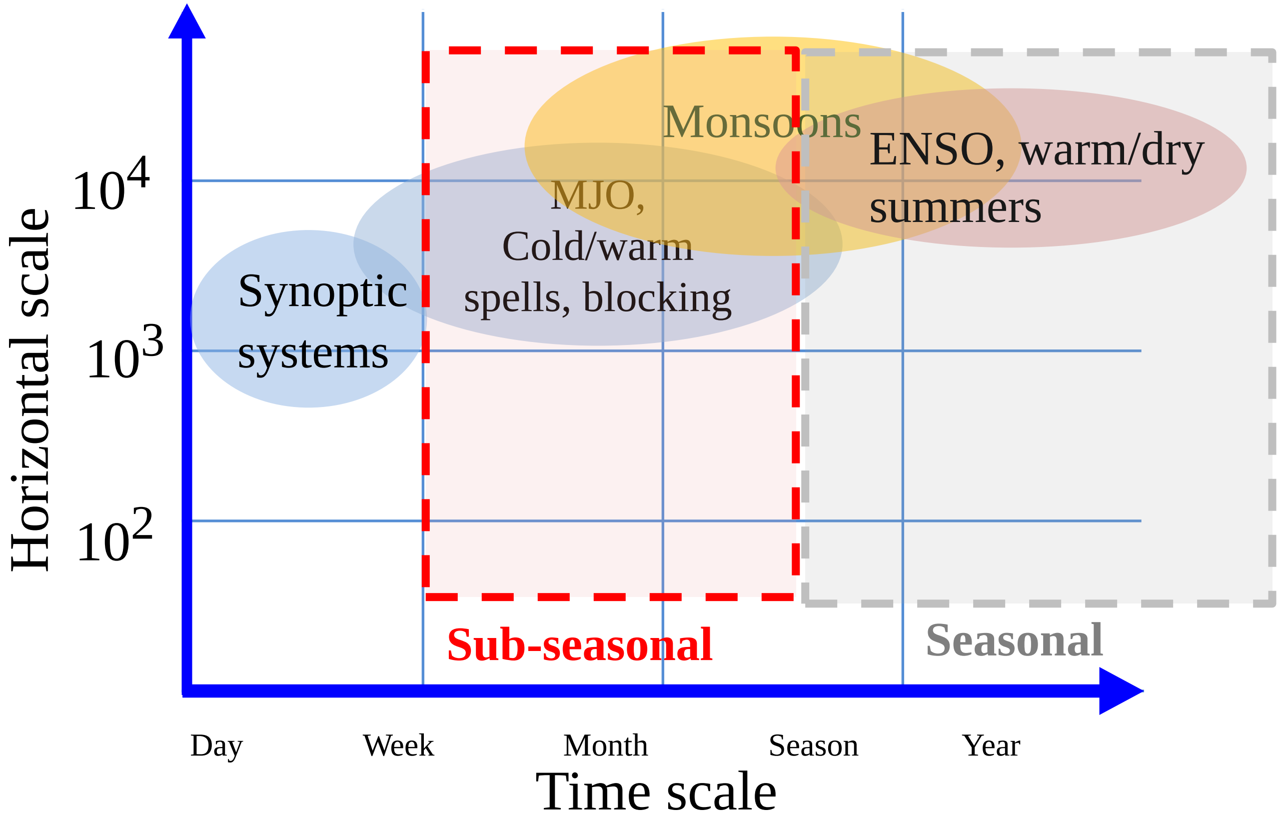
Seasonal forecasting at ECMWF

L. Ferranti

Seasonal time scale: longer than one season shorter than 10 years

Sources of predictability at extended range :



The operational forecasting system

High resolution forecast: twice per day Tco 1279 ~ 9km
137-level, to 10 days ahead

Coupled atmosphere-ocean system

Ensemble Prediction System (ENS): twice daily Tl 639/319 32/64 km
91-level, 51 members to 15 days ahead (next update Tco639 – 18Km)

Extended range forecasts /ENS extension: twice a week (Mon/Thu)

Tco 639/319 ~ 18/36 km 91 levels, 51 members to 46 days ahead

Long range forecasts: once a month 51 members, ~36 km 91 levels, to 7 months ahead

	SEAS4	SEAS5
IFS Cycle	36r4	43r1
IFS horizontal resolution	TL255	TCO319
IFS Gaussian grid	N128 (80 km)	O320 (35 km)
IFS vertical resolution (TOA)	L91 (0.01 hPa)	L91 (0.01 hPa)
Ocean model	NEMO v3.3	NEMO v3.4
Ocean horizontal resolution	ORCA 1.0	ORCA 0.25
Ocean vertical resolution	L42	L75
Sea ice model	Sampled climatology	LIM2

Atmosphere initialization (Re-forecast/Forecast)	ERA-Int/Op	ERA-Int/Op
Land Initialization(Re-forecast/Forecast)	ERA-Int land (36r4)/Op.	ERA-Int land (43r1)/Op.
Ocean initialization	ORA-S4	OCEAN5

Forecast ensemble size	51 (0-7m) /15 (8-13m)	51 (0-7m) /15 (8-13m)
Re-forecast years	30 (1981-2010)	36 (1981-2016)
Re-forecast ensemble size	15 (0-7m)/15 (8-13m)	25 (0-7m) /15 (8-13m)
Calibration period	1981-2010	1993-2016

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

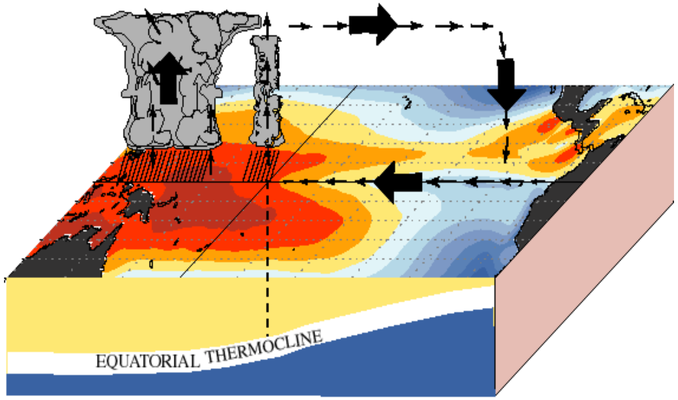
Despite the chaotic nature of the atmosphere, long term predictions rely on a number of components which themselves show variations on long time scales (seasons and years) and, to a certain extent, are predictable.

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.

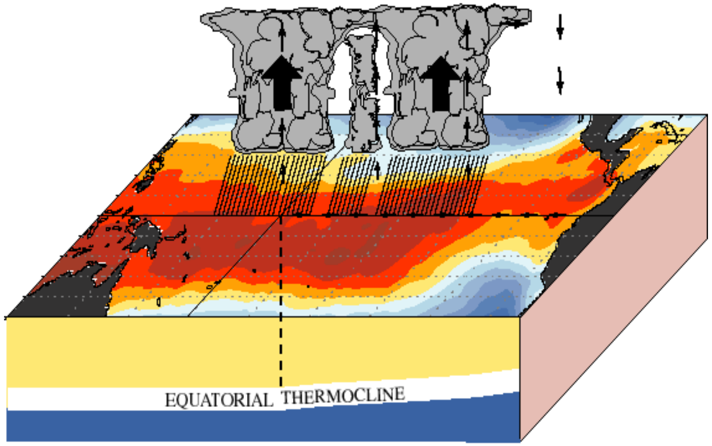
- **ENSO variability**
- **Other tropical ocean SST**
- **Climate change** - long term trends
- **Land surface conditions** - e.g. soil moisture in 2003, sea-ice

THE EL NIÑO/SOUTHERN OSCILLATION (ENSO) CYCLE

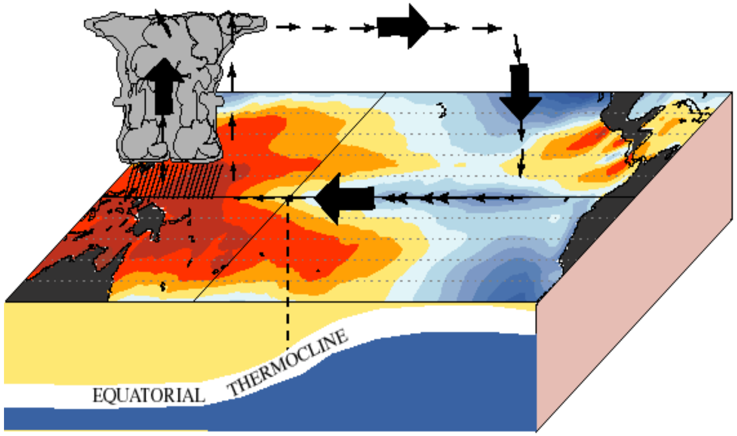
December - February Normal Conditions



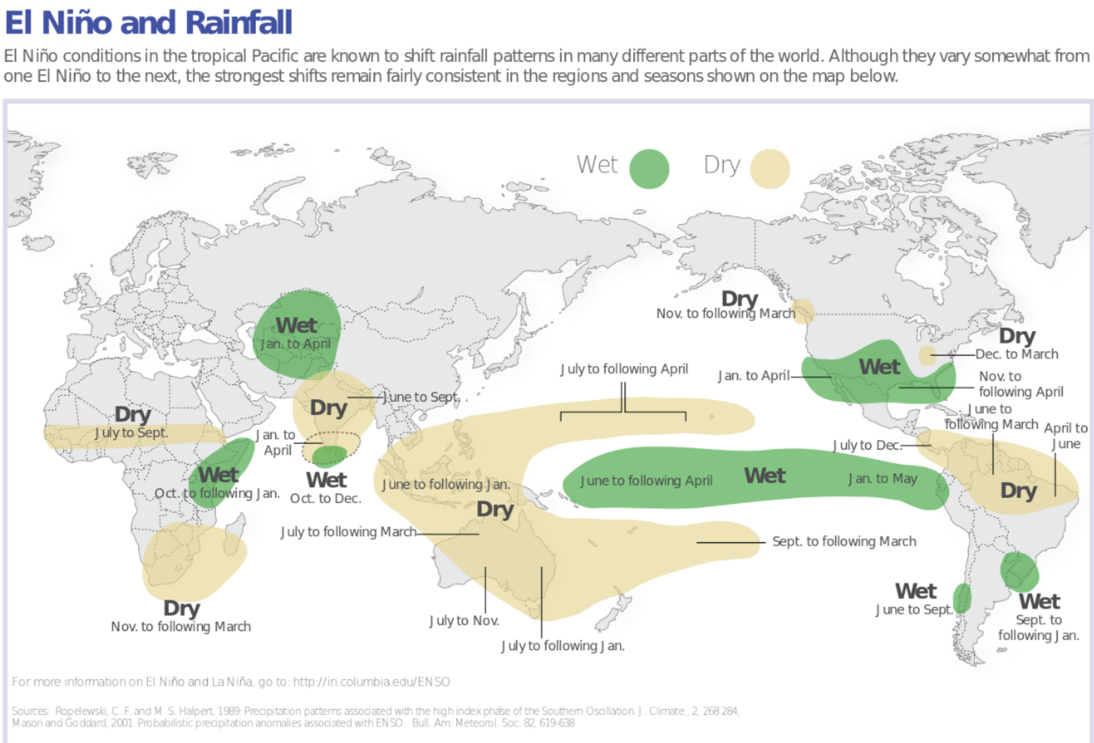
December - February El Niño Conditions

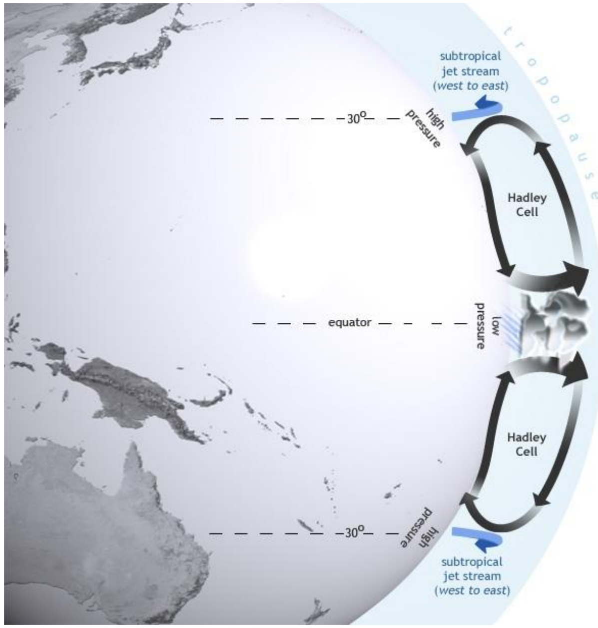


December - February La Niña Conditions



ENSO global impacts:

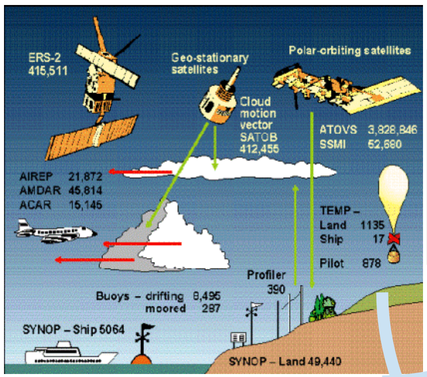




By strengthening the Hadley circulation, El Niño can trigger a cascade of noticeable departures from the normal rainfall patterns around the globe. The changes stretching across the globe are called El Niño teleconnections. Teleconnection patterns emerge in climate simulations, and they show up in historical observations.

ECMWF Seasonal Forecasting System

Observations



Data Assimilation

Current state of the atmosphere

Current state of the ocean

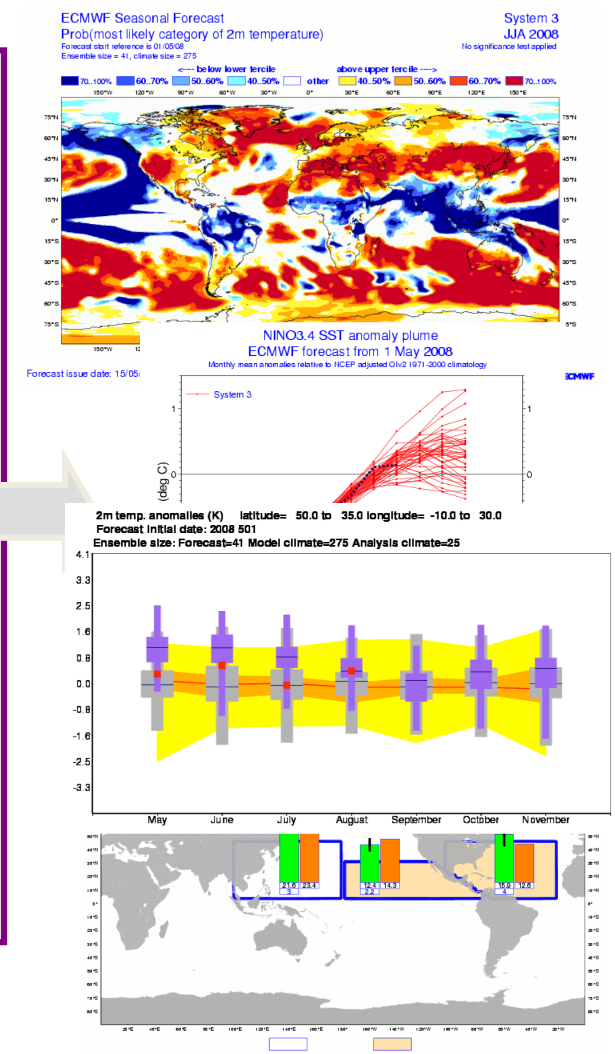
Coupled model

Atmospheric model

Coupler

Ocean Model

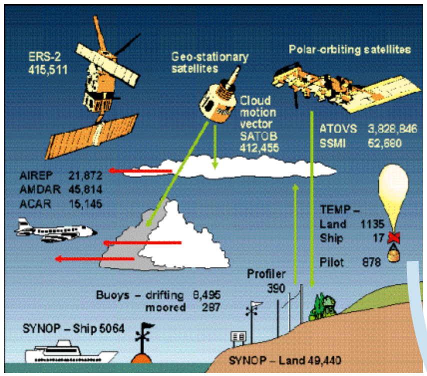
Forecast Products



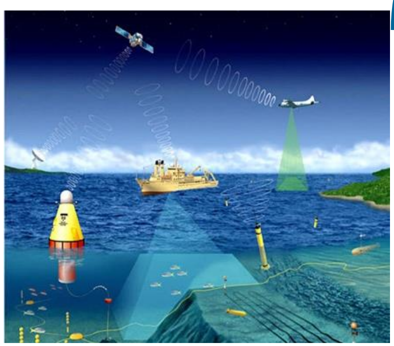
Initialization:

Data Assimilation

Observations



Current state of the atmosphere



Current state of the ocean

4-D variational d.a.

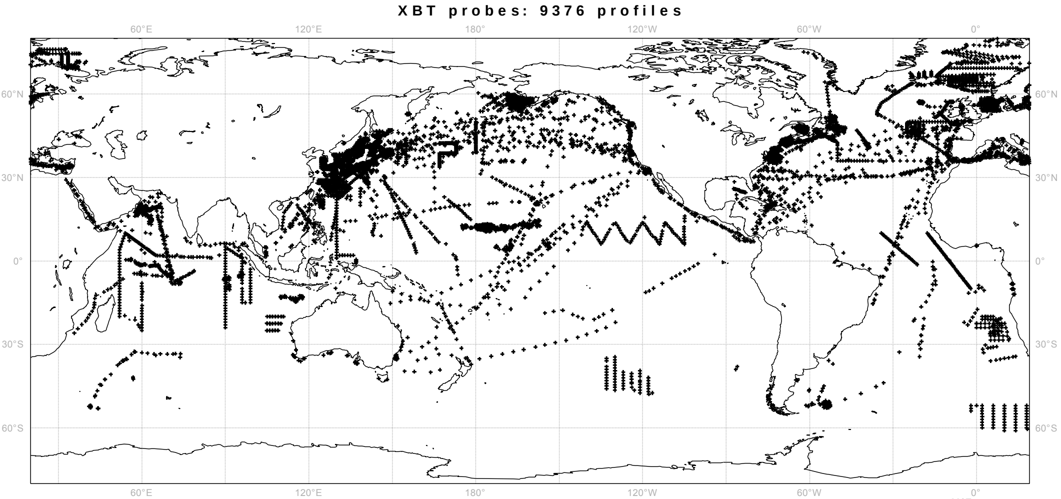
Initial Con.

Gen. of Perturb.

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

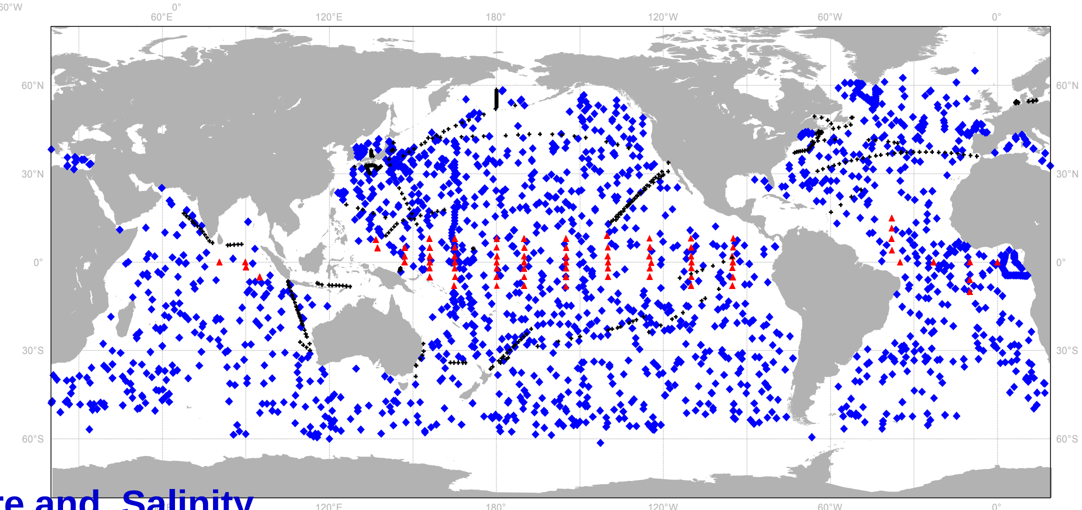
Ocean Observing System

Data coverage for June 1982



Changing observing system is a challenge for consistent reanalysis

Data coverage for Nov 2005

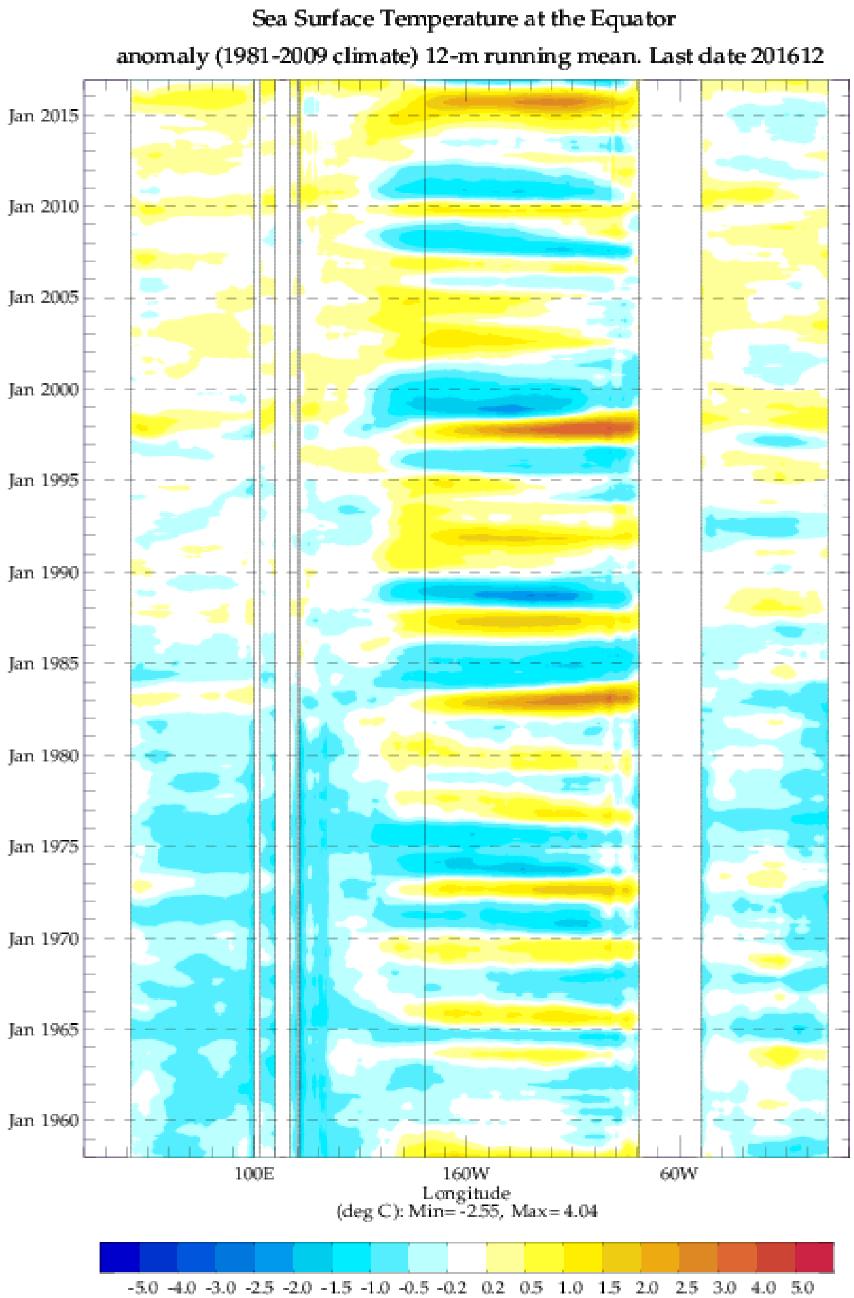


Today's Observations will be used in years to come

▲Moorings: Subsurface Temperature

◊ ARGO floats: Subsurface Temperature and Salinity

+ XBT : Subsurface Temperature



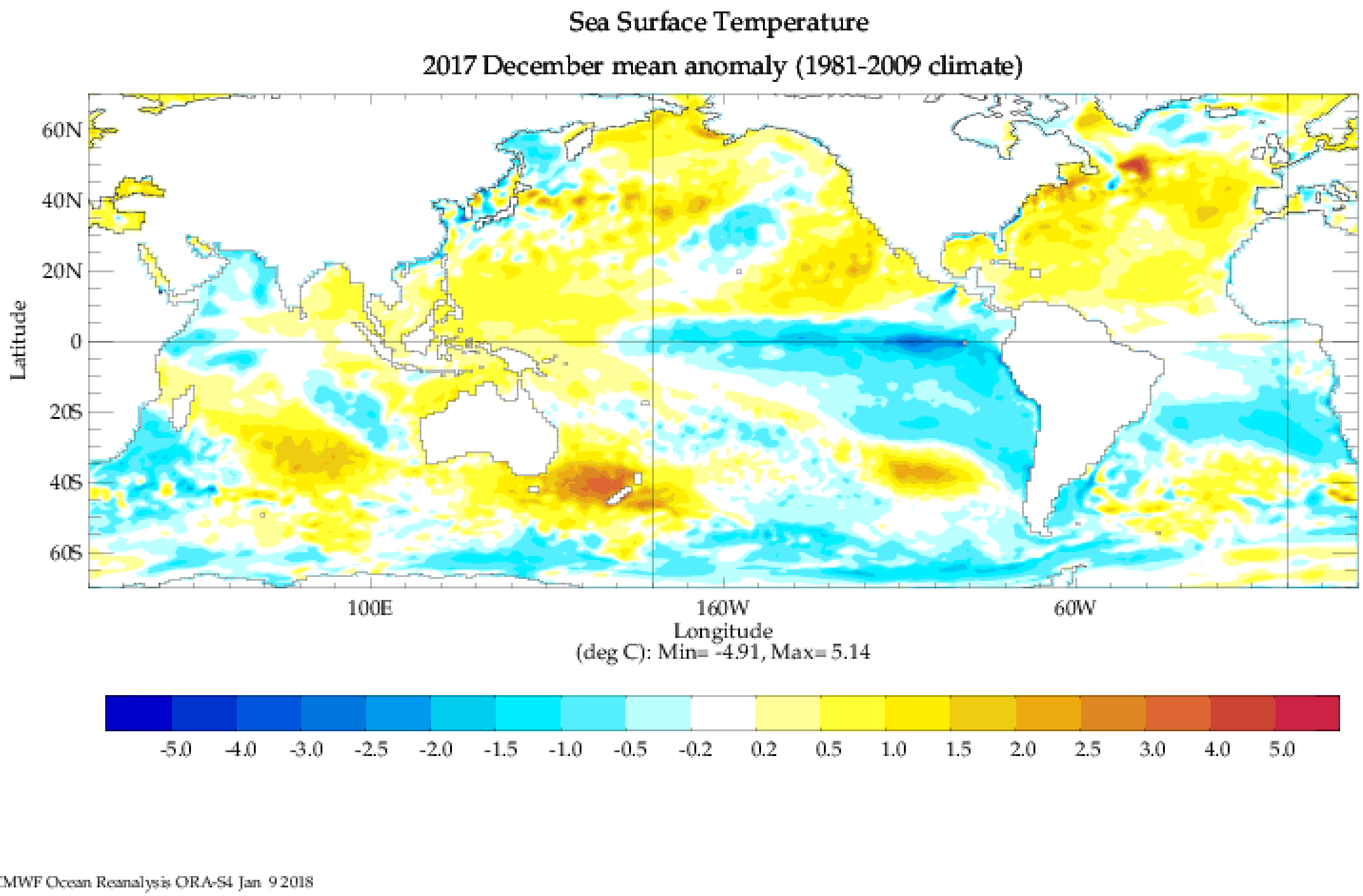
ECMWF Ocean Reanalysis ORA-S4 Jan 14 2017

