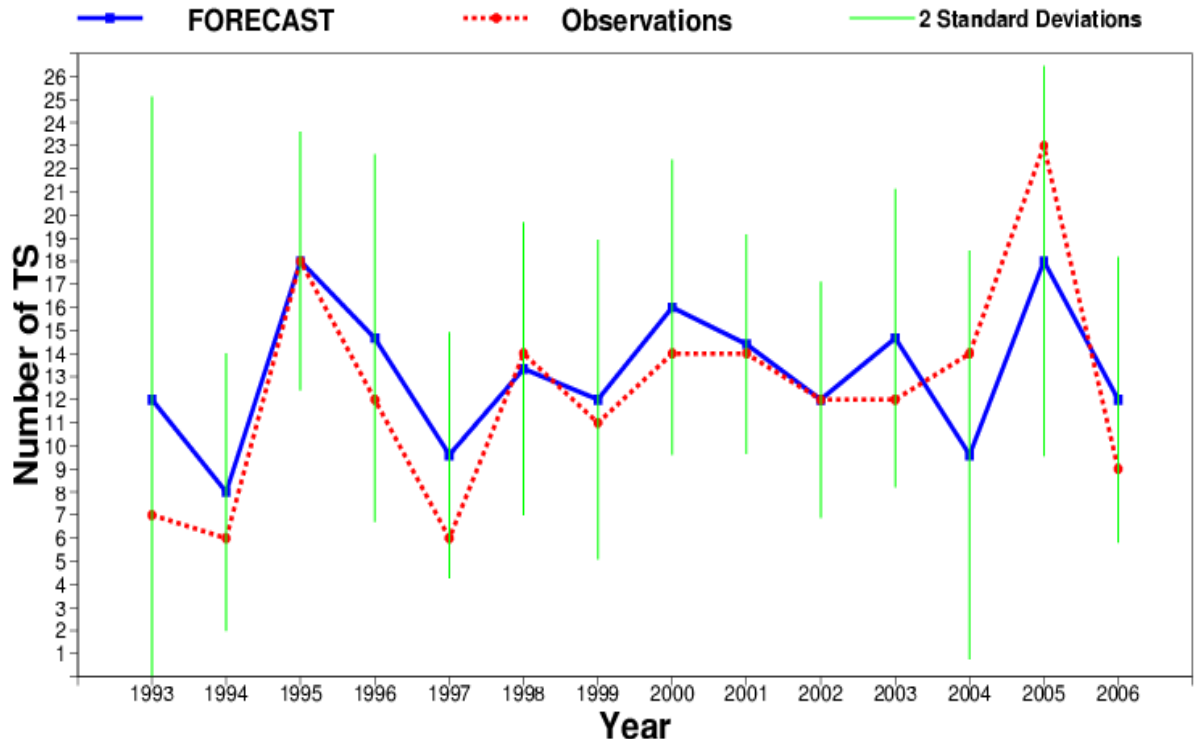
S3 ACC

Pers. ACC





EUROsip seasonal forecasts of tropical storms
Forecasts starting on 1st June



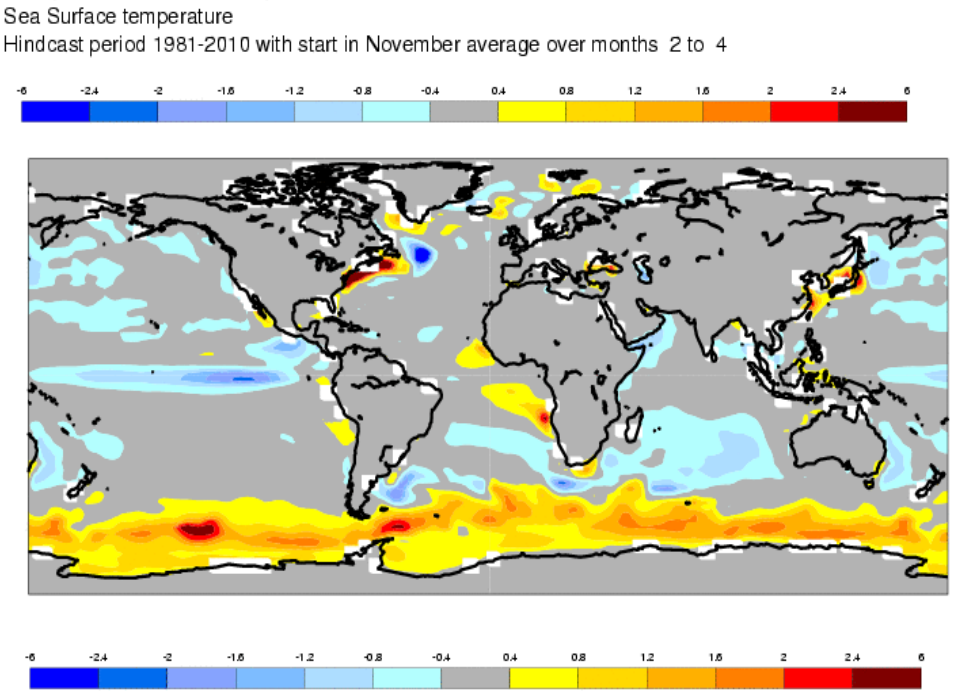
Bias in S4 re-forecasts: SST (DJF)

Start: 1 Nov.