El Nino 2016

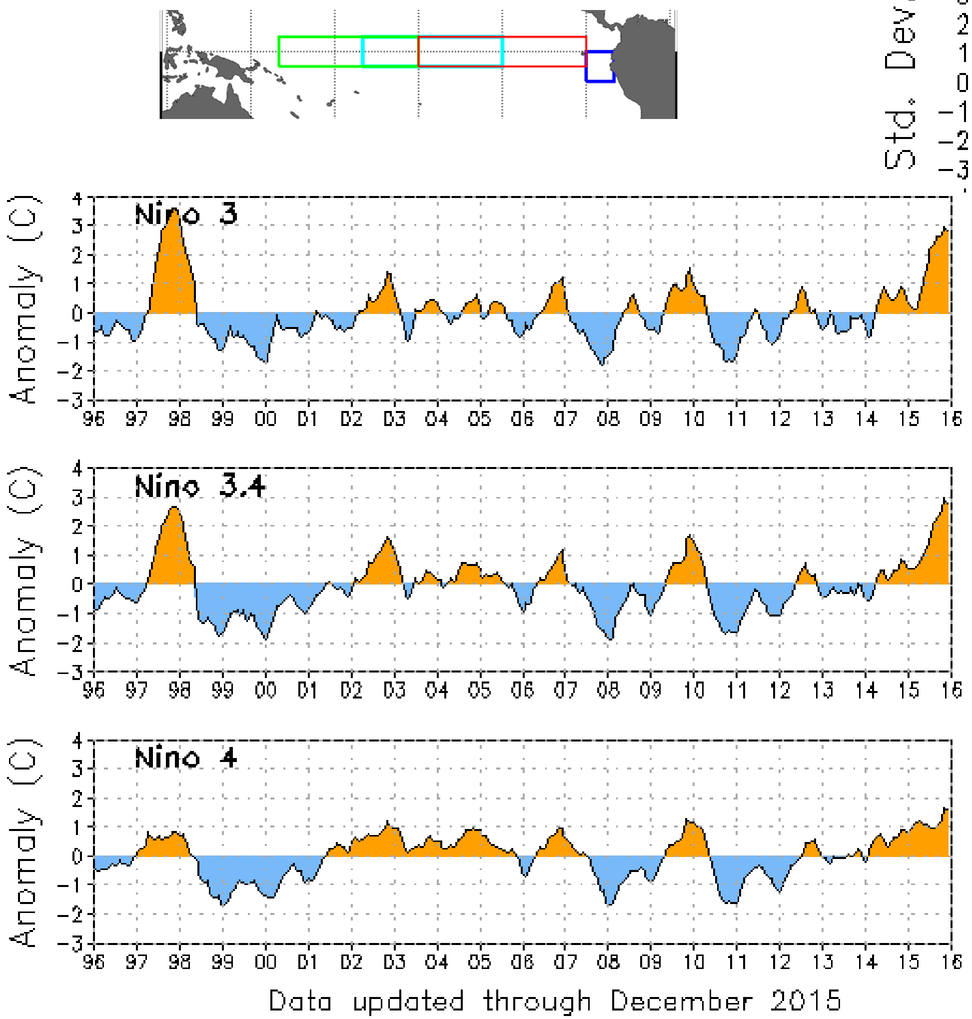
El Nino 1997

El Nino 1982/83

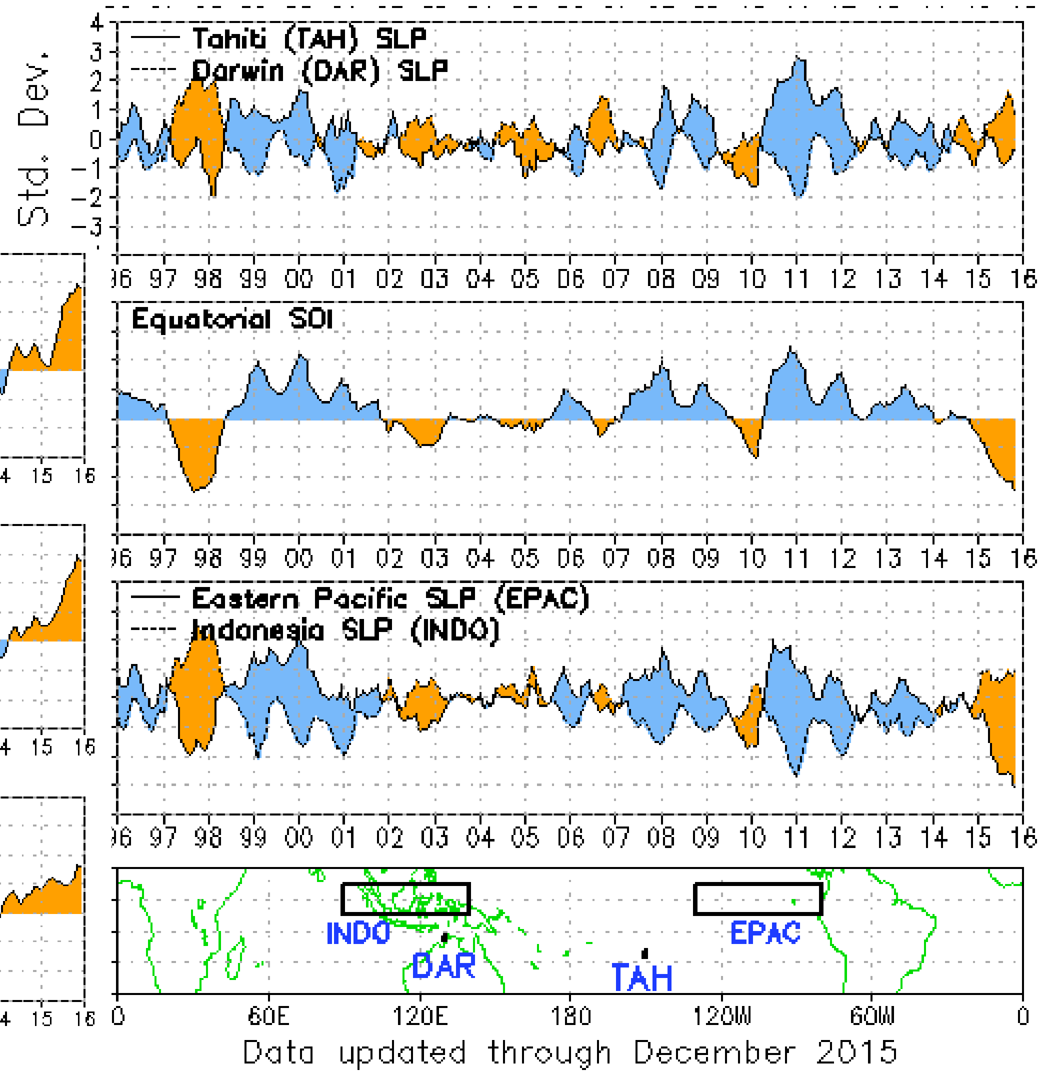
Current ocean conditions from ECMWF ocean data assimilation :



SST anomalies



Southern Oscillation Index (SOI):



ECMWF System 5: main features

- **Operational forecasts**
  - **51-member ensemble from 1st day of the month**
  - **released on the 5th**
  - **7-month integration**

- **Re-forecast set**
  - **36 years, start dates from 1 Jan 1981 to 1 Dec 2016**
  - **25-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**

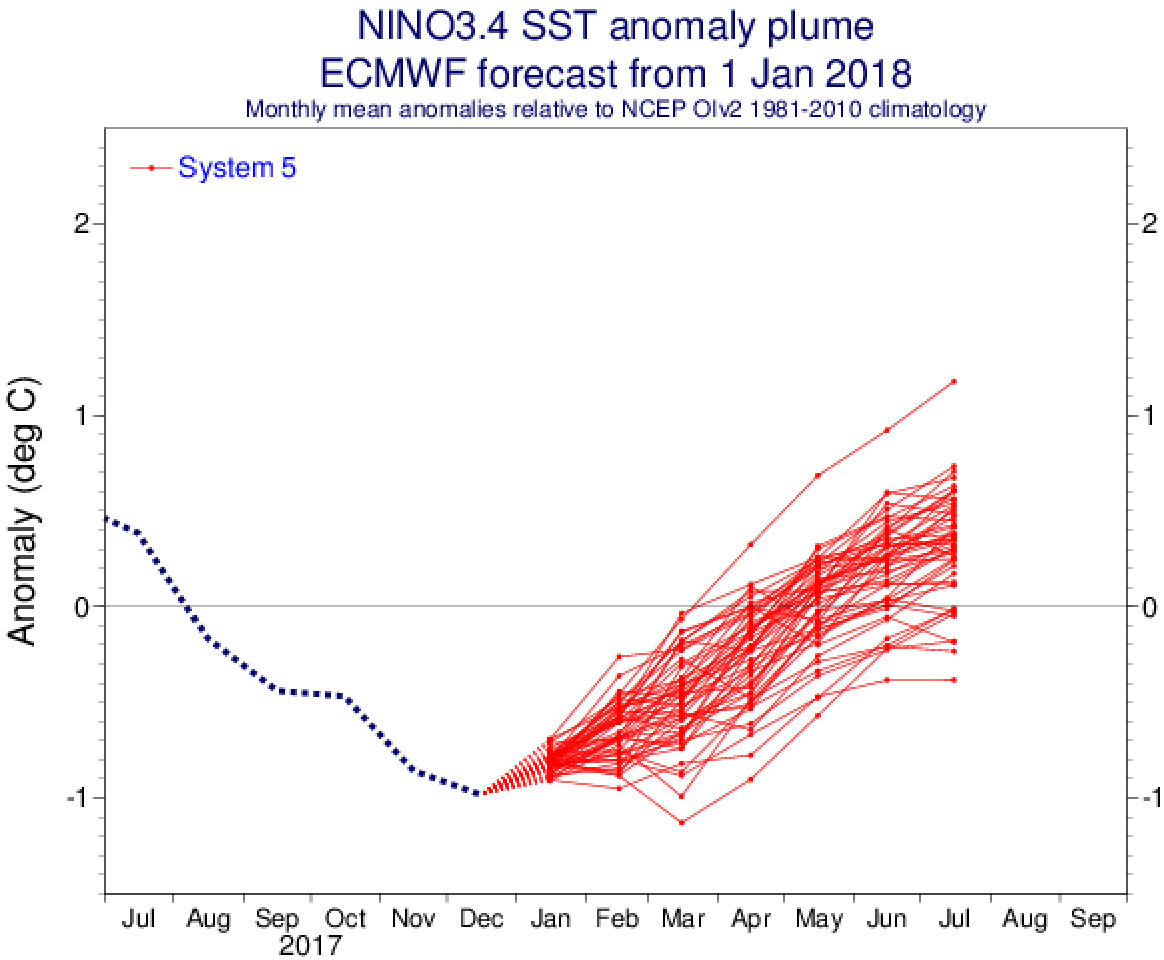
Products :

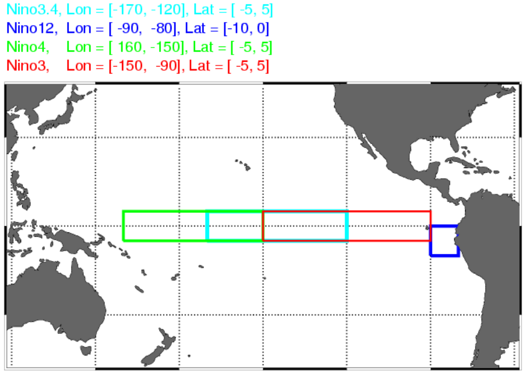
- Ocean Analysis

- Seasonal outlook: (up to 7 months ahead)

  - Forecasts for Nino3, Nino3.4 and Nino4
  - Spatial plots (ens.mean anomaly, terciles ..)
  - Climagrams (similar to Epsgrams, teleconnection patterns)
  - Tropical storms

NINO3.4 plumes

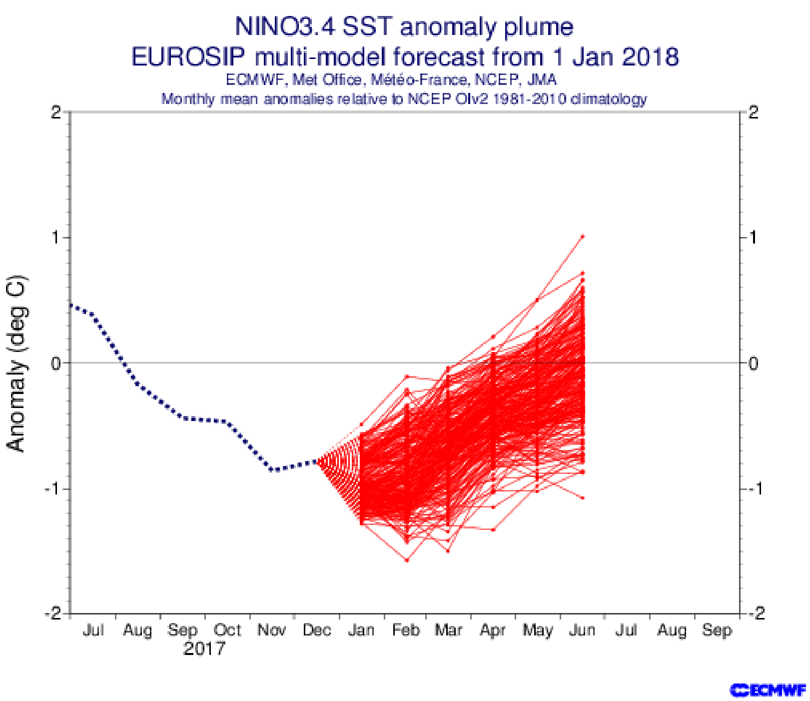


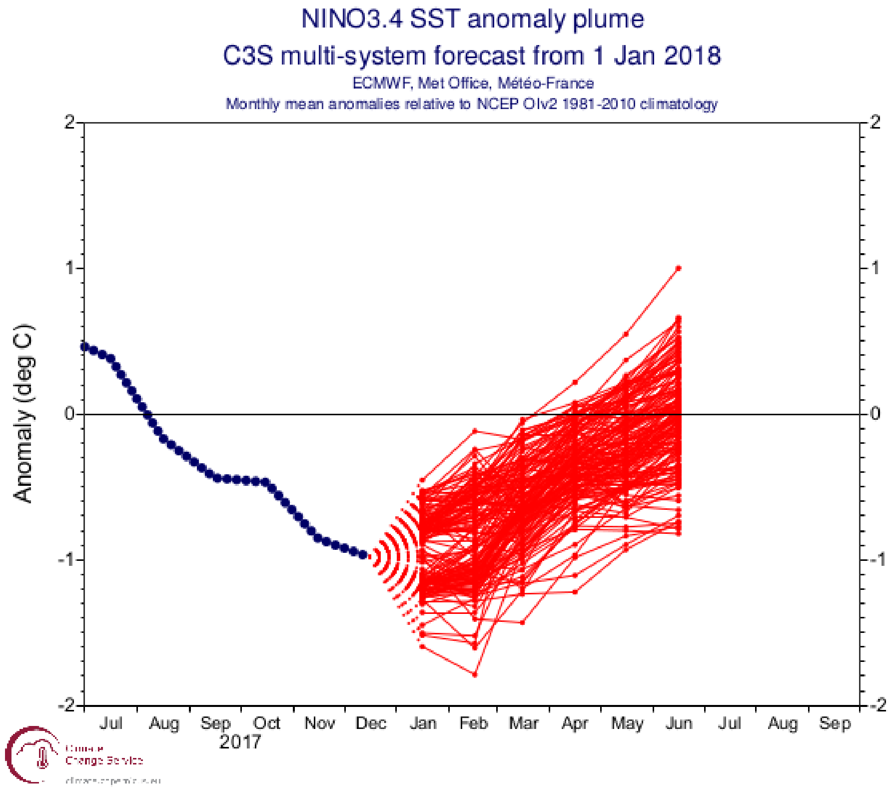


Forecast is made available on the 5h of each month.

EUROSIP and Copernicus Climate Change Service (C3S) multi-model systems:

C3S is still in the development phase and will combine observations of the climate system with the latest science to develop authoritative, quality-assured information about the past, current and future states of the climate in Europe and worldwide.
ECMWF operates the Copernicus Climate Change Service on behalf of the European Union and will bring together expertise from across Europe to deliver the service. C3S will provide key indicators on climate change drivers such as carbon dioxide and impacts, for example, reducing glaciers. The aim of these indicators will be to support European adaptation and mitigation policies in a number of sectors. (http://climate.copernicus.eu/about-c3s)





02/02/2018

Eurosip is issued on the 15th of the month

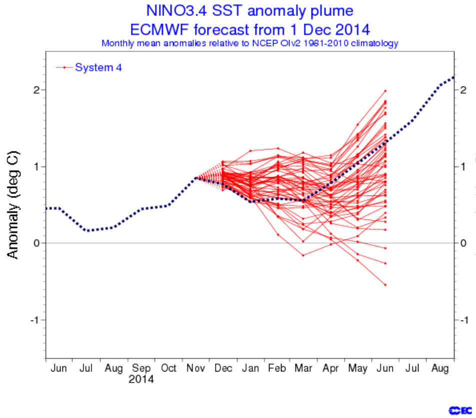
EUROSIP multi-model system:

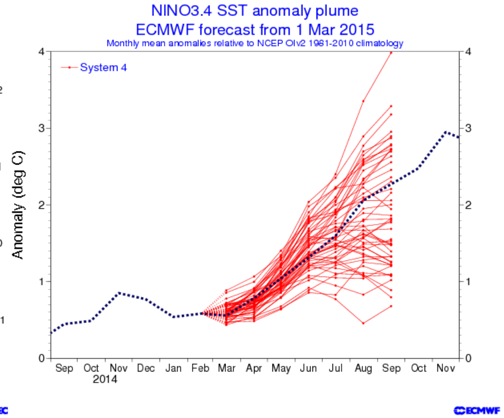
4 Coupled Systems: ECMWF, Météo France, Met Office, NCEP

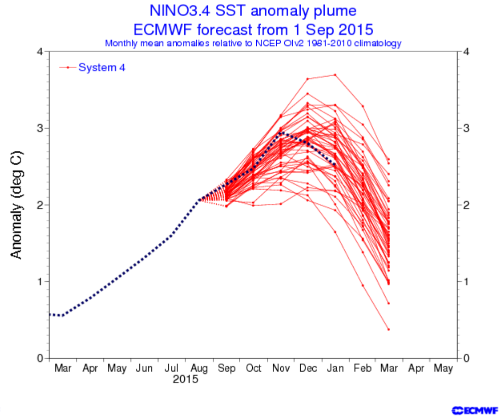
- **Ensemble generation for the 4 systems is different**
- **Development of multi-model products is ongoing**
- **EUROSIP products are available to WMO users**

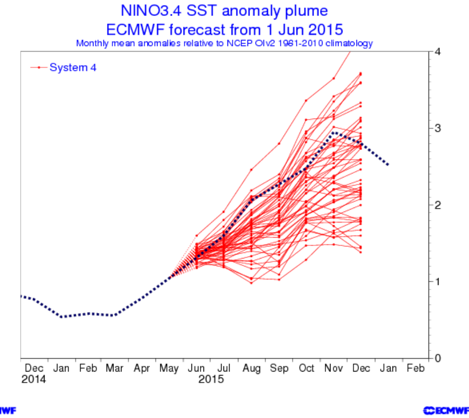
Plumes for Nino 3.4

System 4

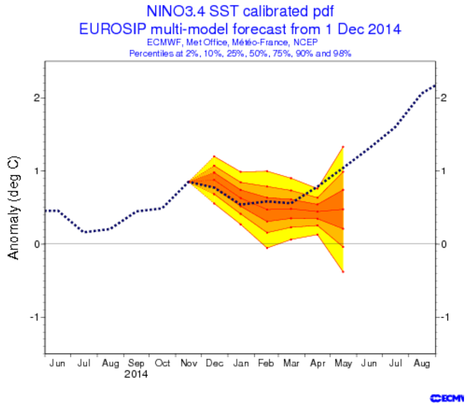


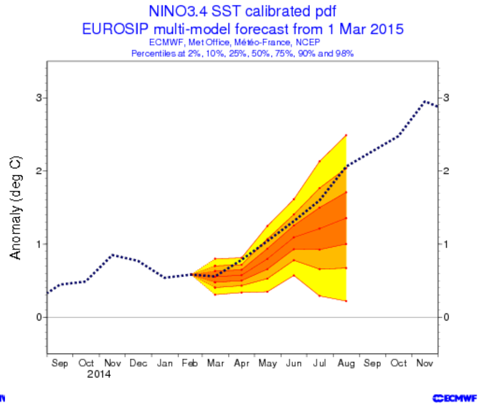


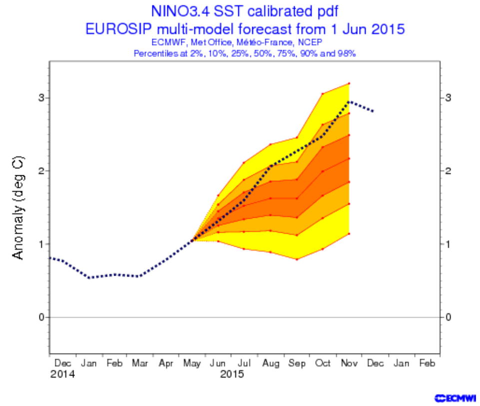


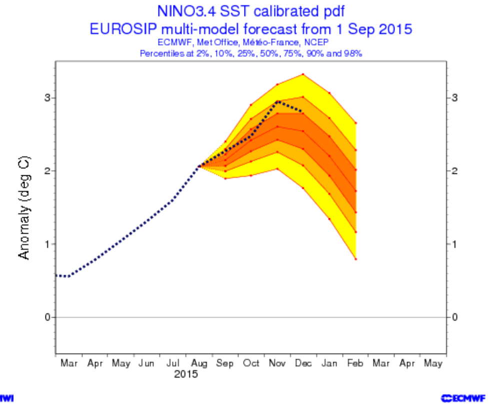


Eurosip



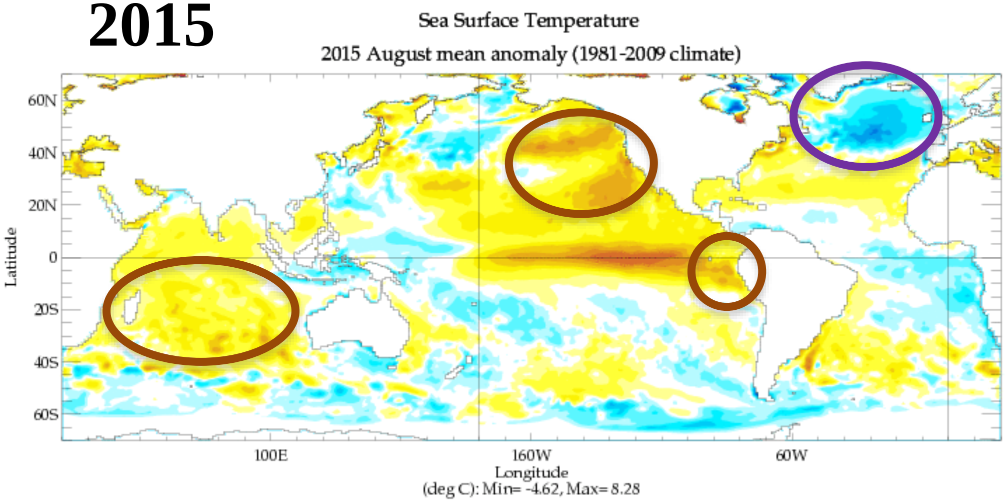




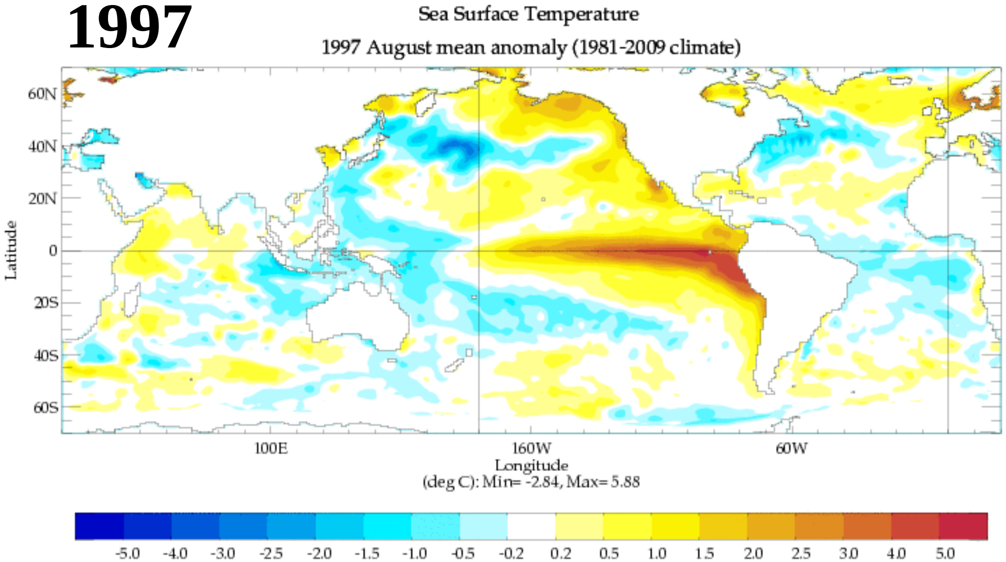


Global SST anomalies for August: 2015 versus 1997

2015

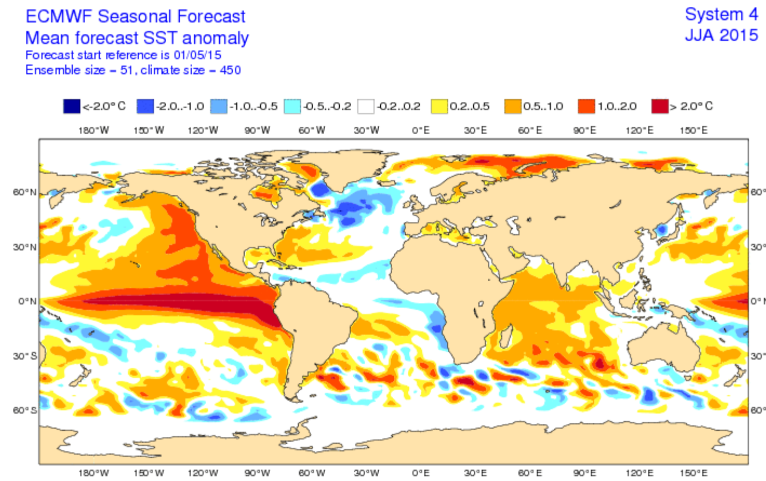


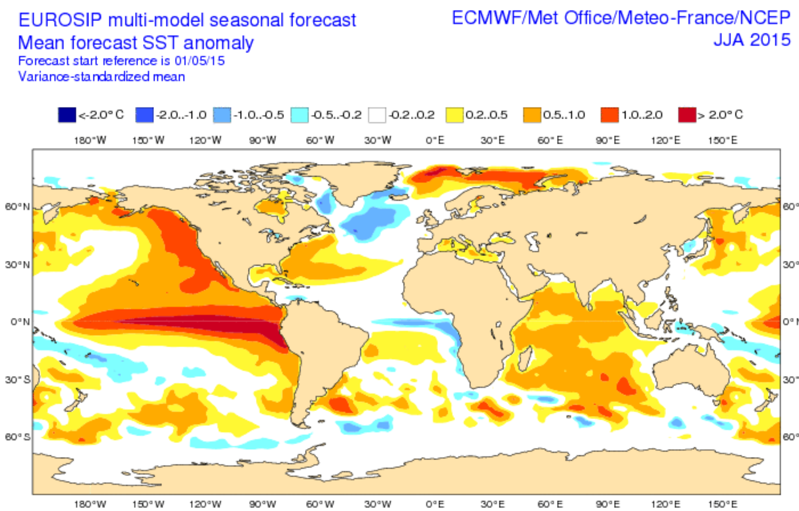
1997



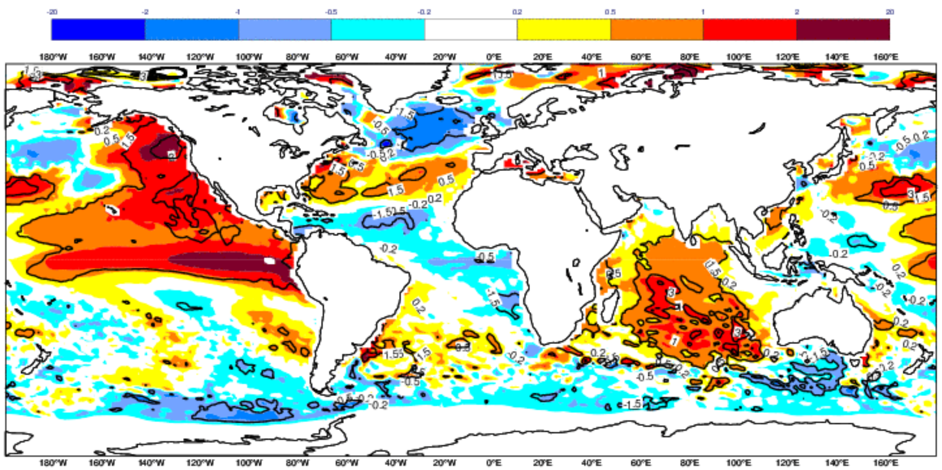
- Smaller anomalies over the pacific East coast (Nino1+2)
- Warm SST over the Pacific (40-15N) Eastern Pacific.
- Cold SST anomalies over the mid-lat. Atlantic likely to affect the ENSO teleconnection over Europe.
- Indian Oc. globally warm

Extended forecasts range performance for JJA 2015:

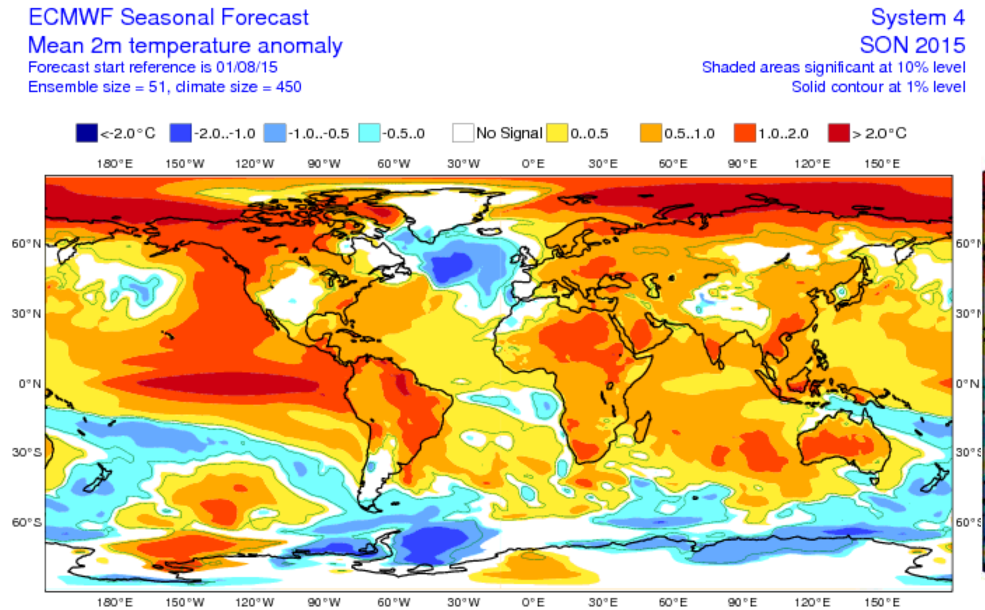




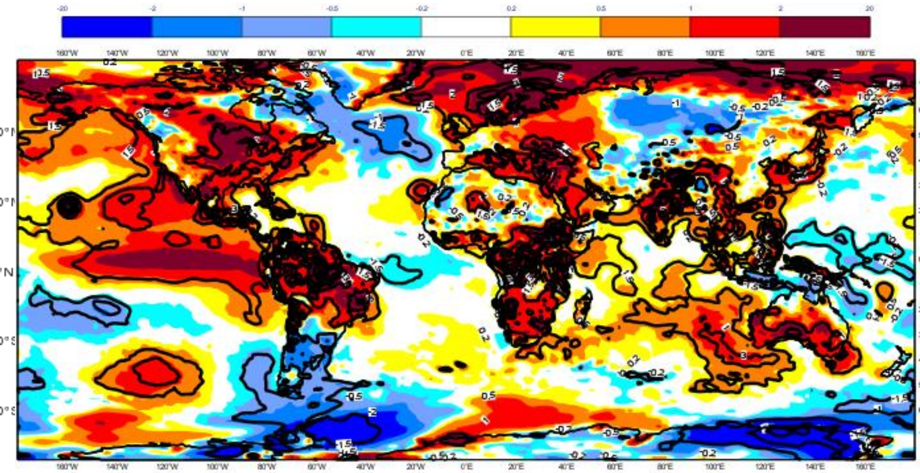
SST anomalies

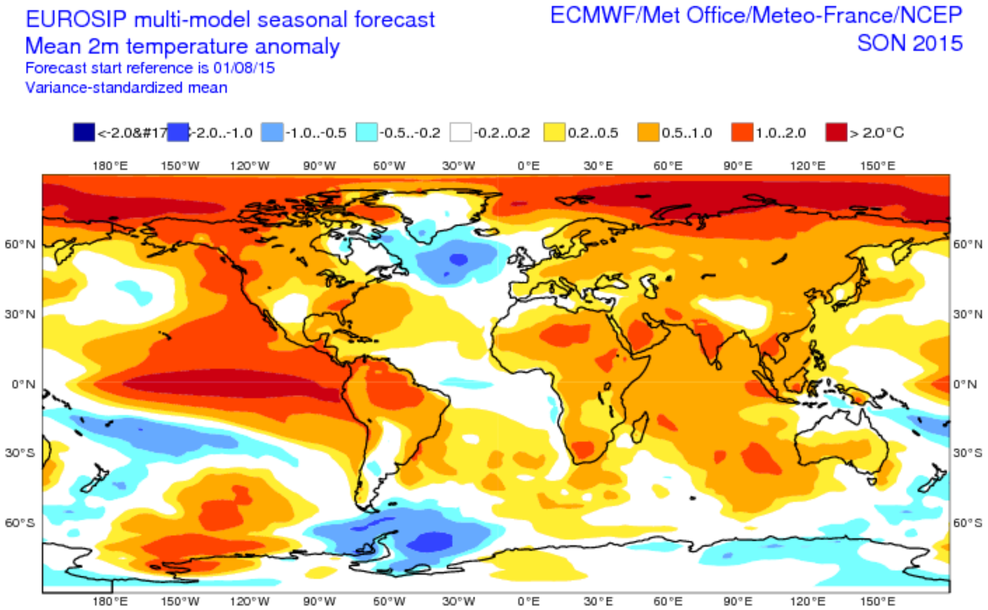


Seasonal forecast SON : 2-metre temperature anomalies



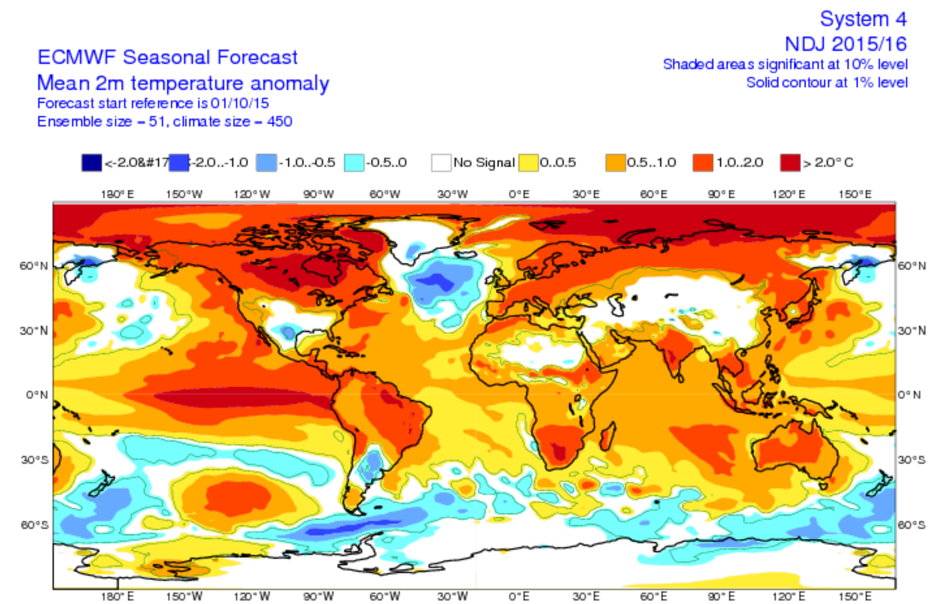
Observed

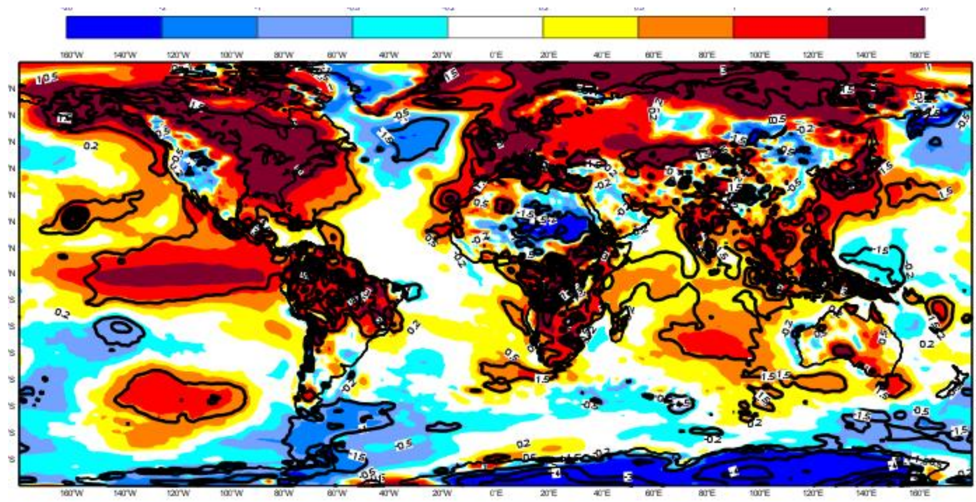


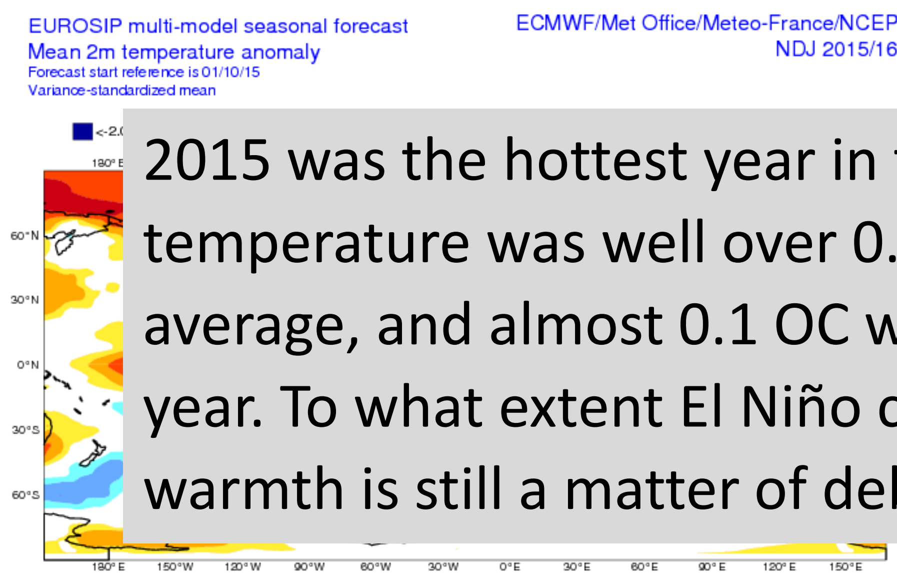


Extended forecasts range performance for NDJ 2016:

2mtemp anomalies

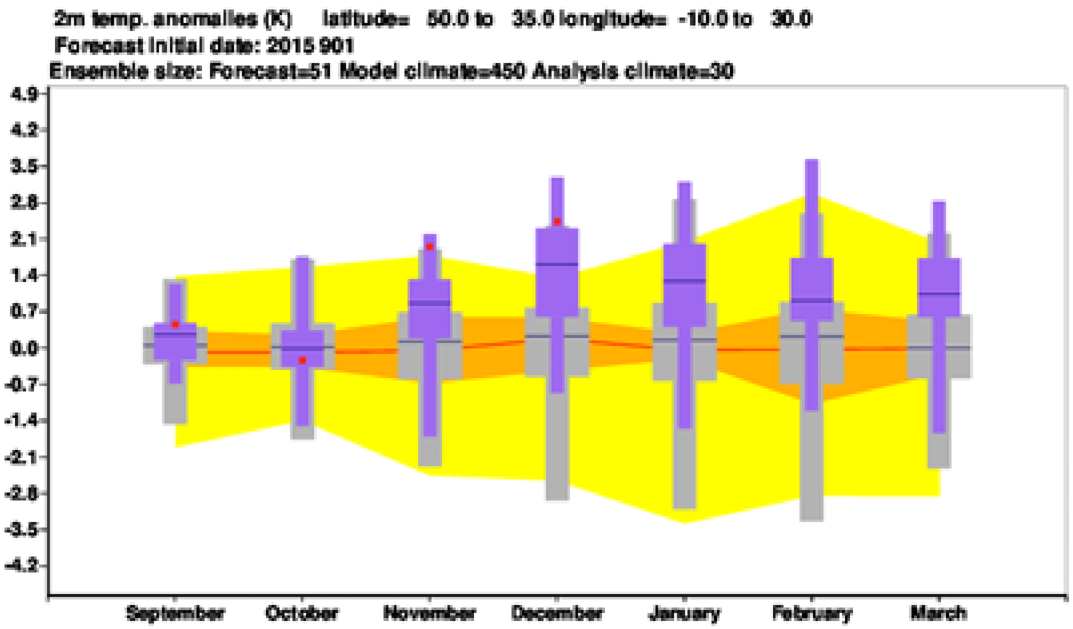


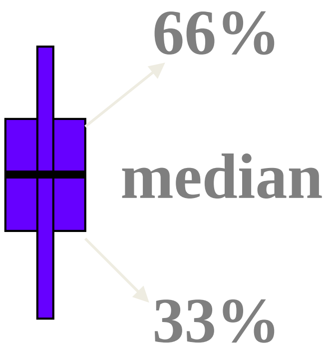


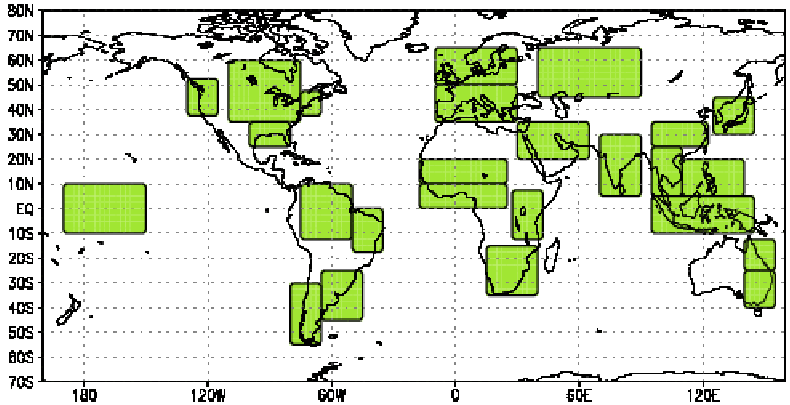


2015 was the hottest year in the modern record, global temperature was well over 0.4 OC warmer than the 1981-2010 average, and almost 0.1 OC warmer than the previous warmest year. To what extent El Niño contributed to the record-breaking warmth is still a matter of debate.

2m temp anomalies for Europe







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.

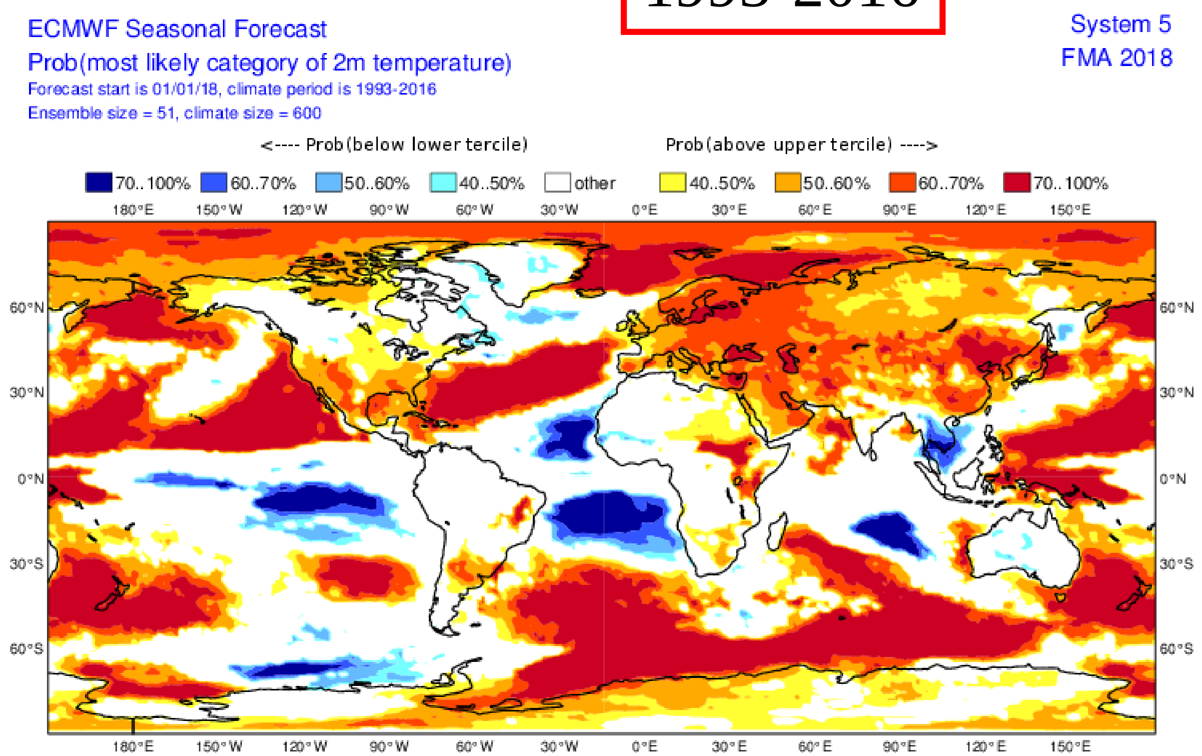
• However non-linearity of the atmosphere seem to play a relevant role over this region.

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

Seasonal forecast charts :

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

1993-2016



Available parameters are:

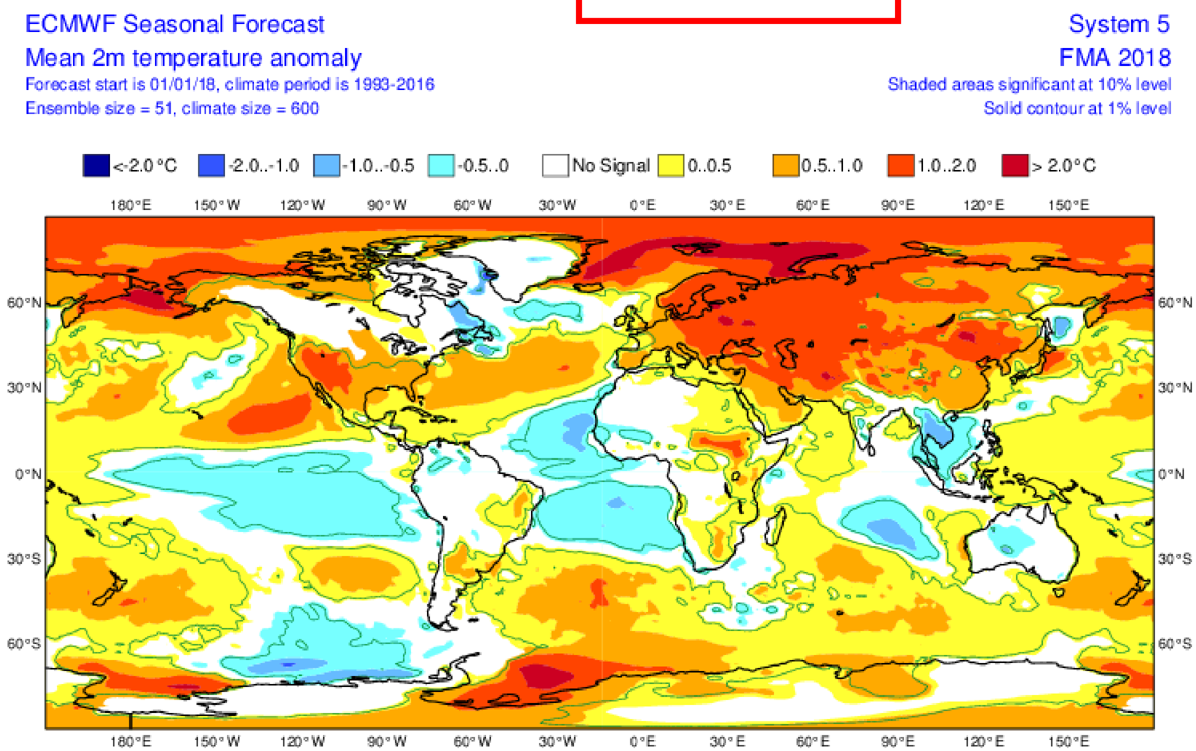
- 2m Temperature
- Mean sea level pressure
- Precipitation
- Sea surface temperature
- 850 hPa temperature
- 500 hPa geopotential

Forecast is made available on the 5th of each month.

Seasonal forecast charts :

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

1993-2016



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 5h of each month.

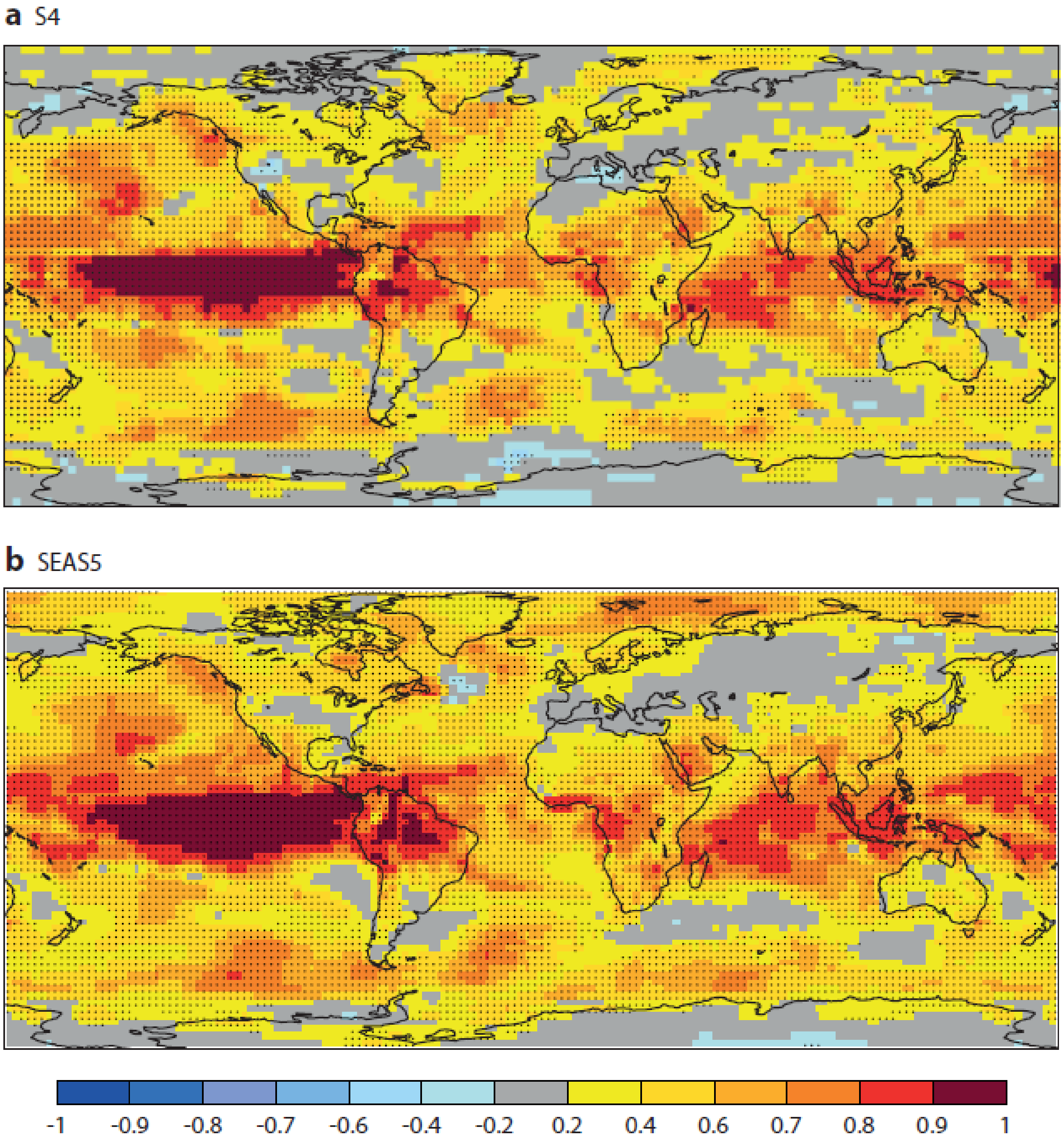


Figure 2 Anomaly correlation for ensemble mean December–January–February 2 m temperature predictions from 1 November for (a) S4 and (b) SEAS5. Measured skill in SEAS5 is higher partly due to the increased ensemble size, but beyond this there are real and statistically significant improvements in the tropics and in the Arctic. An anomaly correlation of 1 corresponds to a perfect deterministic forecast, while 0 means no skill.

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 (36 years)

1981-2016

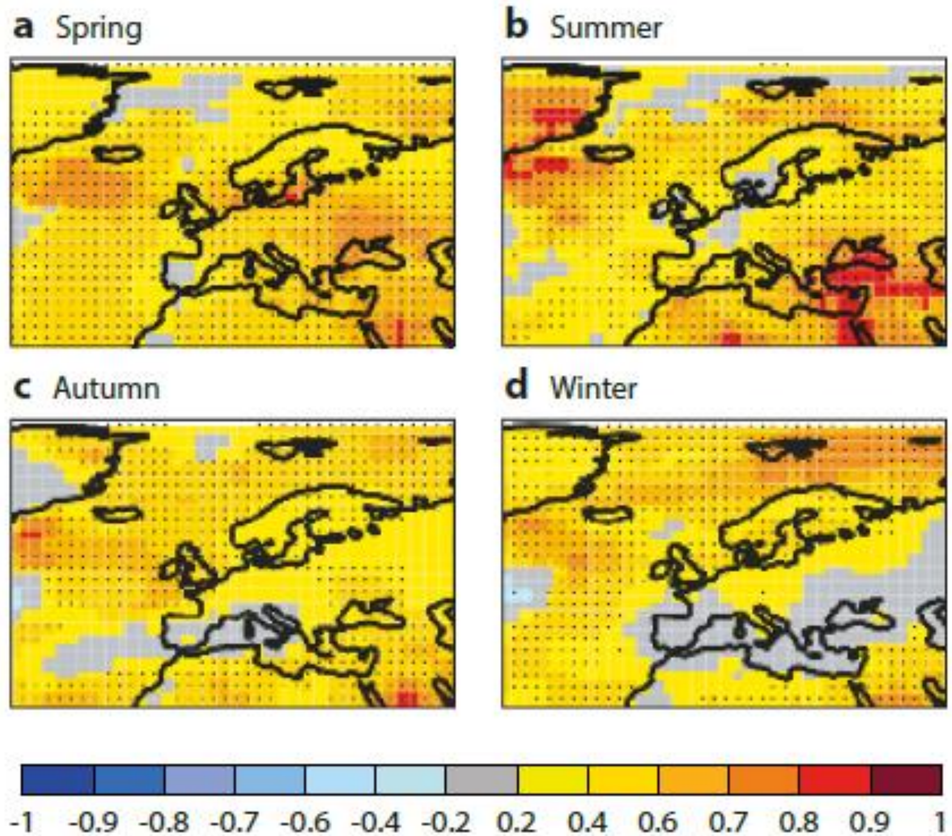


Figure 4 SEAS5 anomaly correlation skill for 2 m temperature in the European region, based on 1981–2016 re-forecasts, for (a) March–April–May, (b) June–July–August, (c) September–October-November, and (d) December–January–February, predicted from 1 February, May, August and November, respectively.