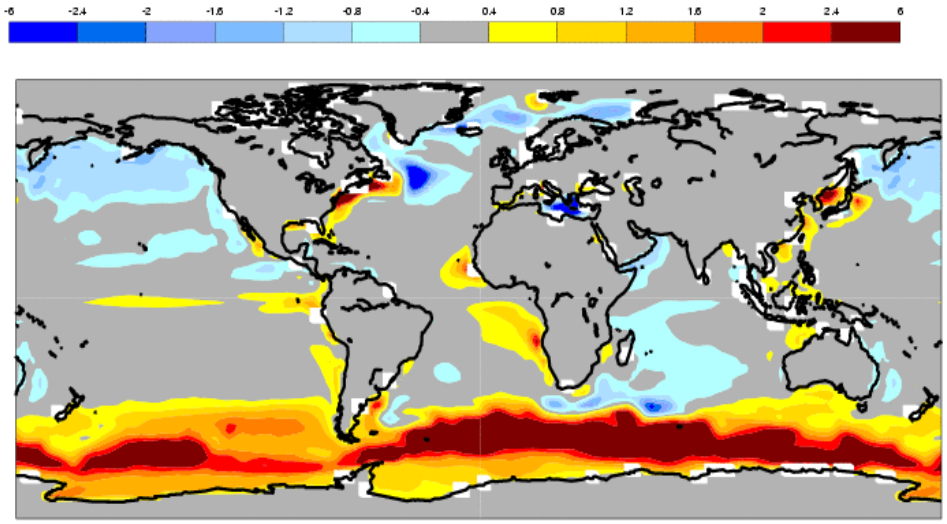
1981/2010

Verify: Dec-Feb

System 4



System 3



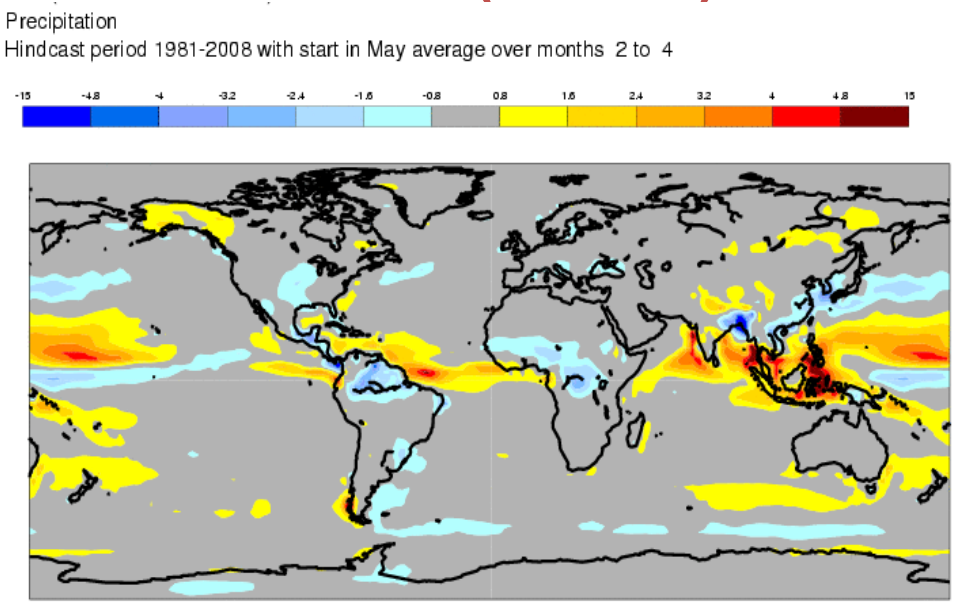
Bias in S4 re-forecasts: rainfall (JJA)