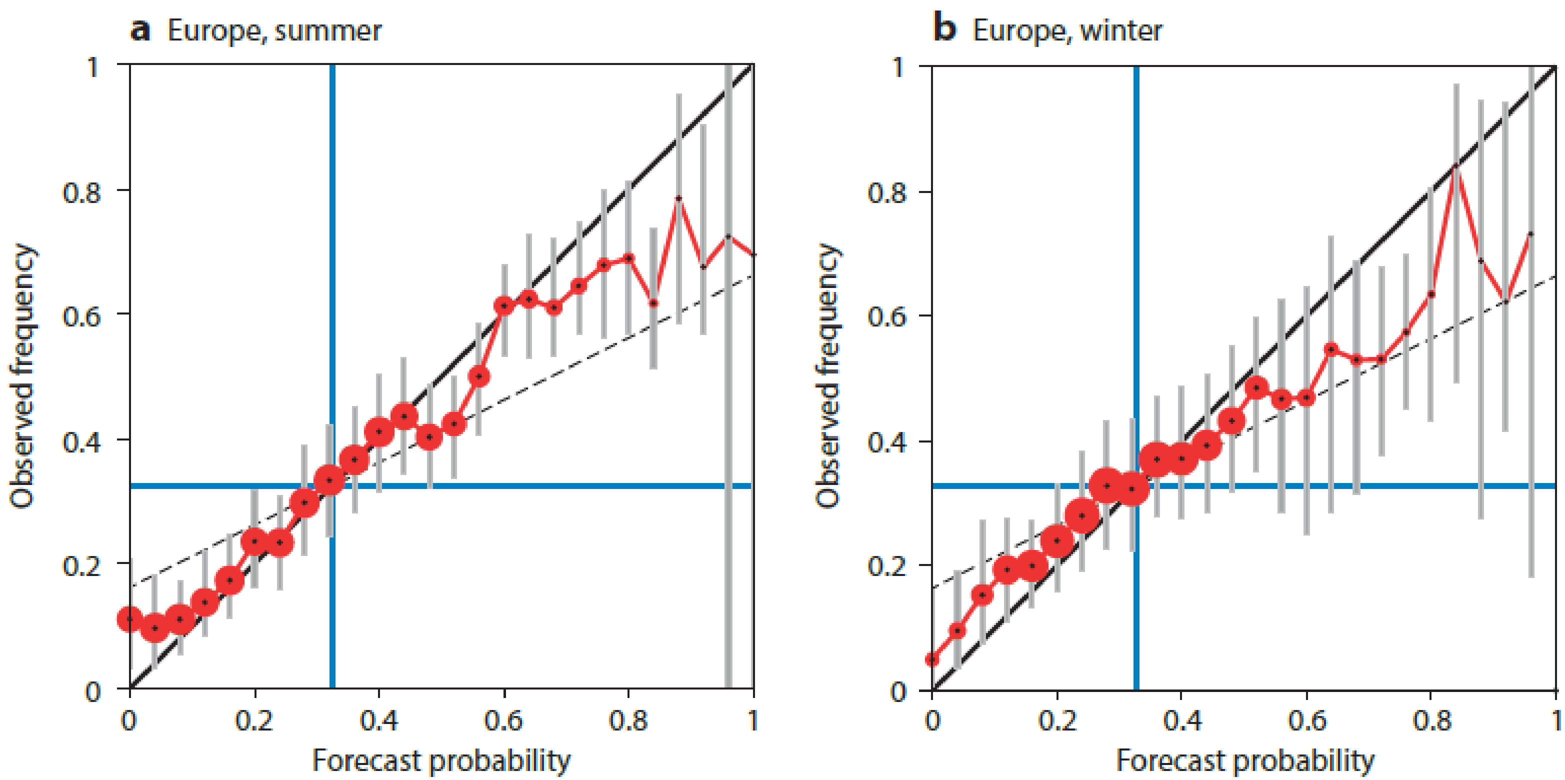


Figure 5 Reliability of forecasts of the probability that 2 m temperature anomalies will be in the upper tercile category for points in Europe (land and sea) for (a) 1 May forecasts for June–July–August and (b) 1 November forecasts for December–January–February. Both seasons have good overall reliability, as indicated by points lying close to the diagonal, but the June–July–August forecasts are sharper, i.e. more forecasts are far from the climatological value of 0.33. The distribution of forecast probabilities is indicated on the plot by the size of the circles, with bigger circles corresponding to more cases.

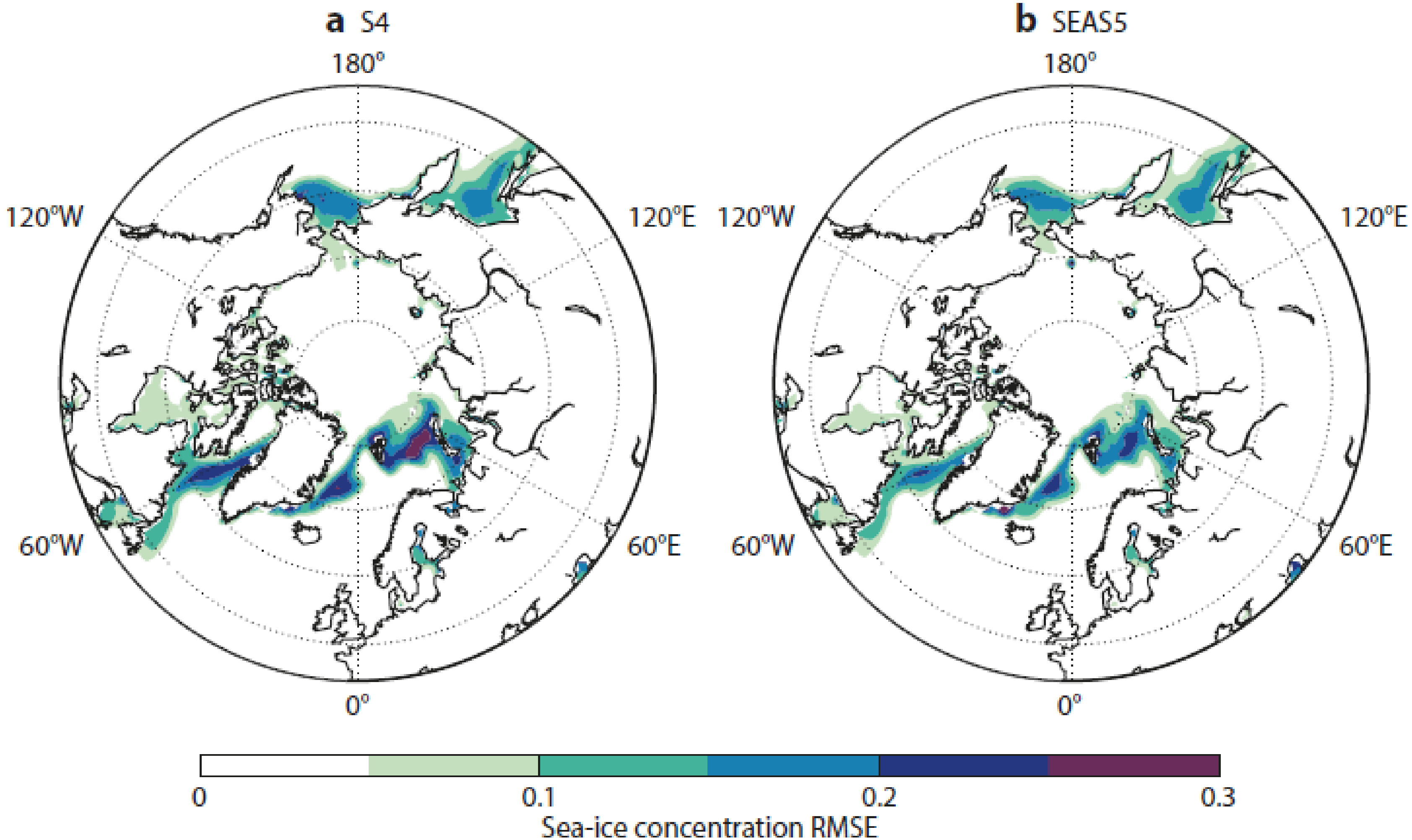


Figure 6 RMSE in predictions of December–January–February sea-ice concentration, for forecasts from 1 November, for the period 1981–2016 from (a) S4 and (b) SEAS5, showing the reduction in error due to the interactive sea-ice model.

Summary (2)

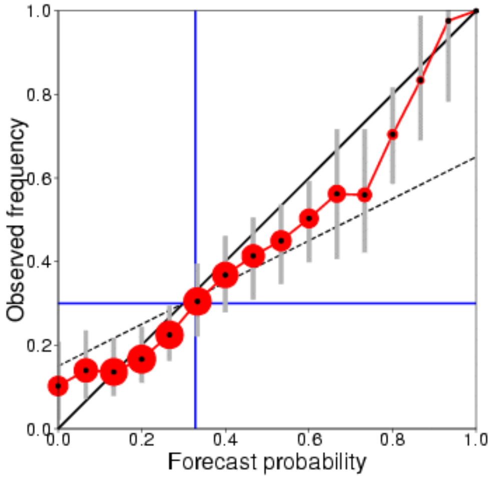
- The current operational seasonal forecast system provides a set graphic products on the web and digital data set to the users.
- The ECMWF seasonal forecast is a good system for El Nino predictions.
- Seasonal forecast predictions, particularly over mid-latitudes, should be used in combination with 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 Newsletter N.154, available at http:// www.ecmwf.int/publications

Reliability for summer predictions: warm events

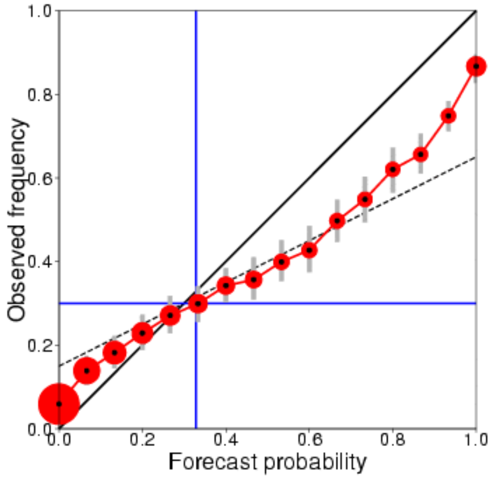
Europe

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

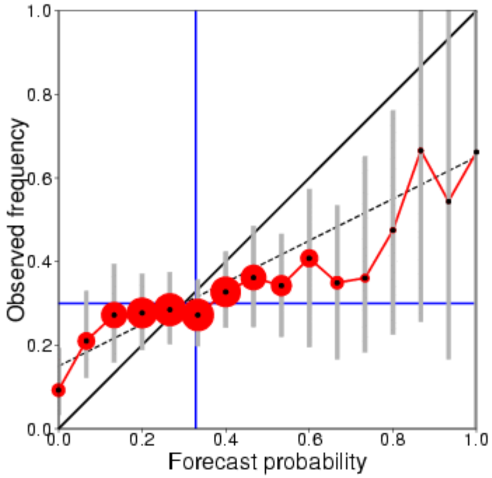
Reliability diagram for ECMWF with 15 ensemble members
Near-surface air temperature anomalies below the lower tercile
Accumulated over tropical band (land and sea points)
Hindcast period 1981-2010 with start in May average over months 2 to 4
Skill scores and 95% conf. intervals (1000 samples)
Brier skill 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

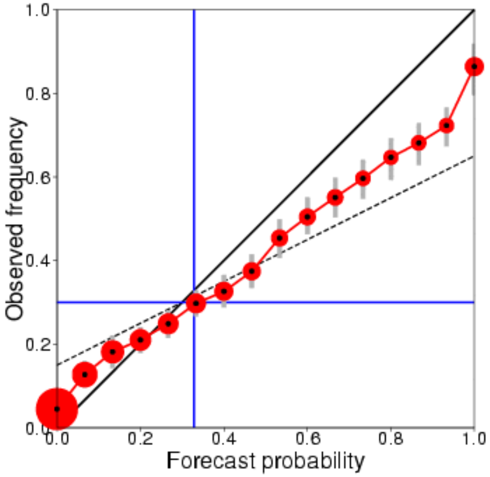
|Europe

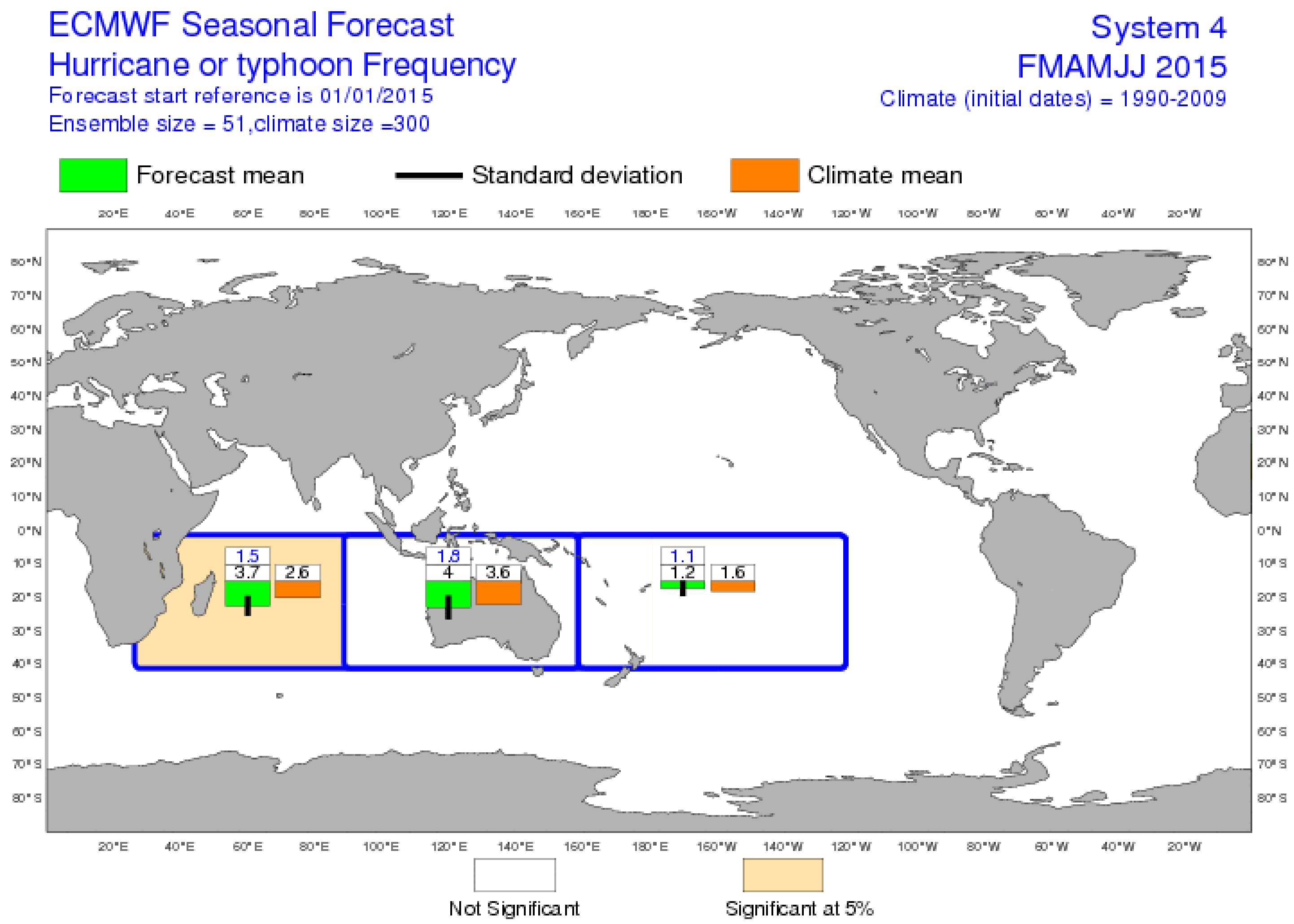
Reliability diagram for ECMWF with 15 ensemble members
Near-surface air temperature anomalies below the lower tercile
Accumulated over Europe (land and sea points)
Hindcast period 1981-2010 with start in November average over months 2 to 4
Skill scores and 95% conf. intervals (1000 samples)
Brier skill 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

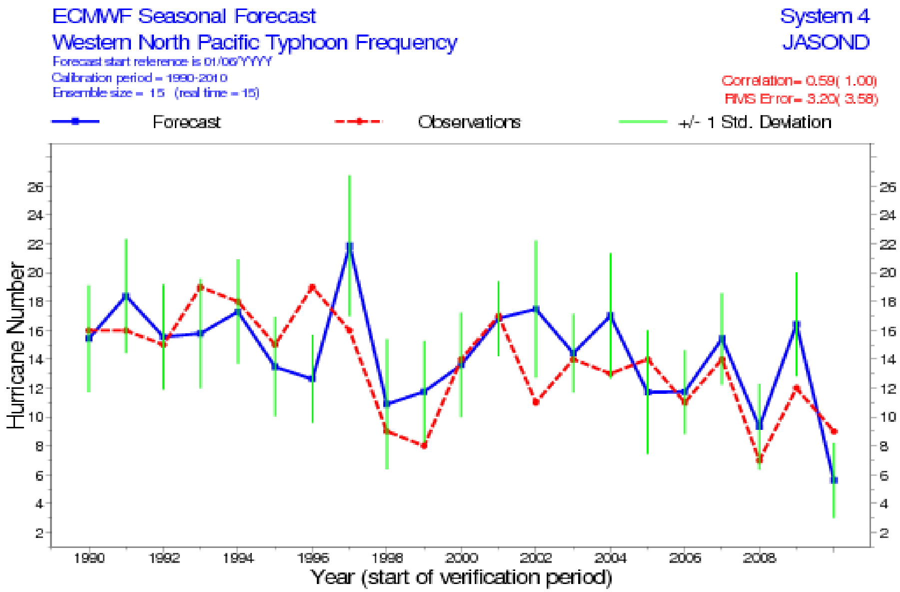
Reliability diagram for ECMWF with 15 ensemble members
Near-surface air temperature anomalies below the lower tercile
Accumulated over tropical band (land and sea points)
Hindcast period 1981-2010 with start in November average over months 2 to
Skill scores and 95% conf. intervals (1000 samples)
Brier 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)

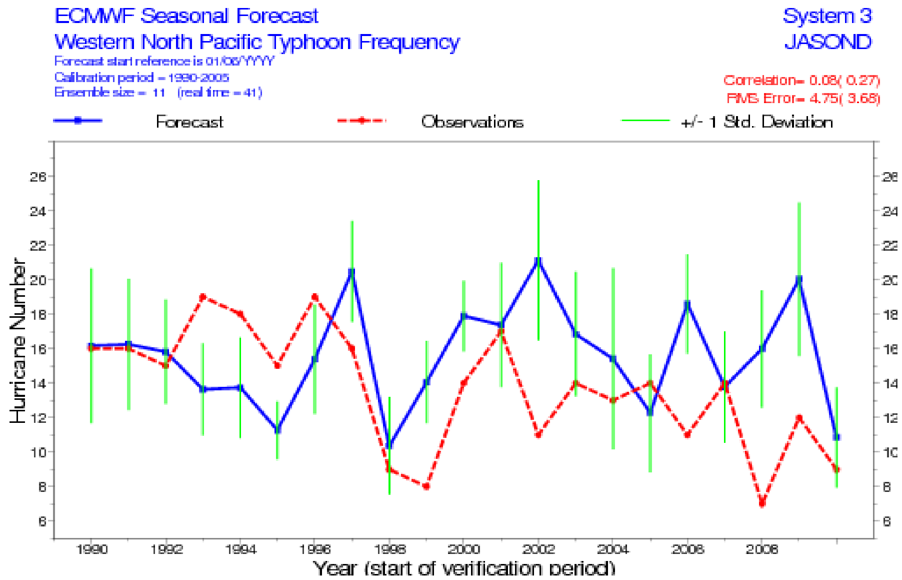




ECMWF Seasonal Forecast
Hurricane or typhoon Frequency
Forecast start reference is 01/01/2015
Ensemble size = 51,climate size =300
System 4
FMAMJJ 2015
Climate (initial dates) = 1990-2009
Forecast mean
Standard deviation
Climate mean
1.5
3.7
2.6
1.8
4
3.6
1.1
1.2
1.6
Not Significant
Significant at 5%

Prediction of tropical cyclone frequency: NW Pacific



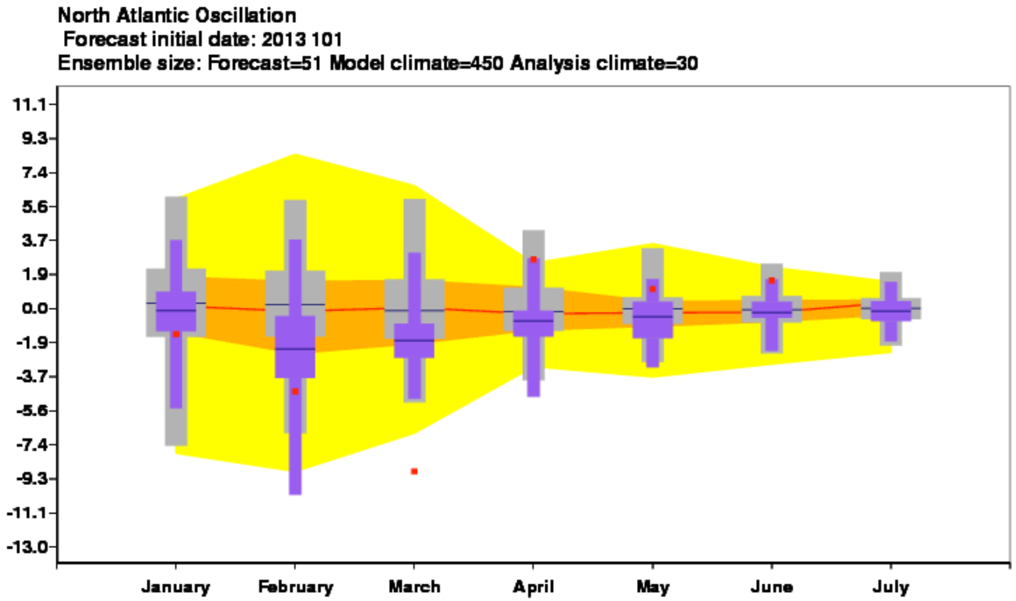


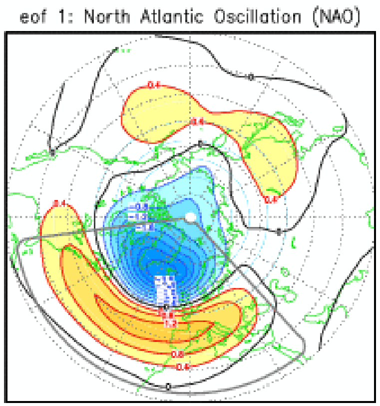
System 4
vs. ERA-Int.

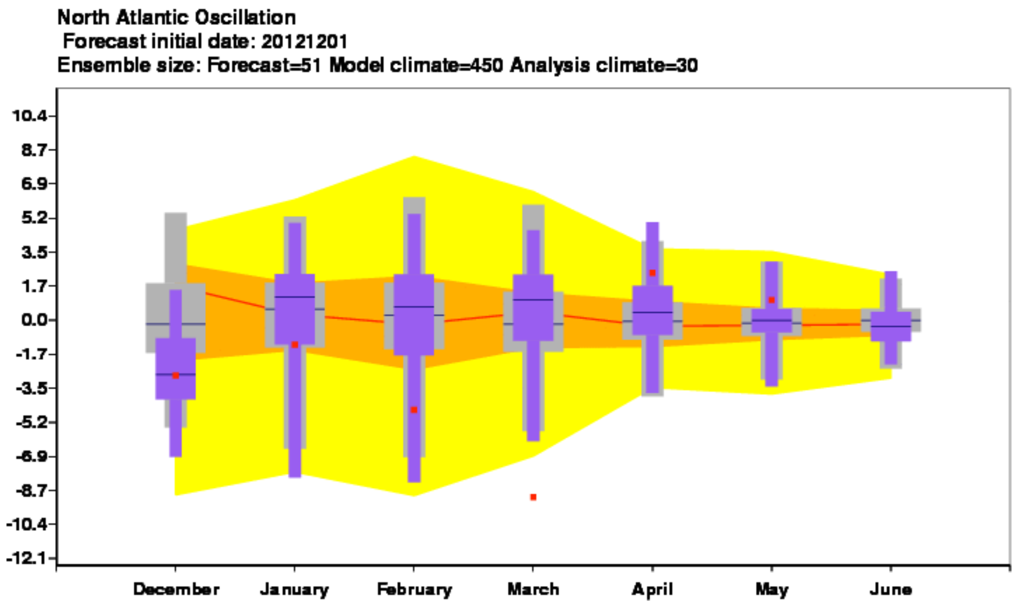
July-Dec.
1990-2010

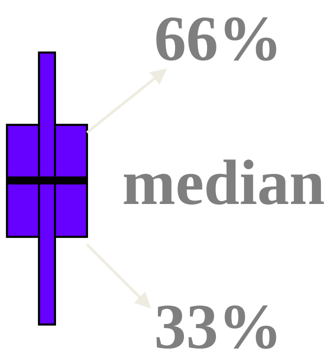
System 3
vs. ERA-Int.

Climagrams : teleconnections indices NAO

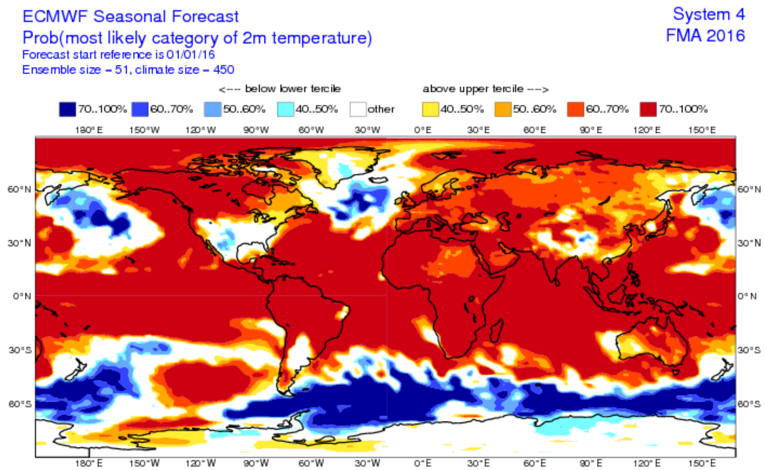


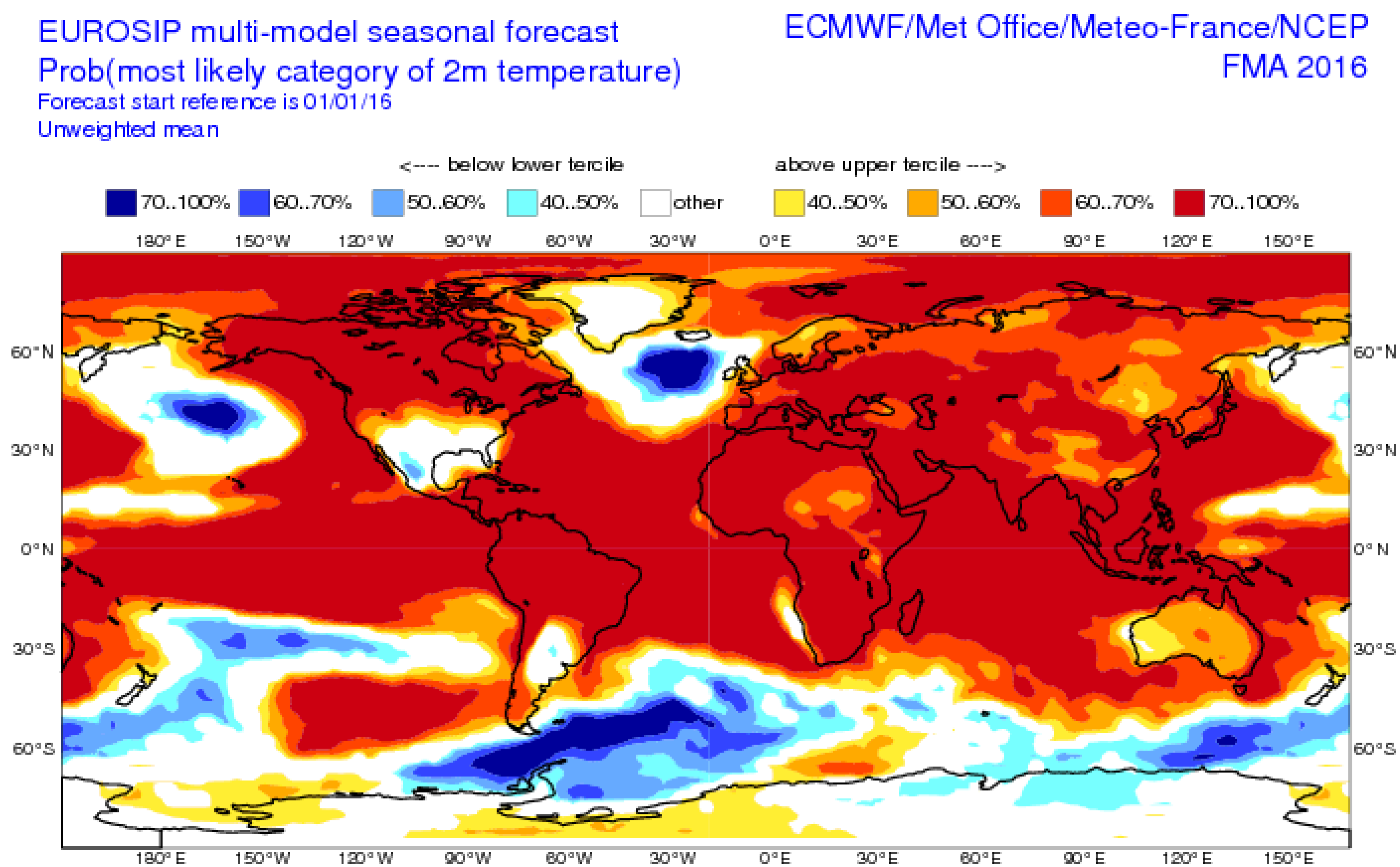




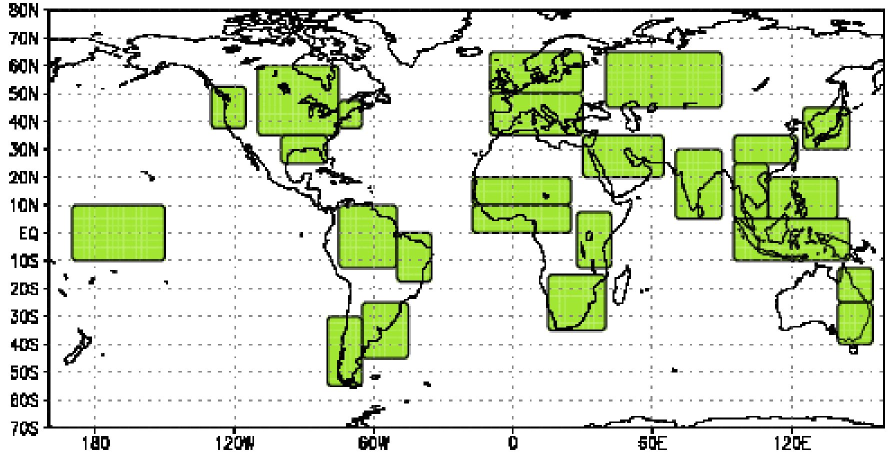


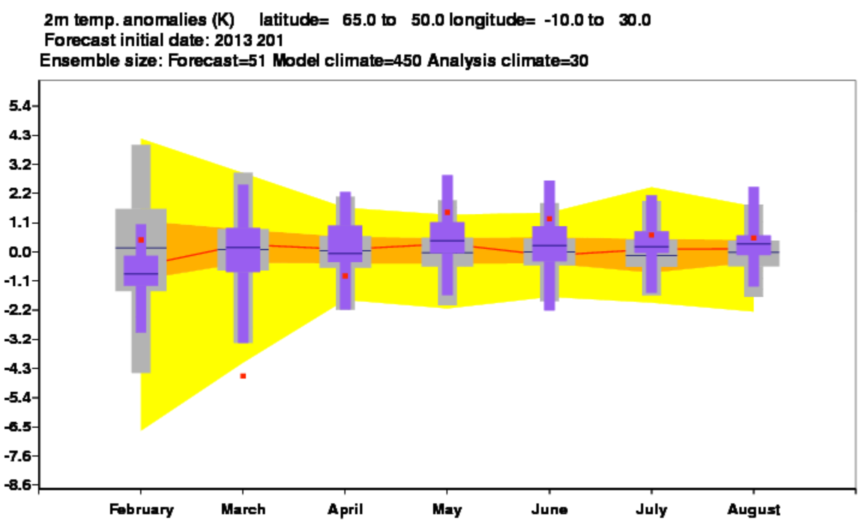
EUROSIP 2mt predictions:

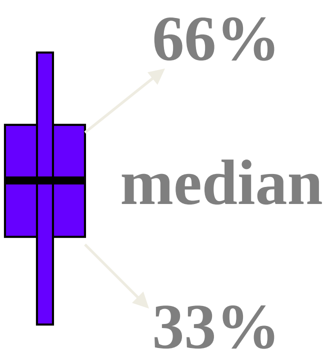




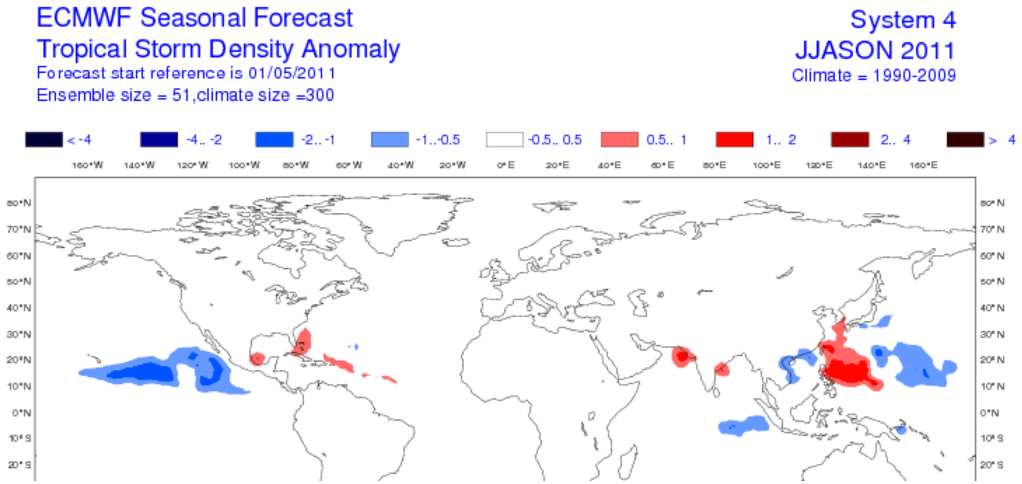
Climagrams : temp. area averages

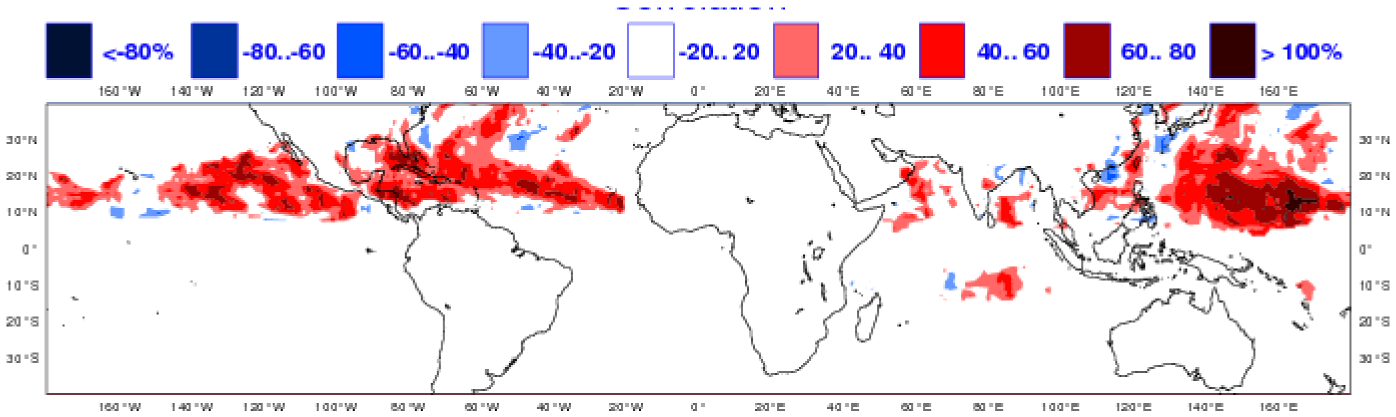




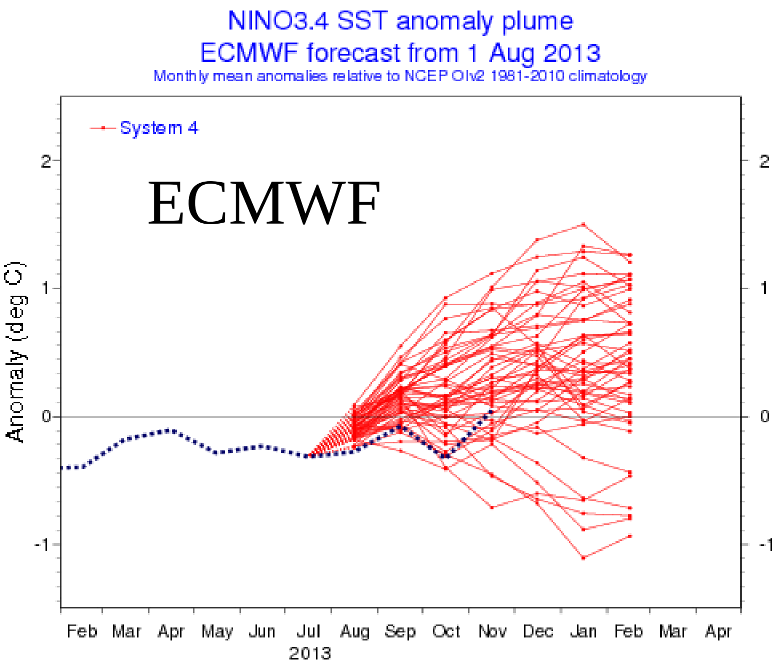


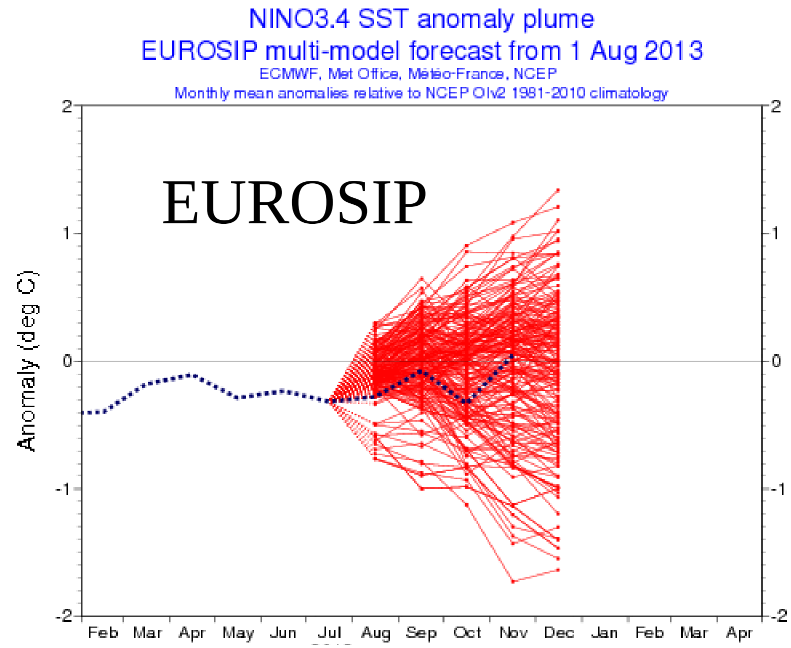
Cyclone track density new product from S4 and its verification

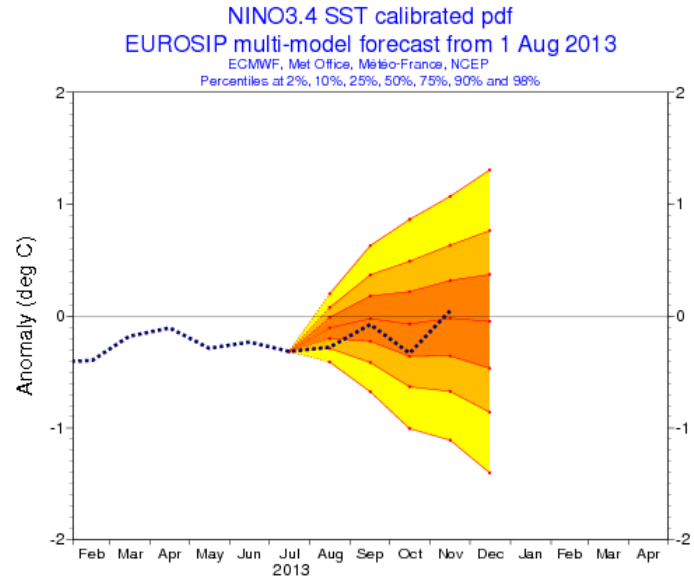




Track density for the July-Dec. period from fc. started on 1 May 1990-2010

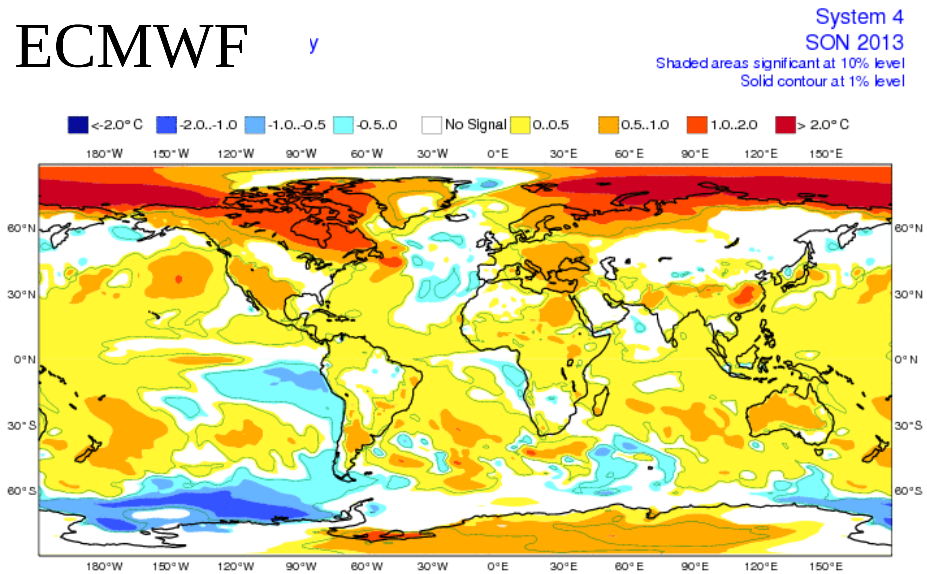

NINO3.4 SST anomaly plume
ECMWF forecast from 1 Aug 2013
Monthly mean anomalies relative to NCEP OIv2 1981-2010 climatology
System 4
ECMWF
Anomaly (deg C)
Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr
2013


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

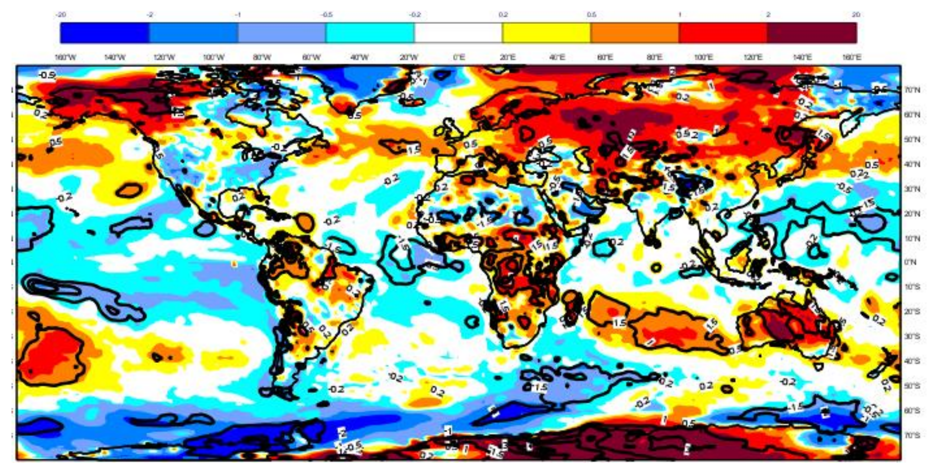

NINO3.4 SST calibrated pdf
EUROSIP multi-model forecast from 1 Aug 2013
ECMWF, Met Office, Météo-France, NCEP
Percentiles at 2%, 10%, 25%, 50%, 75%, 90% and 98%
Anomaly (deg C)
Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr
2013

2m temperature anomalies SON 2013

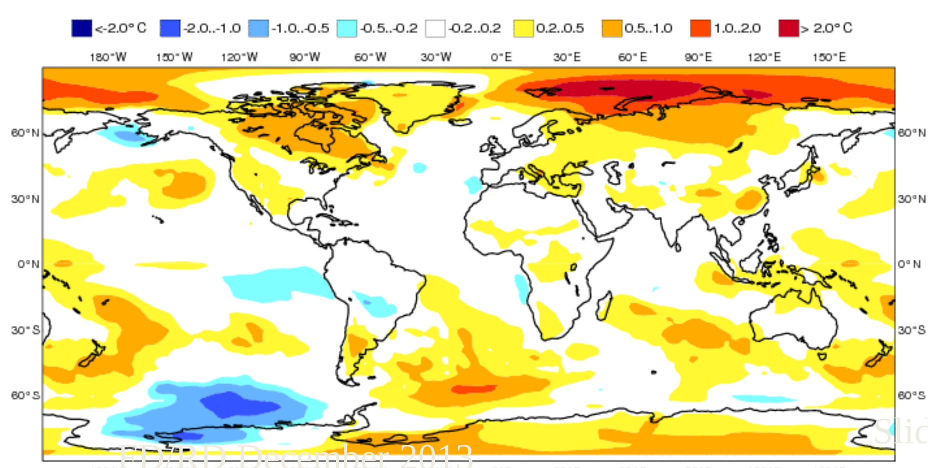
ECMWF



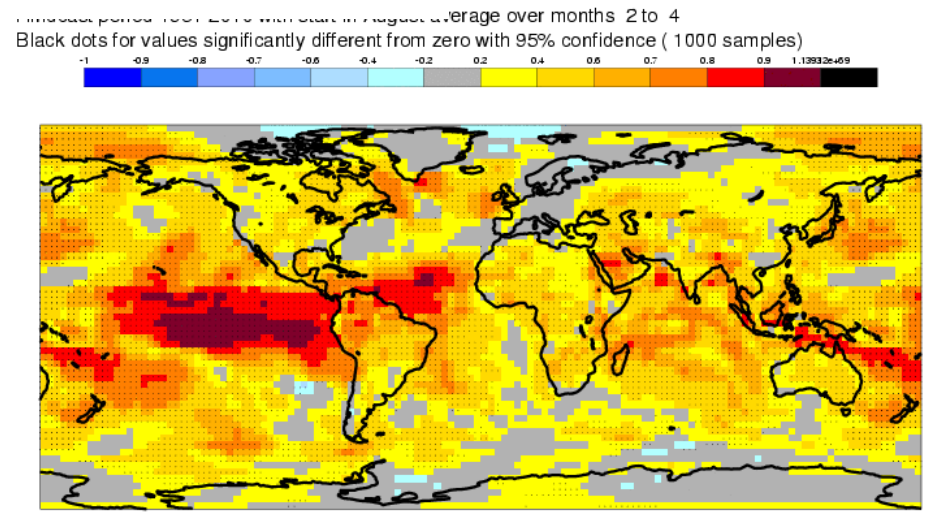
ANALYSIS



EUROSIP

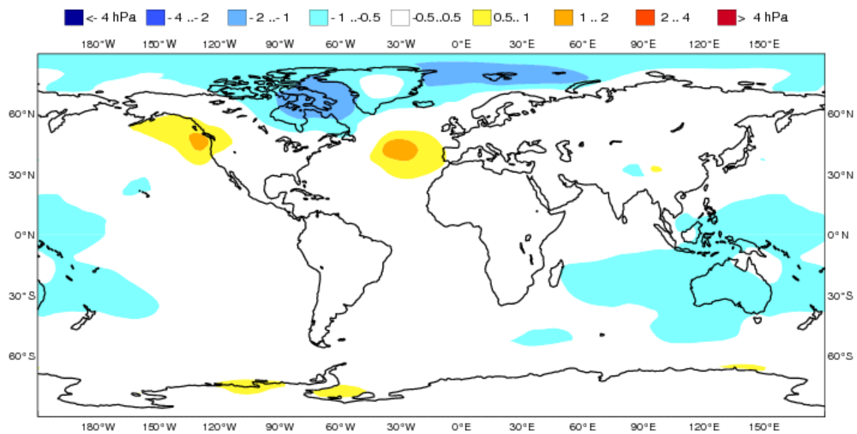


ECMWF skill



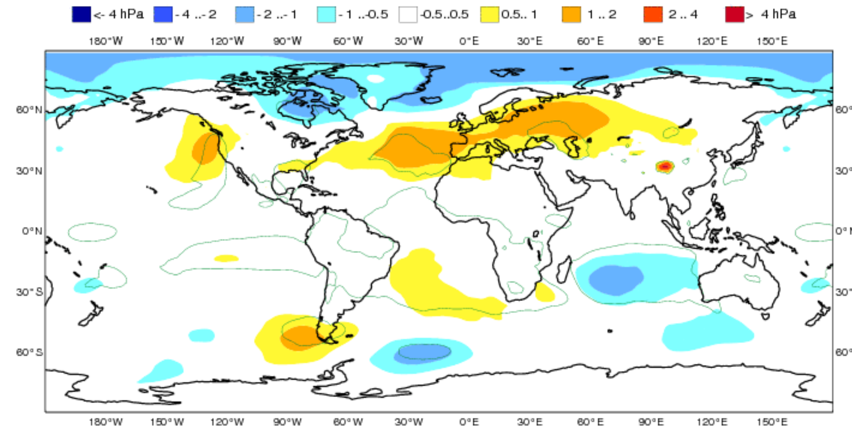
EUROSIP multi-model seasonal forecast
Mean MSLP anomaly
Forecast start reference is 01/11/13
Variance-standardized mean

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



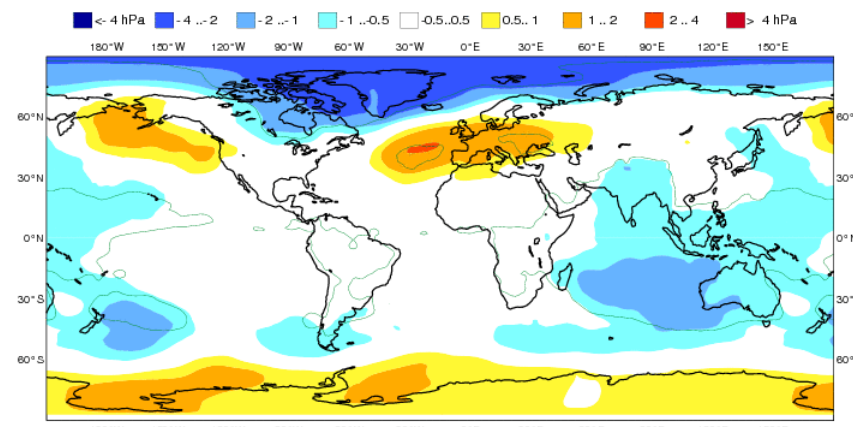
ECMWF Seasonal Forecast
Mean MSLP anomaly
Forecast start reference is 01/11/13
Ensemble size = 51, climate size = 450

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



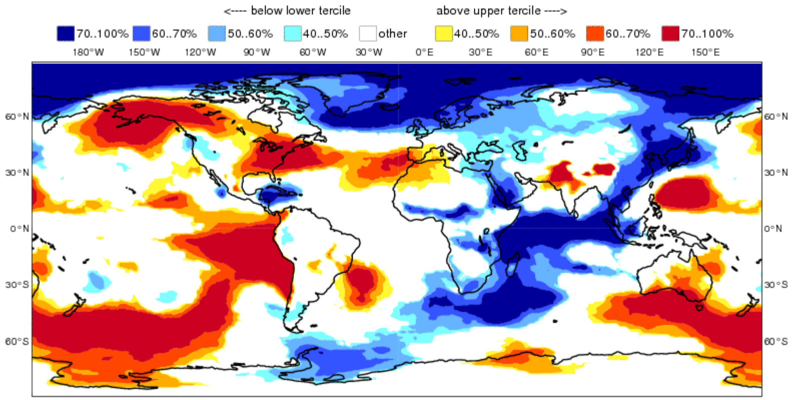
EUROSIP: Met Office contribution
Mean MSLP anomaly
Forecast start reference is 01/11/13
Ensemble size = 40, climate size = 168

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



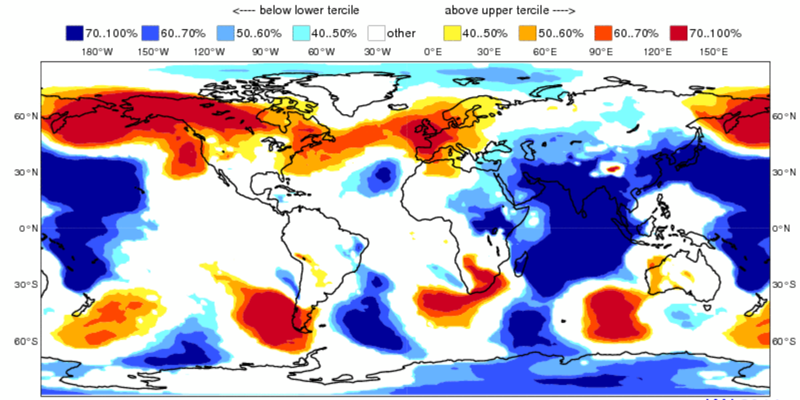
ECMWF Seasonal Forecast
Prob(most likely category of MSLP)
Forecast start reference is 01/11/13
Ensemble size = 51, climate size = 450

System 4
NOV 2013



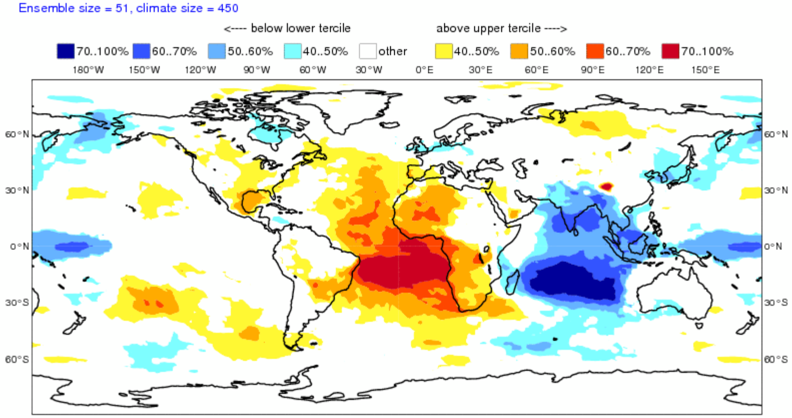
ECMWF Seasonal Forecast
Prob(most likely category of MSLP)
Forecast start reference is 01/12/13
Ensemble size = 51, climate size = 450

System 4
DEC 2013



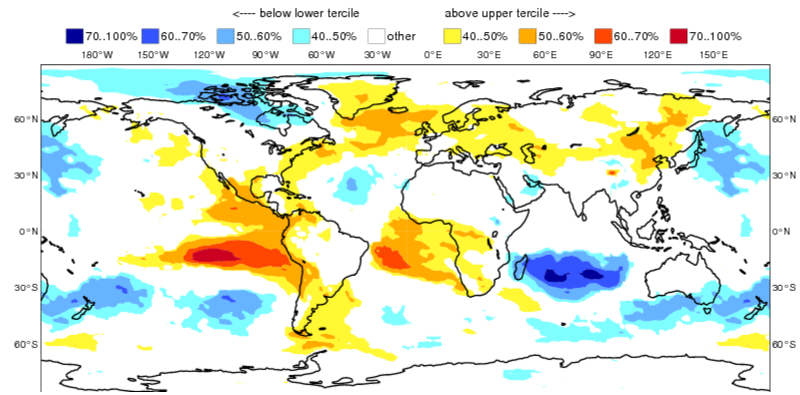
Prob(most likely category of MSLP)
Forecast start reference is 01/11/13
Ensemble size = 51, climate size = 450