Start: 1 May

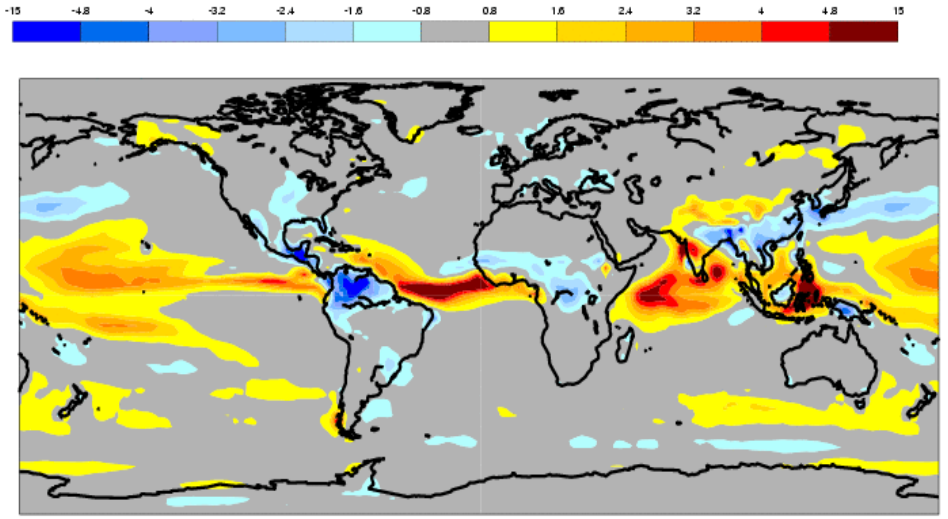
1981/2010

Verify: Jun-Aug

System 4



System 3



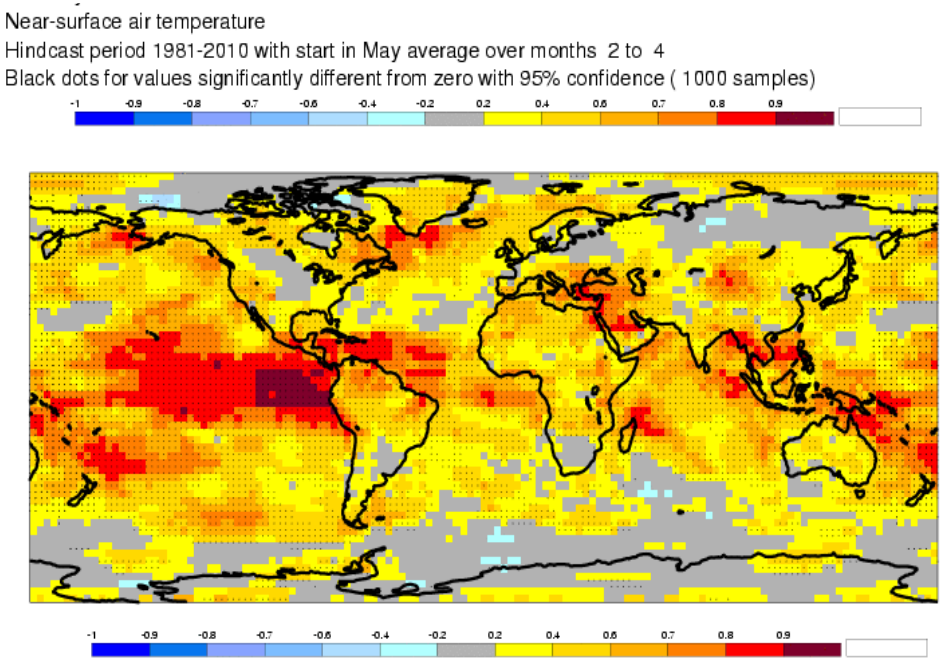
Ens-mean ACC in S4 re-forecasts: 2m T (JJA)

Start: 1 May

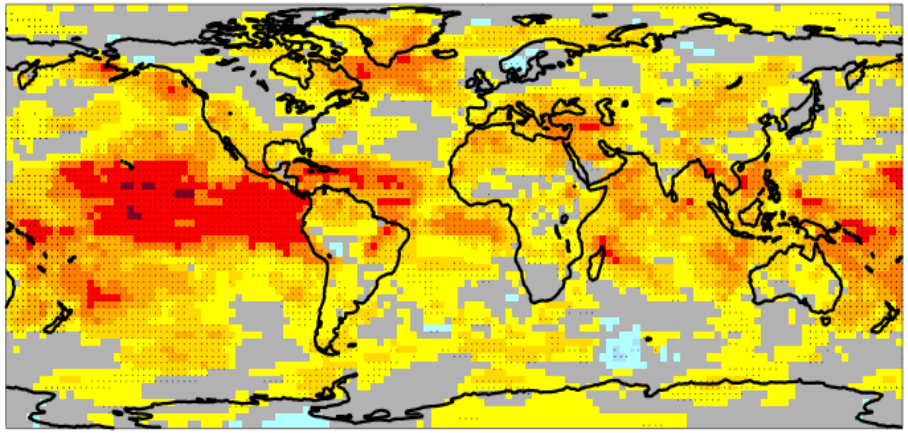
1981/2010

Verify: Jun-Aug

System 4



System 3



Outlook for Europe

Long-term predictions over Europe are particularly difficult:

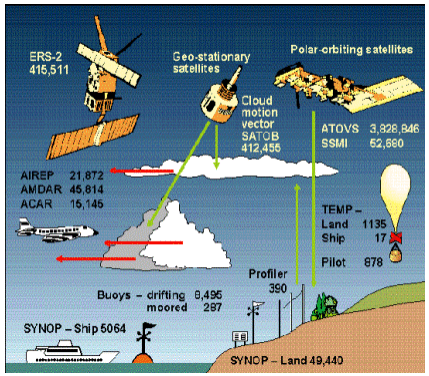
• At times during very large El Niño part of Europe seem to be affected.

• However non-linearity of the atmosphere seem to play a relevant role over this region.

• The Atlantic Ocean influence on the weather over Europe is not yet well understood.

Initialization:

Observations



Data Assimilation

Current state of the atmosphere

Current state of the ocean

System 4

4-D variational d.a.

3-D v.d.a. (NEMOVAR)

Initial Con.

Gen. of Perturb.