DEC 2013



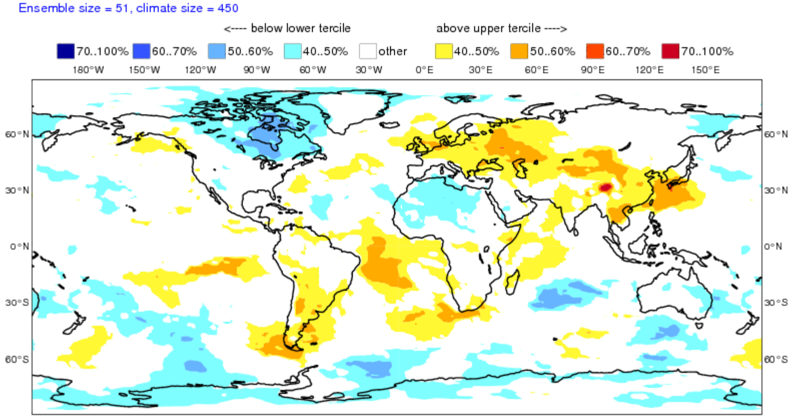
Prob(most likely category of MSLP)
Forecast start reference is 01/12/13
Ensemble size = 51, climate size = 450

JAN 2014



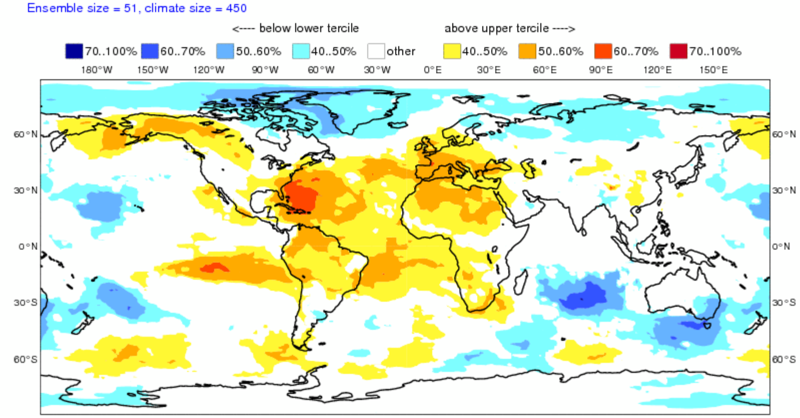
Prob(most likely category of MSLP)
Forecast start reference is 01/11/13
Ensemble size = 51, climate size = 450

JAN 2014



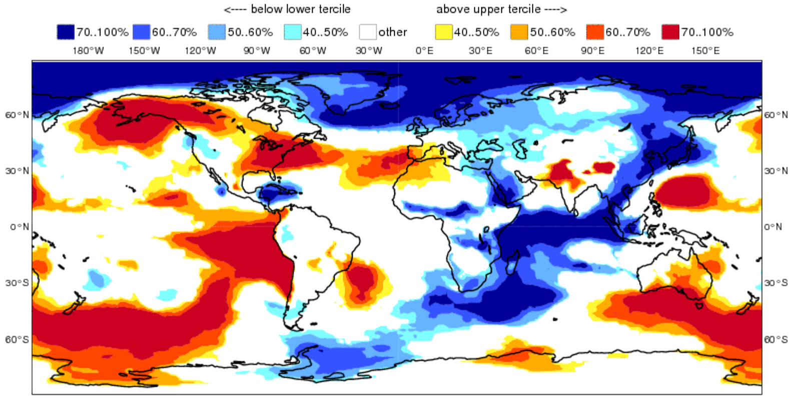
Prob(most likely category of MSLP)
Forecast start reference is 01/12/13
Ensemble size = 51, climate size = 450

FEB 2014



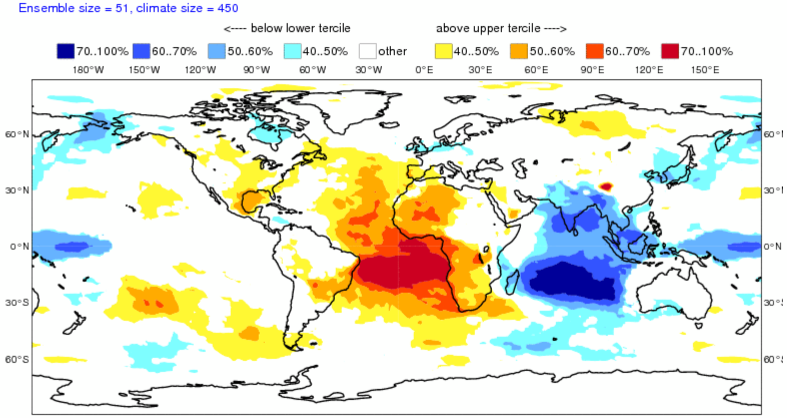
ECMWF Seasonal Forecast
Prob(most likely category of MSLP)
Forecast start reference is 01/11/13
Ensemble size = 51, climate size = 450

System 4
NOV 2013



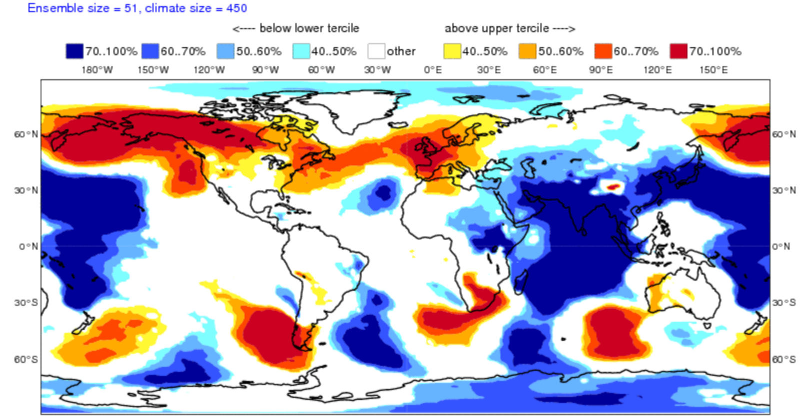
Prob(most likely category of MSLP)
Forecast start reference is 01/11/13
Ensemble size = 51, climate size = 450

DEC 2013

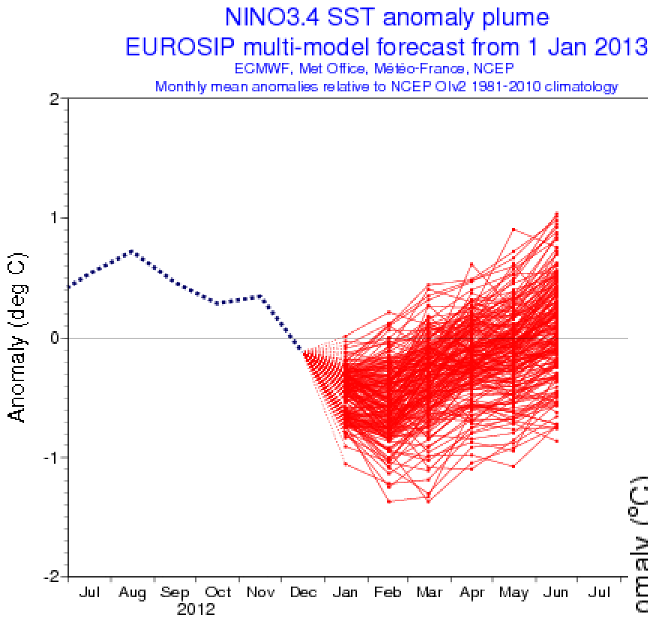


ECMWF Seasonal Forecast
Prob(most likely category of MSLP)
Forecast start reference is 01/12/13
Ensemble size = 51, climate size = 450

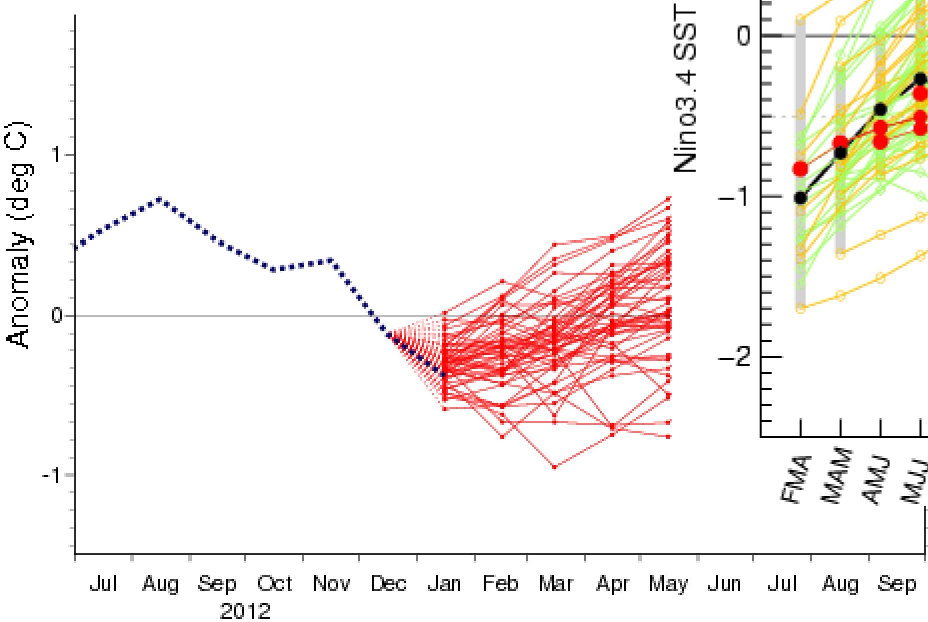
System 4
DEC 2013



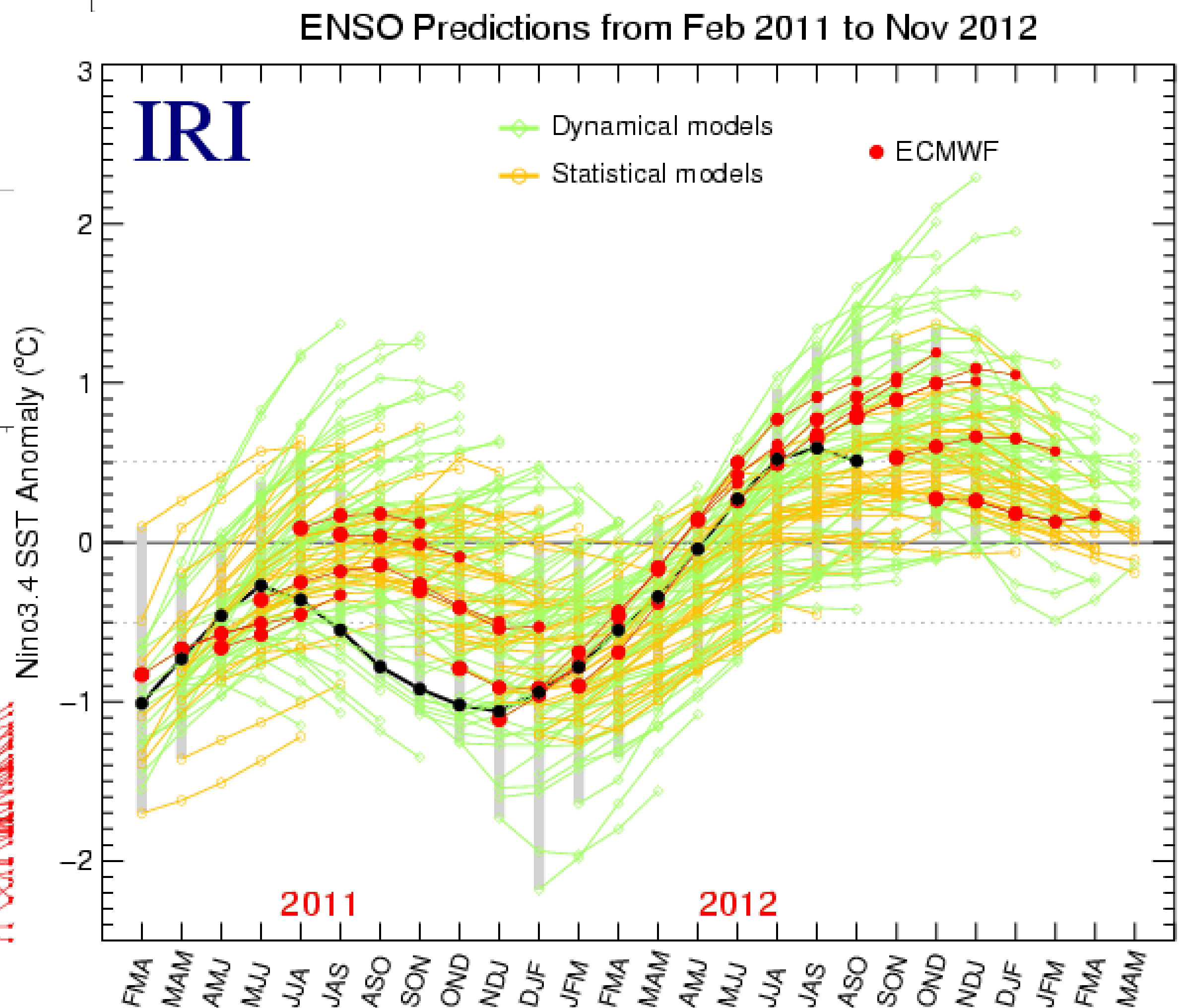
3.4 outlook



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)
2
1
0
-1
-2
Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul
2012

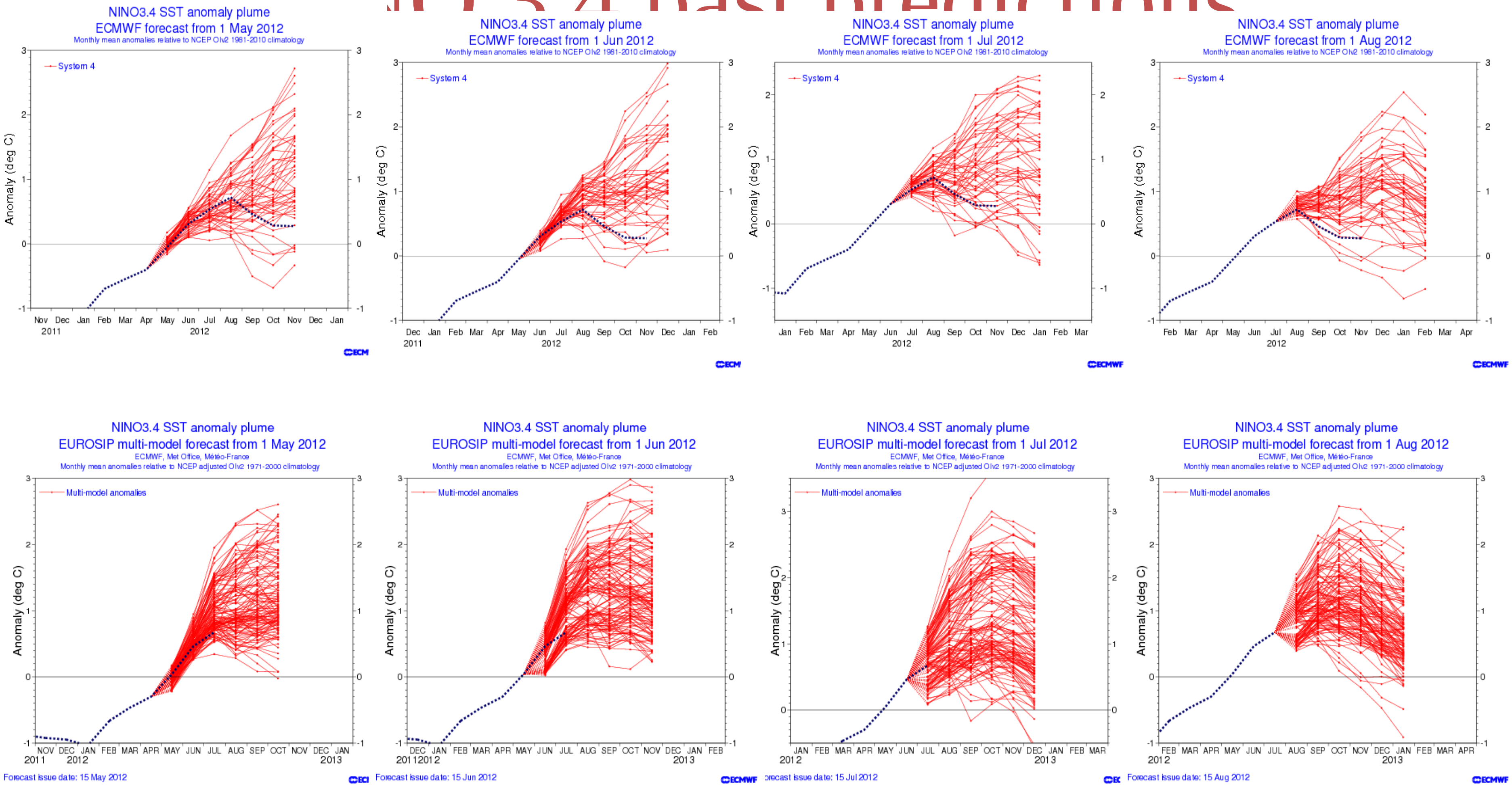


Anomaly (deg C)
1
0
-1
Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep
2012



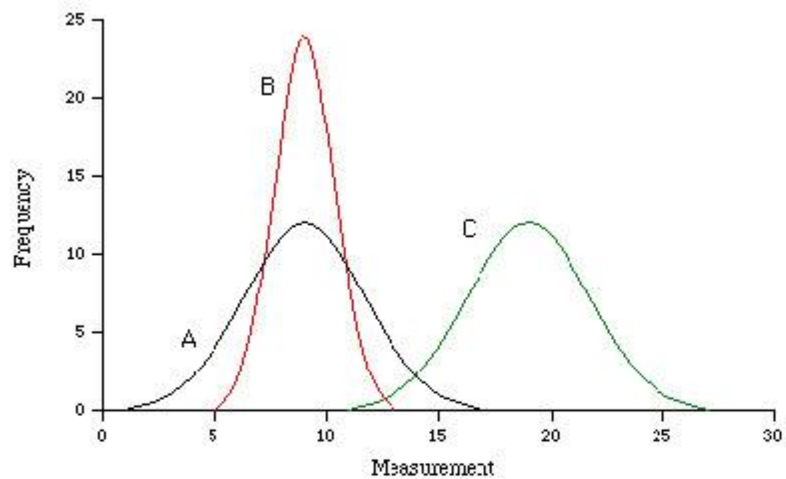
ENSO Predictions from Feb 2011 to Nov 2012
IRI
Dynamical models
Statistical models
ECMWF
Nino3.4 SST Anomaly (°C)
3
2
1
0
−1
−2
2011
2012
FMA MAM AMJ MJJ JJA JAS ASO SON OND NDJ DJF JFM FMA MAM AMJ MJJ JJA JAS ASO SON OND NDJ DJF JFM FMA MAM

NINO 3.4 past predictions



Extended range predictions

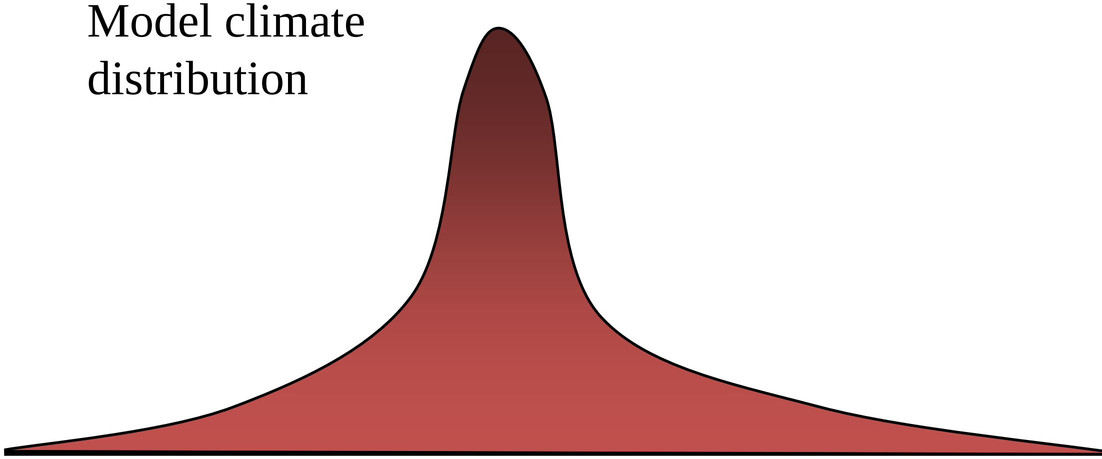
• Products from Extended range predictions are generally defined with reference to the model climate estimated by the re-forecast data.

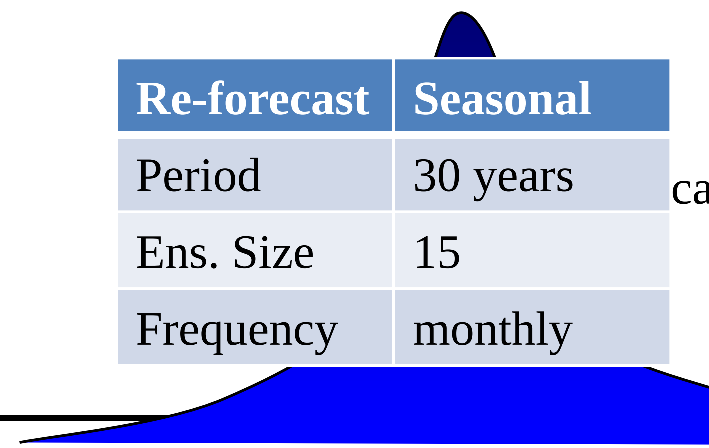


• Post-processing/calibration of model data is inc sts.

• For each member of the ensemble we define the

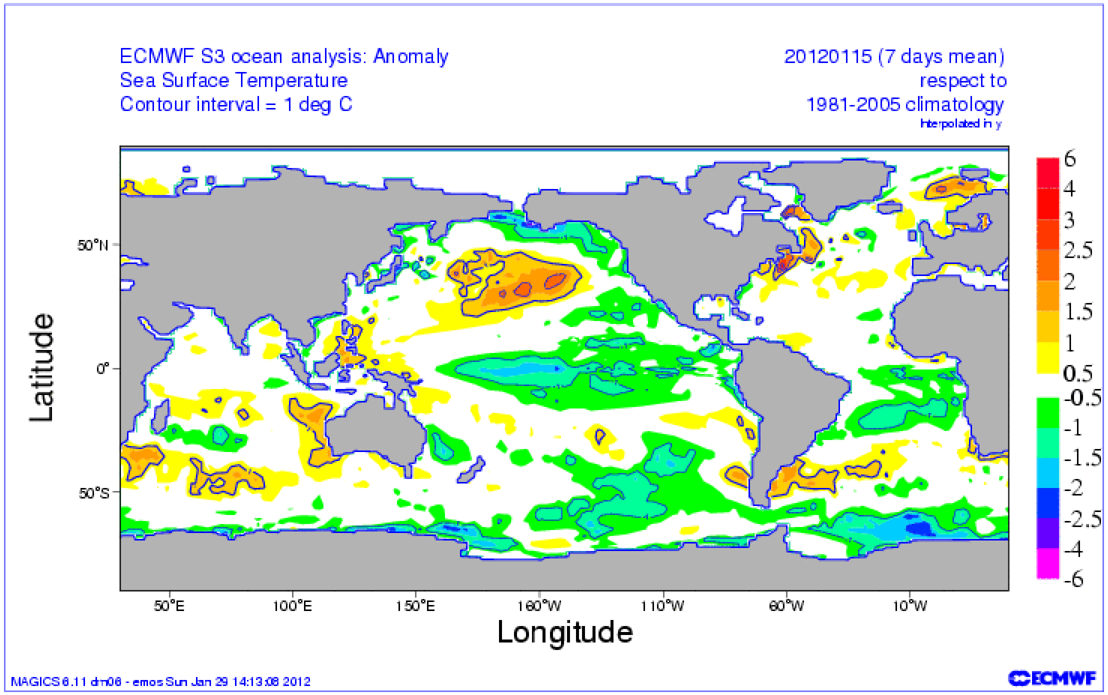
•An (t) = For. (t) – Model Climate (t)

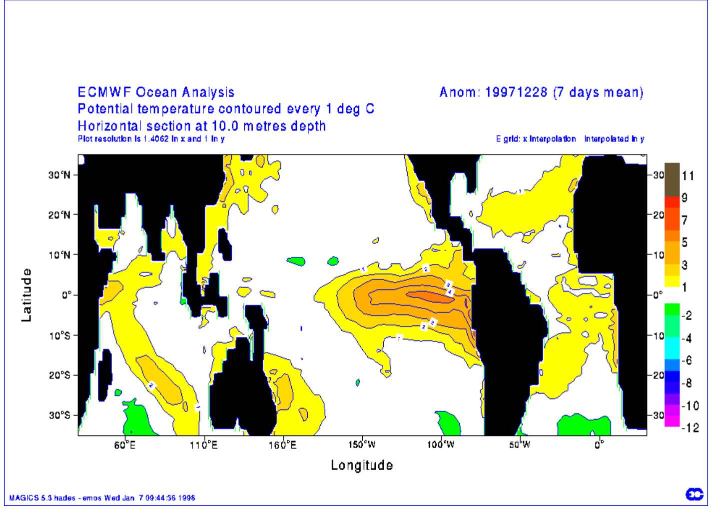


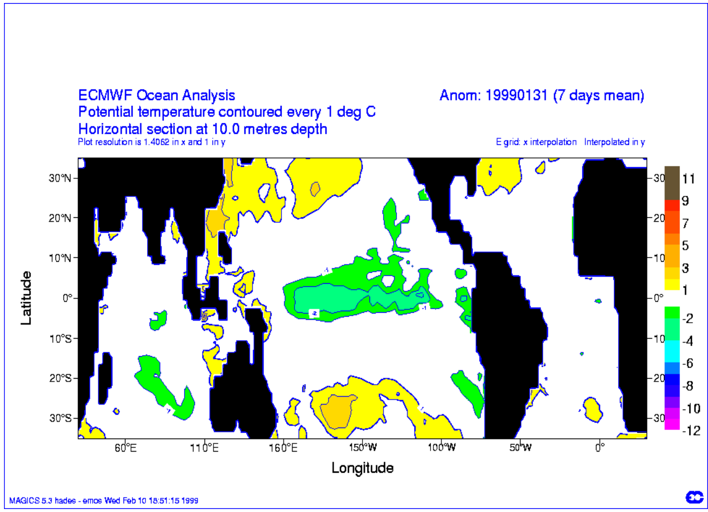


Re-forecast	Seasonal
Period	30 years
Ens. Size	15
Frequency	monthly

Ocean analysis:

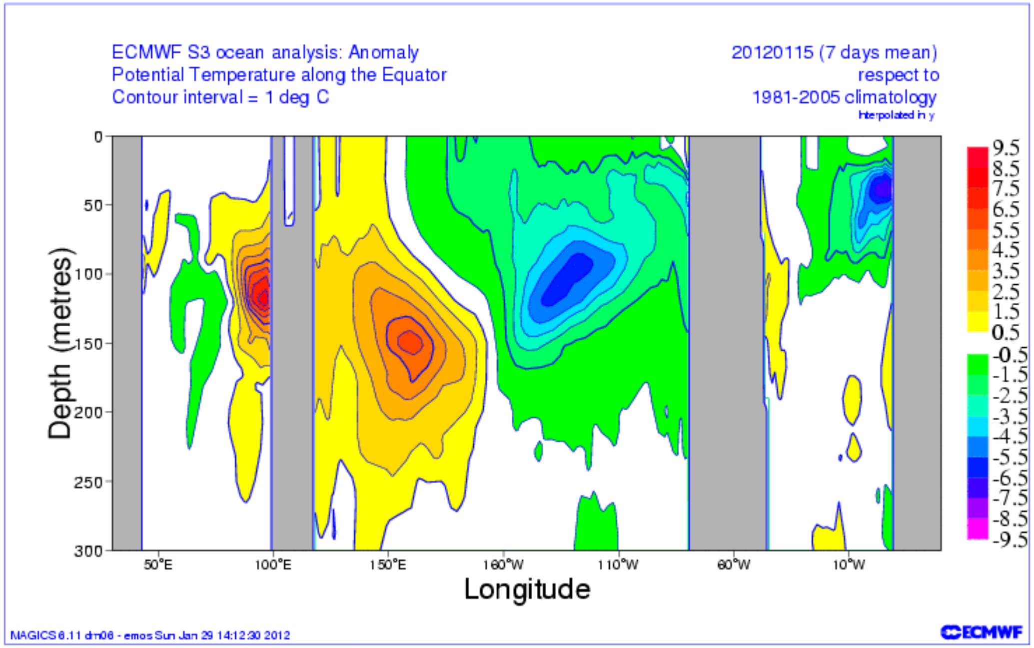


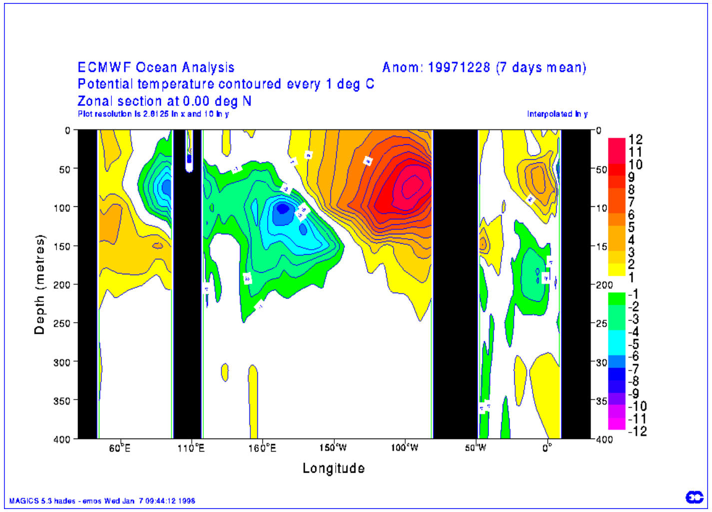


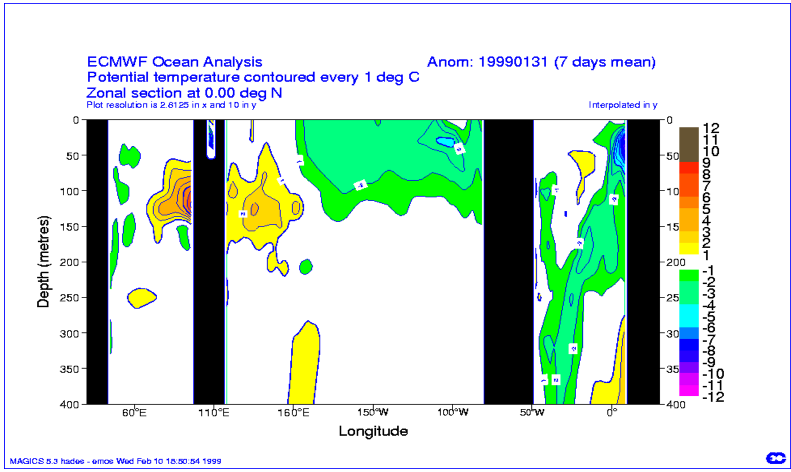


Daily weekly and monthly products are available on the web

Ocean analysis:





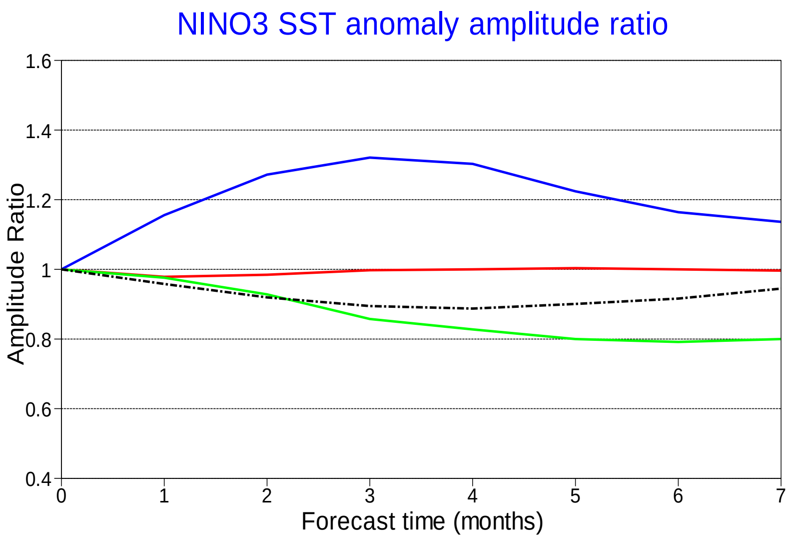


Chaotic nature of the atmosphere:

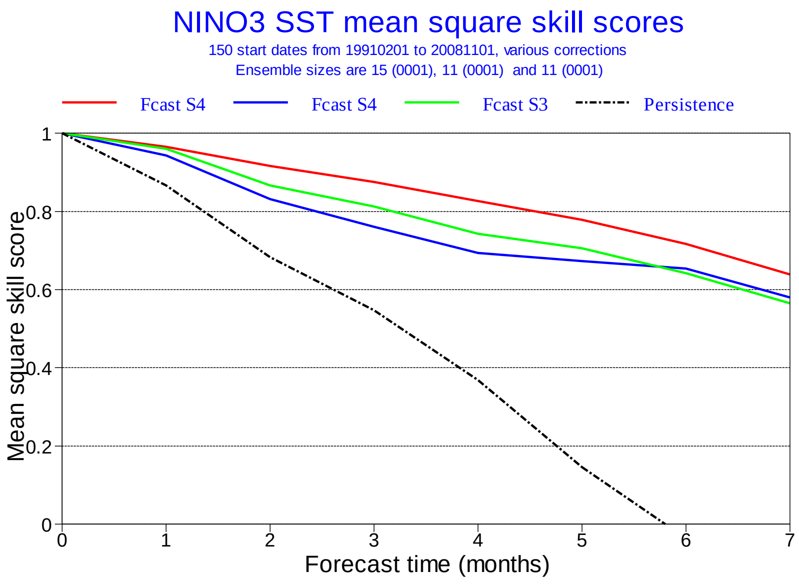
- To deal with the chaotic processes in the atmosphere we use an ensemble of simulations: on the 1st of the month 40 forecasts are run for 6 months. They have initial conditions from 5-member ensemble of ocean analyses (wind perturbations throughout analysis and SST perturbations at start of forecasts)

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

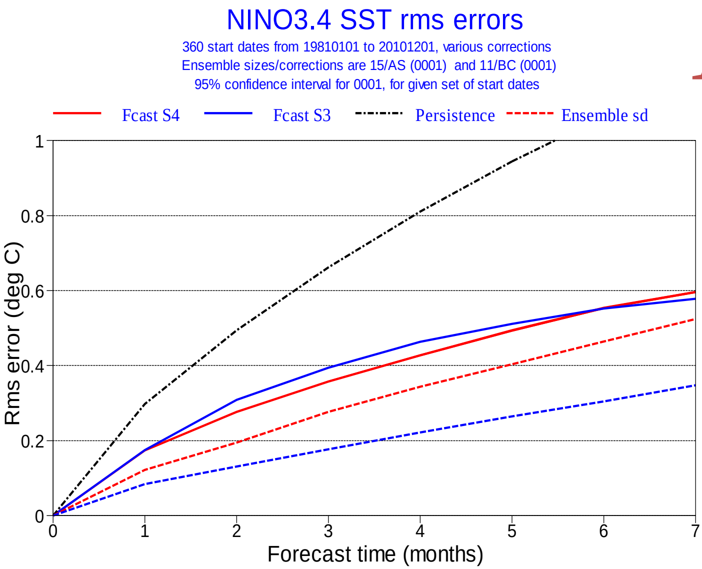
Calibration of ENSO SST indices

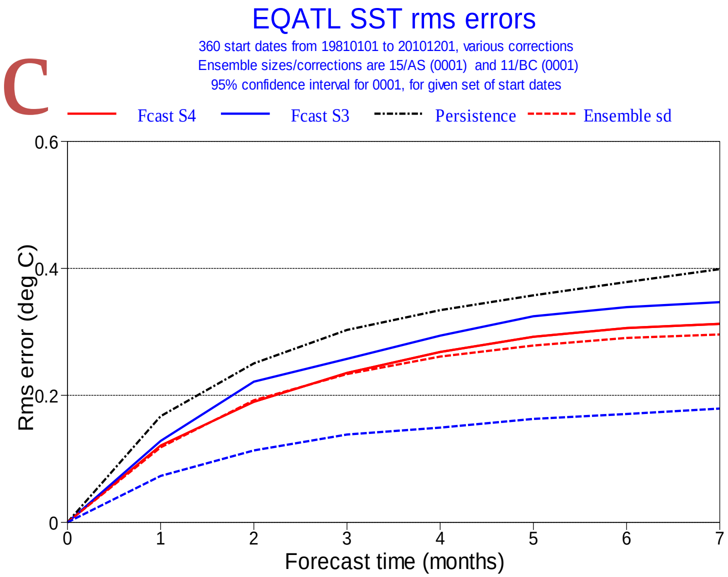


S4 non calib.
S4 calibrated
S3



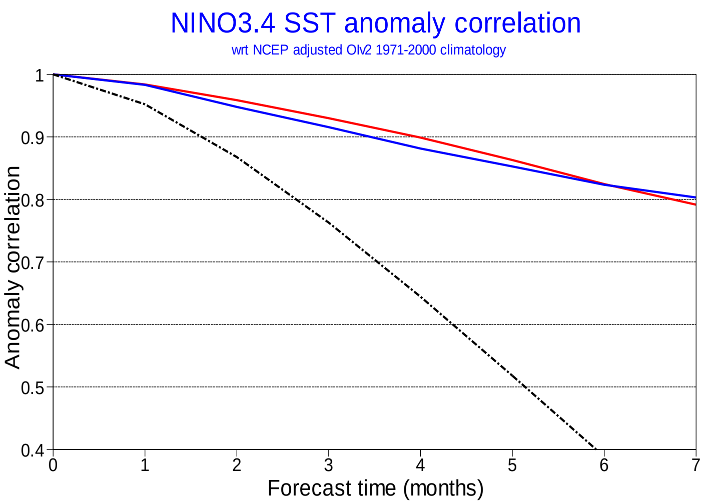
SST scores: Nino 3.4 and Eq. Atlantic

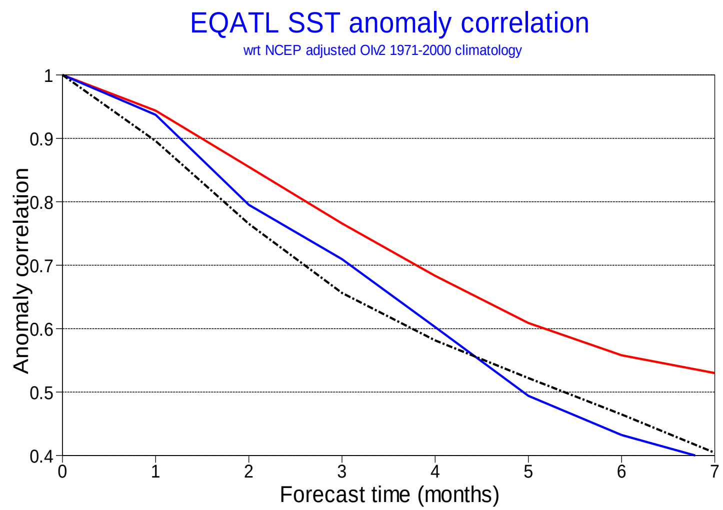




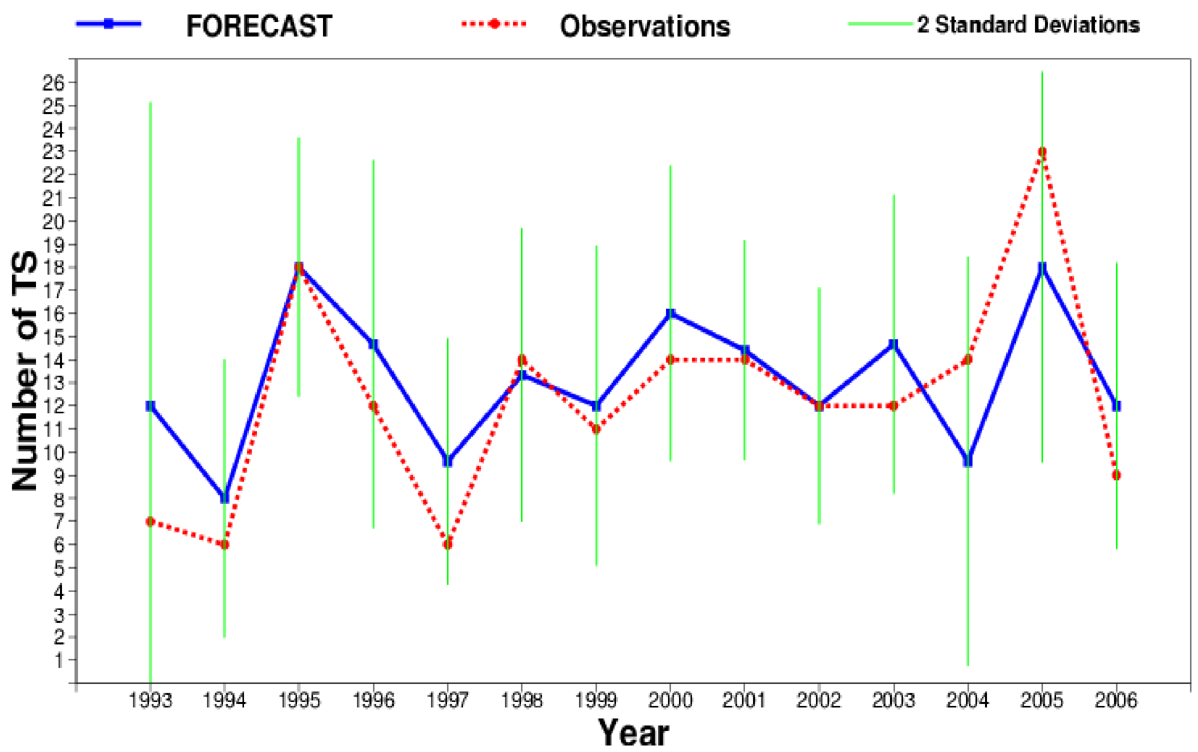
Solid:
S4 error
S3 error
Dashed:
S4 spread
S3 spread

S4 ACC
S3 ACC
Pers. ACC





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



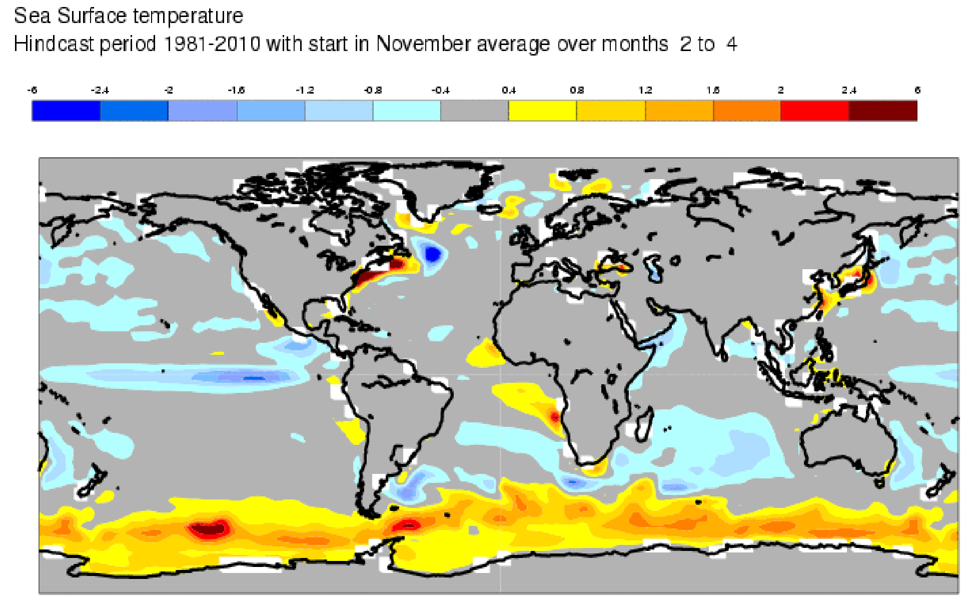
Bias in S4 re-forecasts: SST (DJF)

Start: 1 Nov.

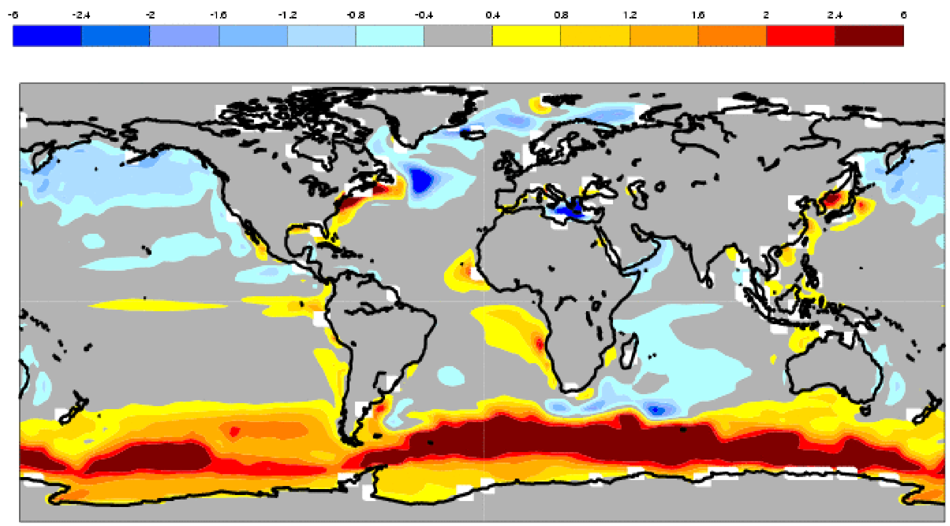
1981/2010

Verify: Dec-Feb

System 4



System 3



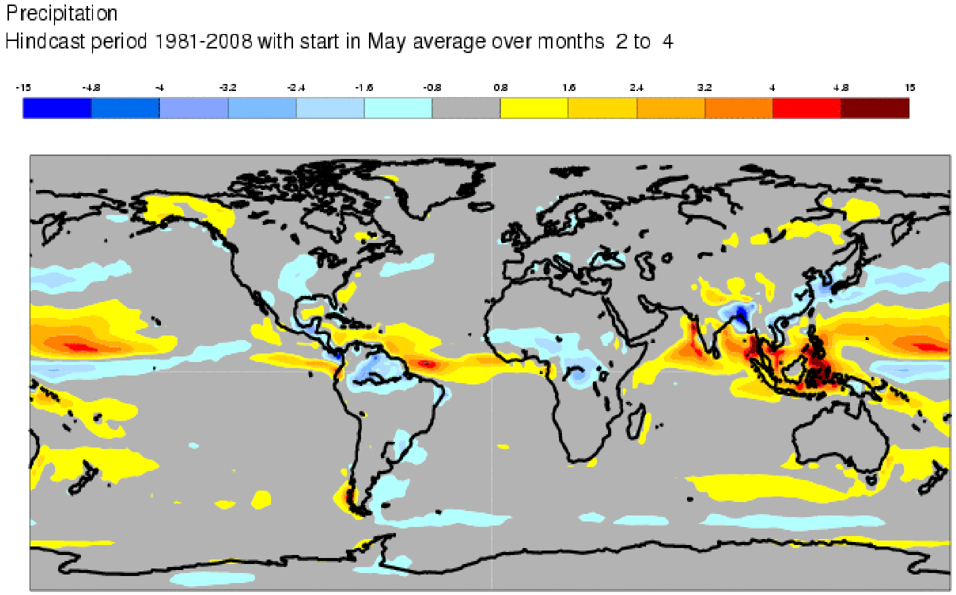
Bias in S4 re-forecasts: rainfall (JJA)

Start: 1 May

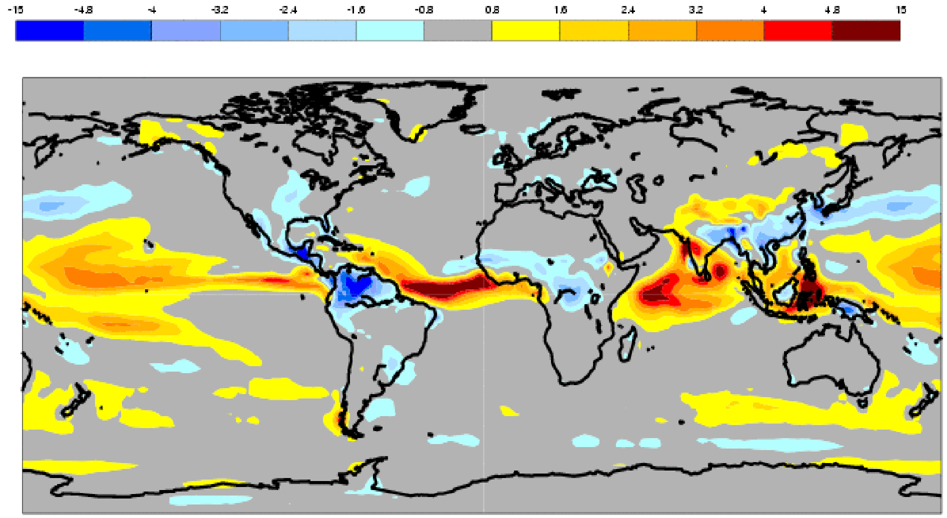
1981/2010

Verify: Jun-Aug

System 4



System 3



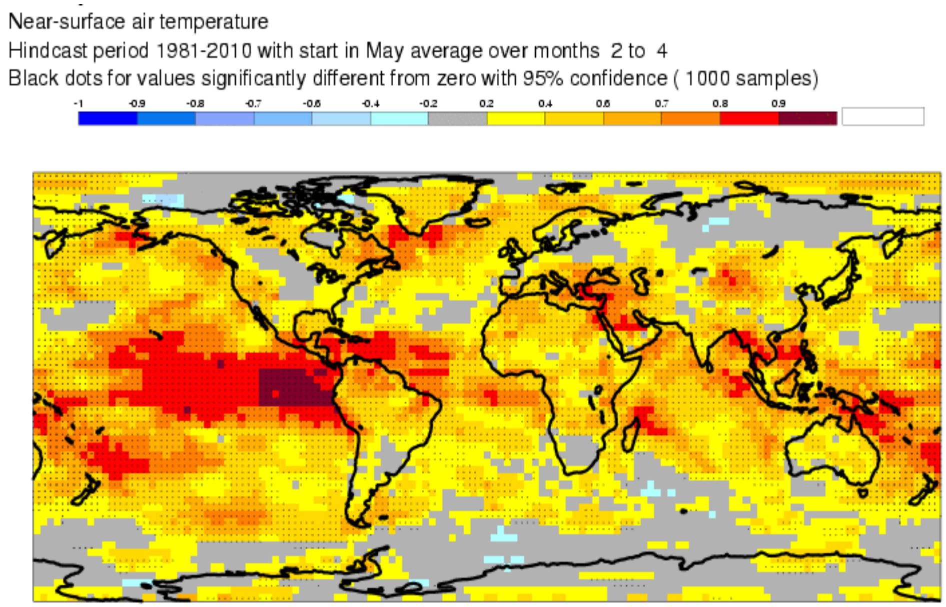
Ens-mean ACC in S4 re-forecasts: 2m T (JJA)

Start: 1 May

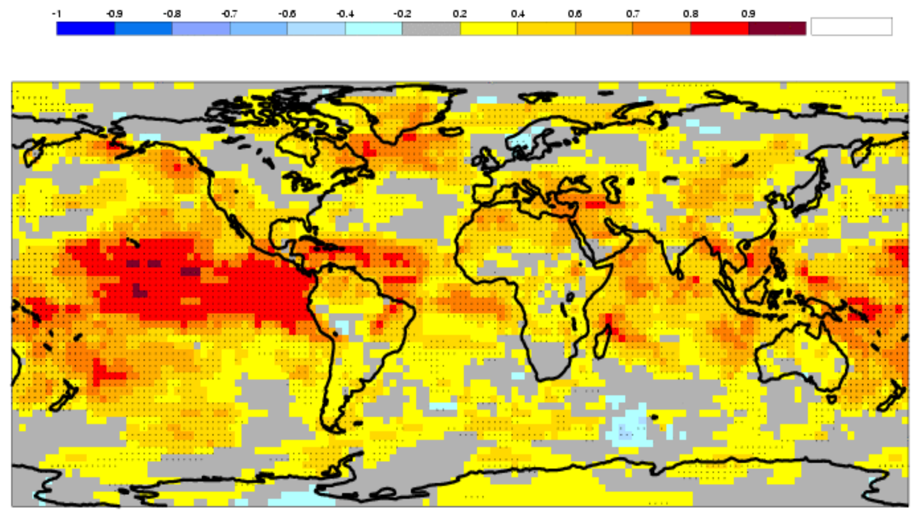
1981/2010

Verify: Jun-Aug

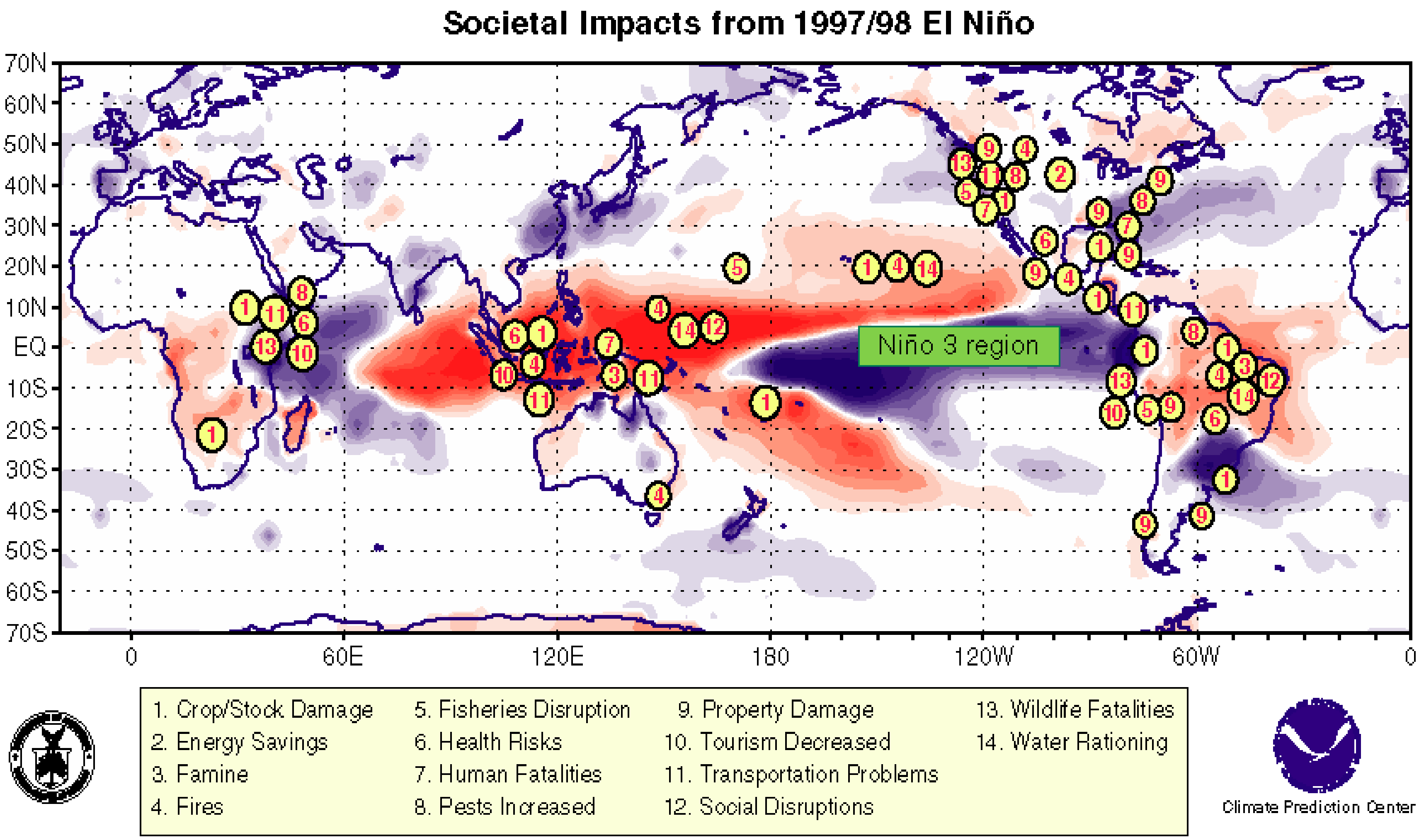
System 4



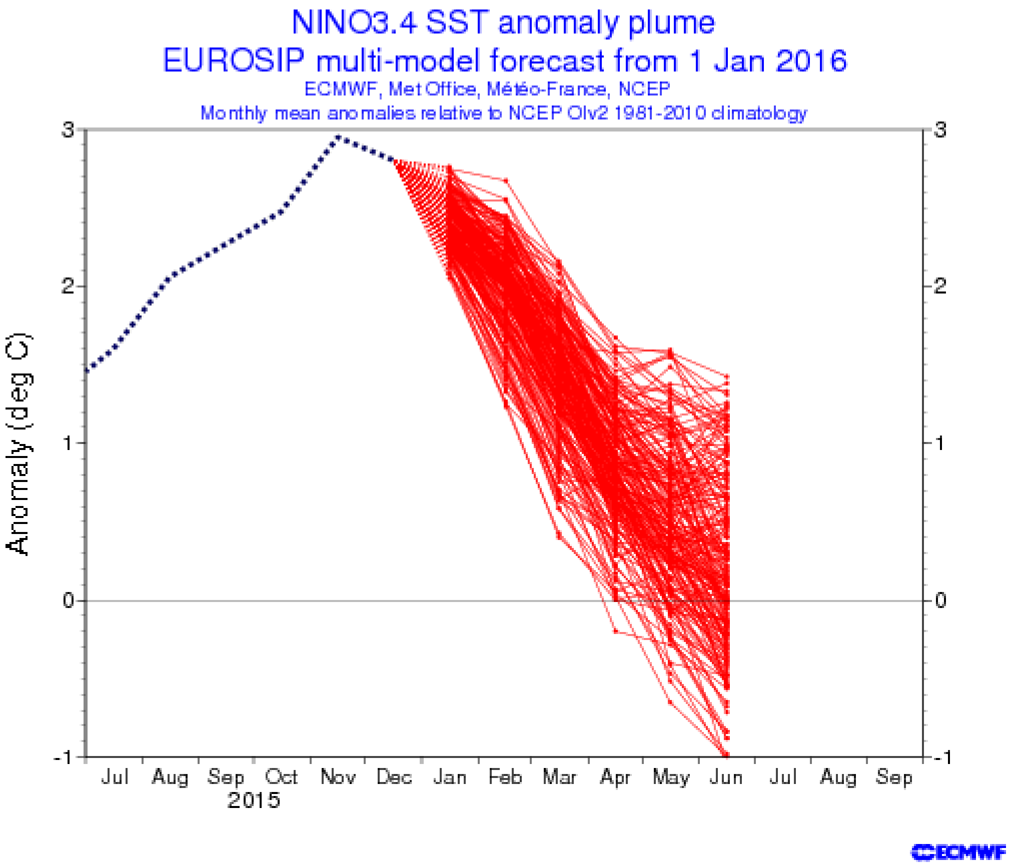
System 3

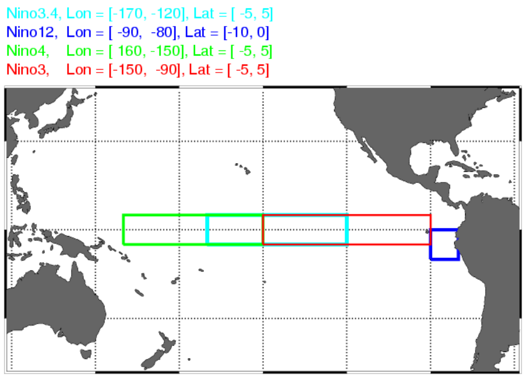


Weather-related natural disasters

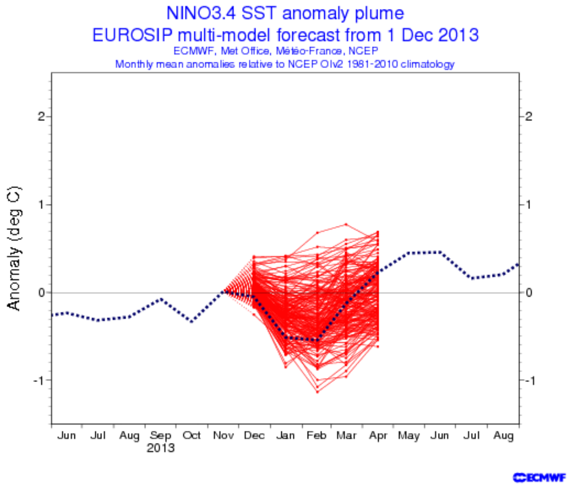


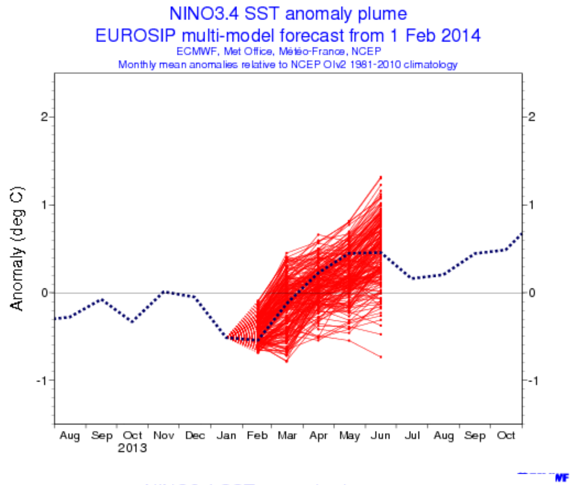
NINO3.4 plumes

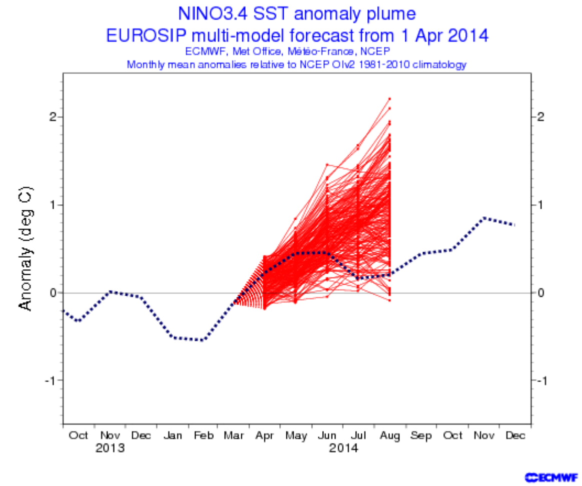


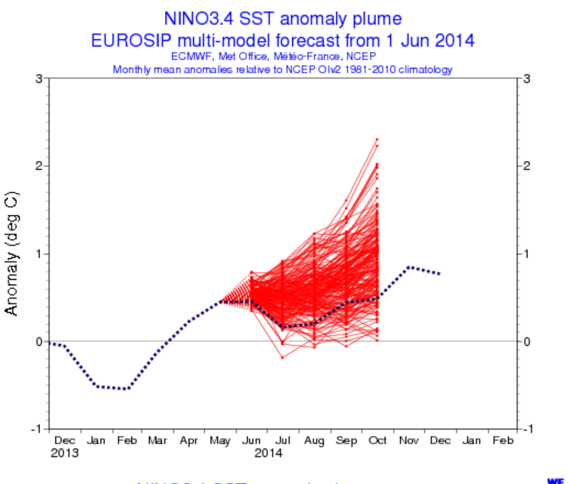


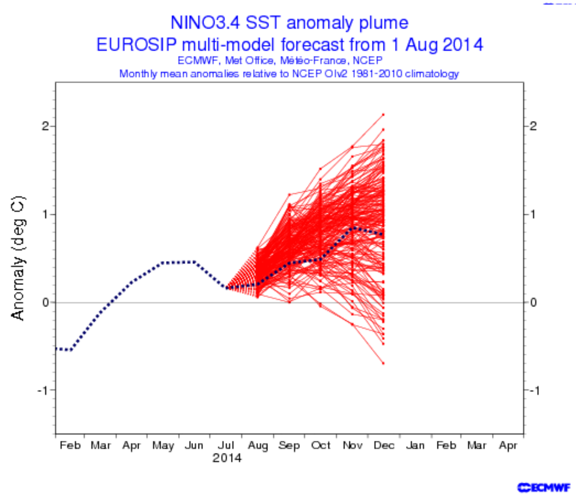
Forecast is made available on the 8h of each month

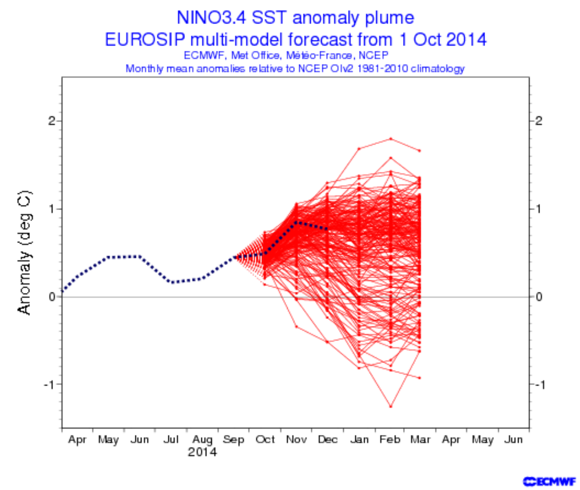

NINO3.4 SST anomaly plume
EUROSIP multi-model forecast from 1 Dec 2013
ECMWF, Met Office, Météo-France, NCEP
Monthly mean anomalies relative to NCEP OIv2 1981-2010 climatology
Anomaly (deg C)
Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug
2013
ECMWF

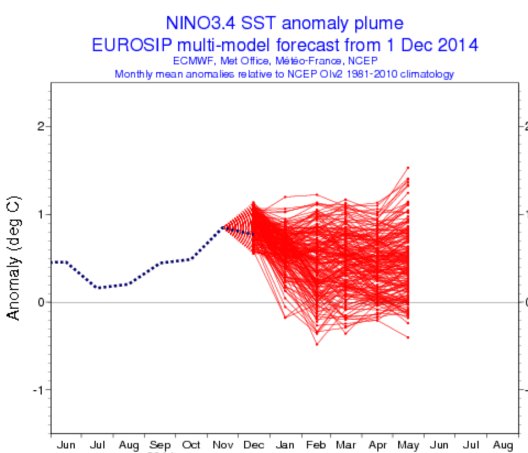

NINO3.4 SST anomaly plume
EUROSIP multi-model forecast from 1 Feb 2014
ECMWF, Met Office, Météo-France, NCEP
Monthly mean anomalies relative to NCEP OIv2 1981-2010 climatology
Anomaly (deg C)
Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct
2013

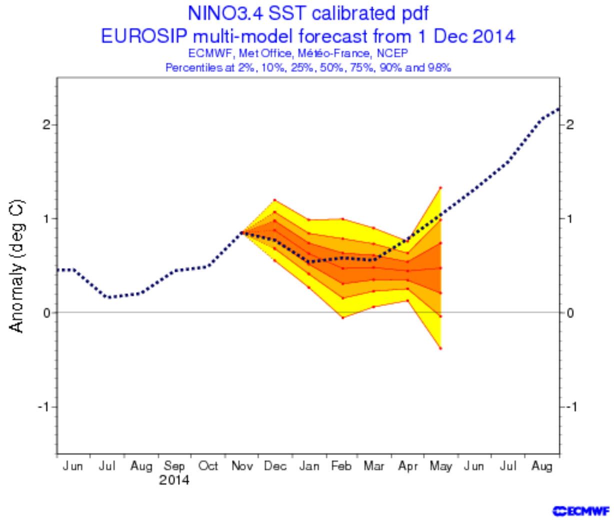

NINO3.4 SST anomaly plume
EUROSIP multi-model forecast from 1 Apr 2014
ECMWF, Met Office, Météo-France, NCEP
Monthly mean anomalies relative to NCEP OIv2 1981-2010 climatology
Anomaly (deg C)
Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
2013
2014
ECMWF

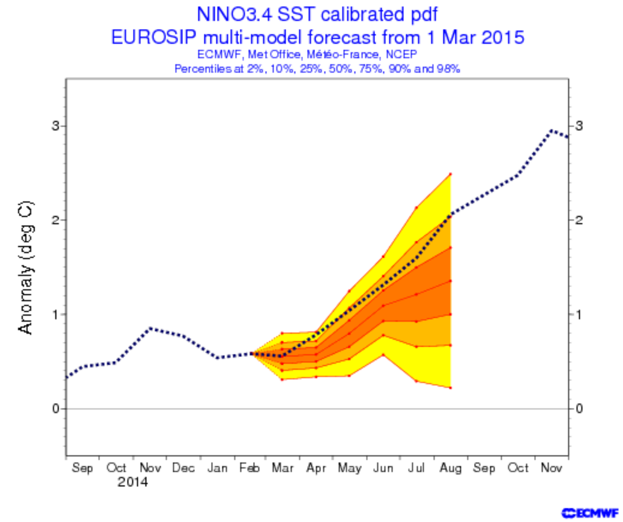

NINO3.4 SST anomaly plume
EUROSIP multi-model forecast from 1 Jun 2014
ECMWF, Met Office, Météo-France, NCEP
Monthly mean anomalies relative to NCEP OIv2 1981-2010 climatology
Anomaly (deg C)
Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb
2013
2014

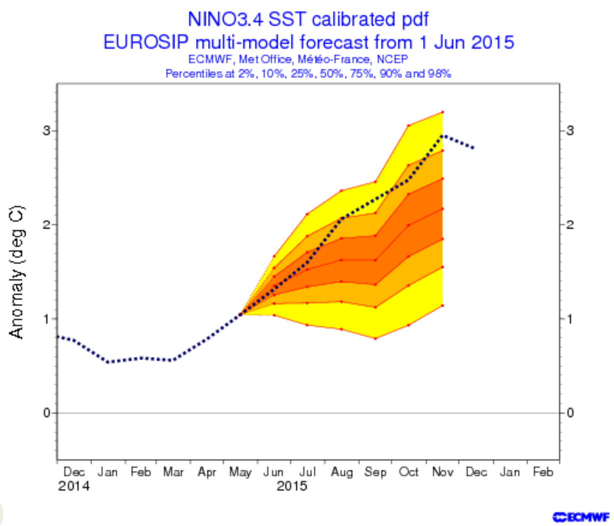

NINO3.4 SST anomaly plume
EUROSIP multi-model forecast from 1 Aug 2014
ECMWF, Met Office, Météo-France, NCEP
Monthly mean anomalies relative to NCEP OIv2 1981-2010 climatology
Anomaly (deg C)
Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr
2014
ECMWF

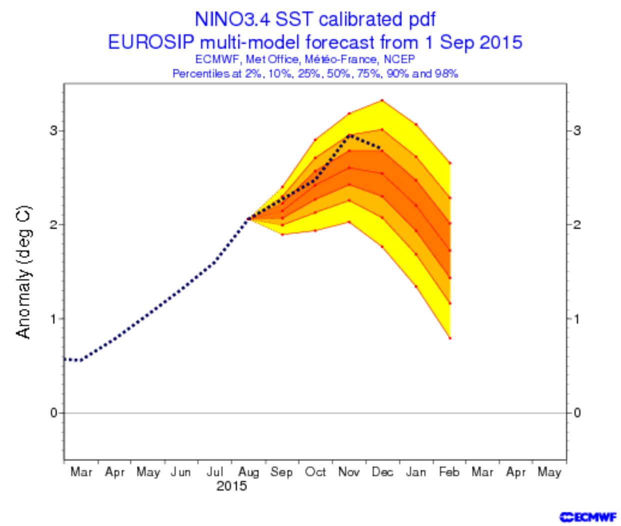

NINO3.4 SST anomaly plume
EUROSIP multi-model forecast from 1 Oct 2014
ECMWF, Met Office, Météo-France, NCEP
Monthly mean anomalies relative to NCEP OIv2 1981-2010 climatology
Anomaly (deg C)
Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun
2014
ECMWF


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


NINO3.4 SST calibrated pdf
EUROSIP multi-model forecast from 1 Dec 2014
ECMWF, Met Office, Météo-France, NCEP
Percentiles at 2%, 10%, 25%, 50%, 75%, 90% and 98%
Anomaly (deg C)
Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug
2014
ECMWF


NINO3.4 SST calibrated pdf
EUROSIP multi-model forecast from 1 Mar 2015
ECMWF, Met Office, Météo-France, NCEP
Percentiles at 2%, 10%, 25%, 50%, 75%, 90% and 98%
Anomaly (deg C)
Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov
2014
ECMWF

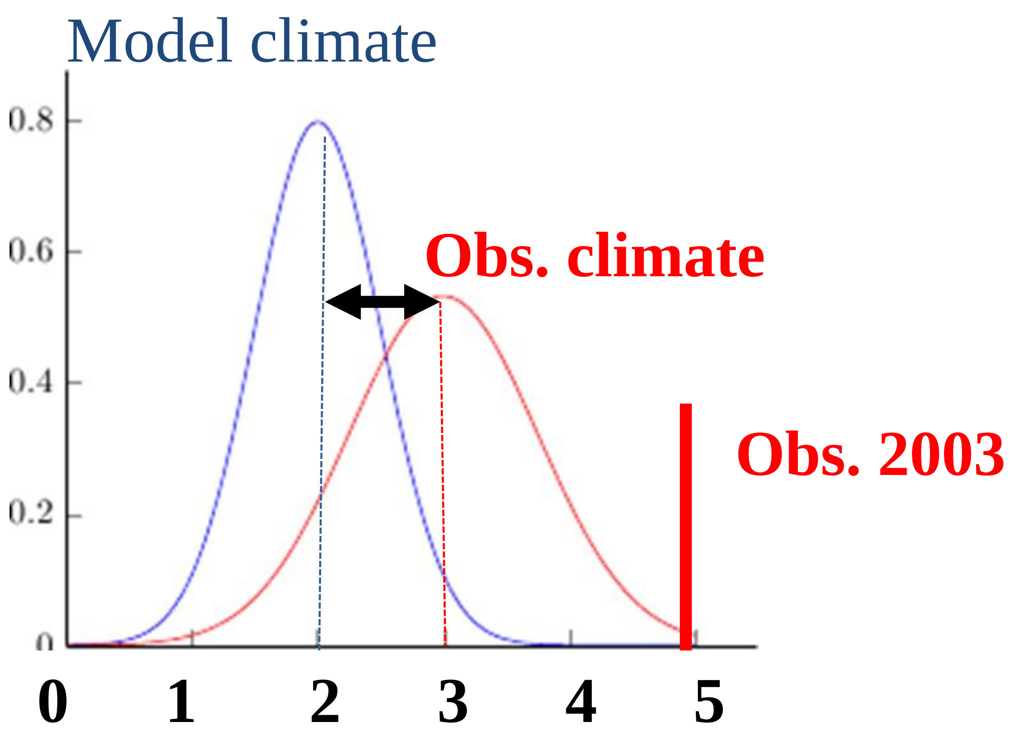

NINO3.4 SST calibrated pdf
EUROSIP multi-model forecast from 1 Jun 2015
ECMWF, Met Office, Météo-France, NCEP
Percentiles at 2%, 10%, 25%, 50%, 75%, 90% and 98%
Anomaly (deg C)
Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb
2014
2015
ECMWF

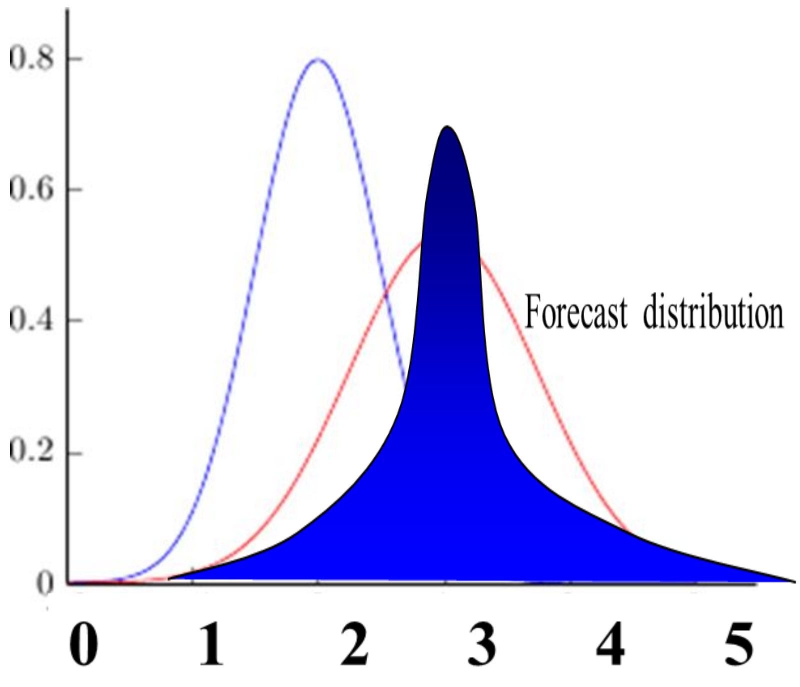

NINO3.4 SST calibrated pdf
EUROSIP multi-model forecast from 1 Sep 2015
ECMWF, Met Office, Météo-France, NCEP
Percentiles at 2%, 10%, 25%, 50%, 75%, 90% and 98%
Anomaly (deg C)
Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May
2015
ECMWF

Extended range predictions

Products from Extended range predictions are generally defined with reference to the model climate estimated by the re-forecast data.

In this way we remove the systematic biases from the forecast

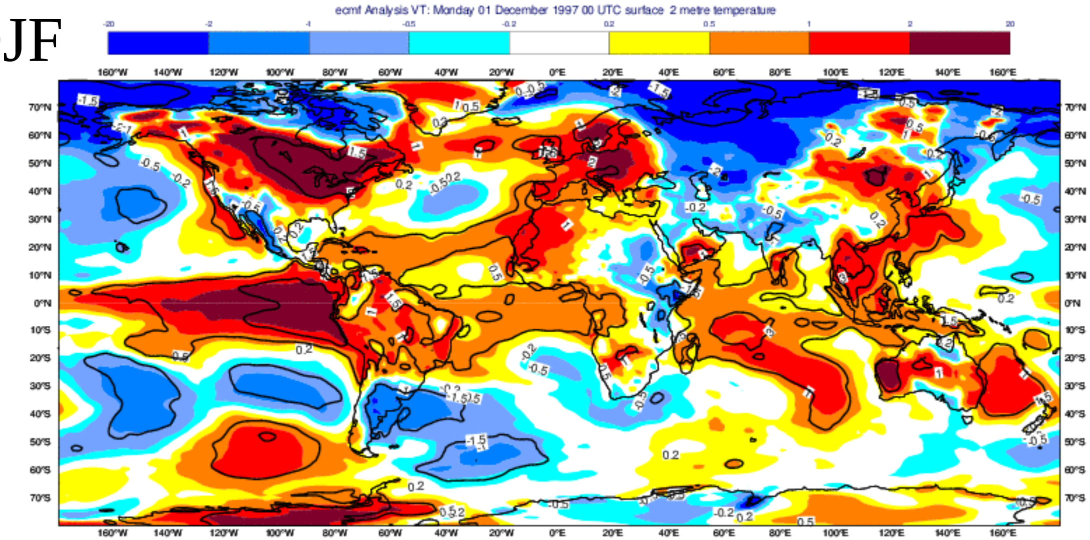


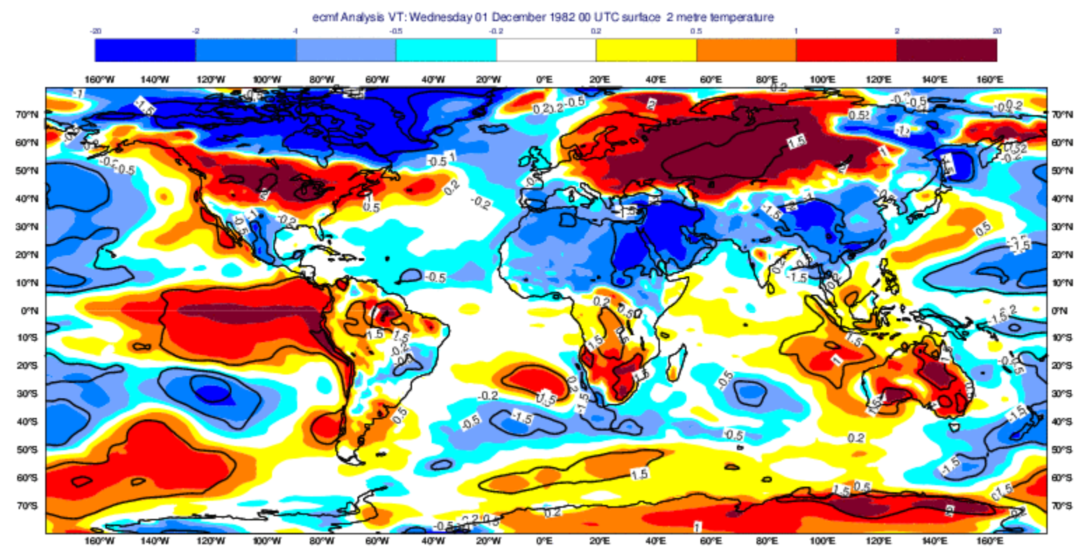


Implication for ENSO teleconnections :

2m temp anomalies in DJF

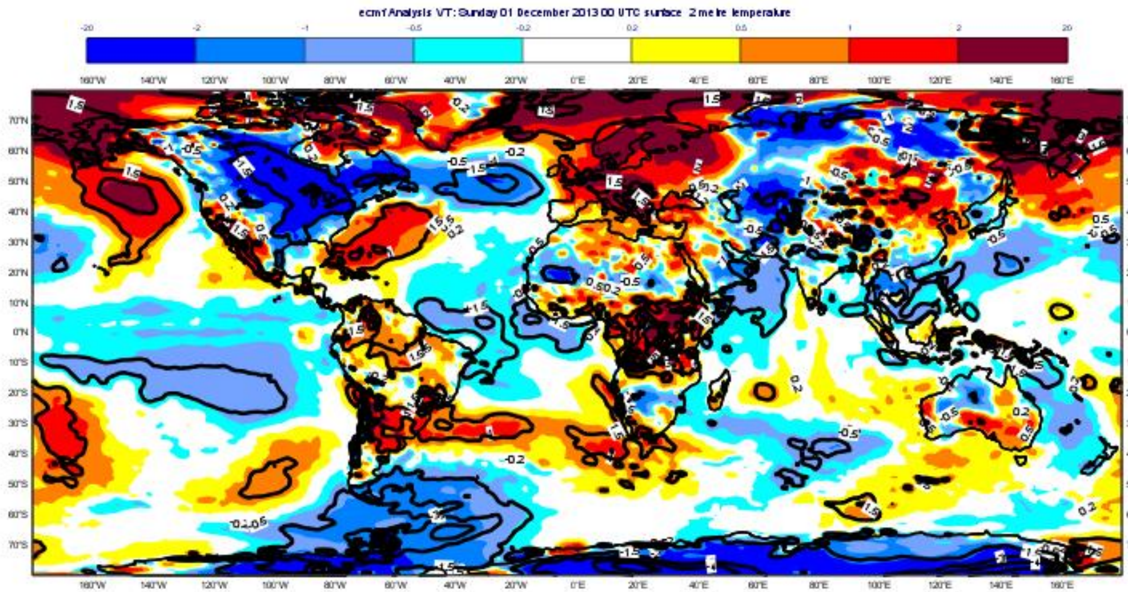
El Nino 1997/98





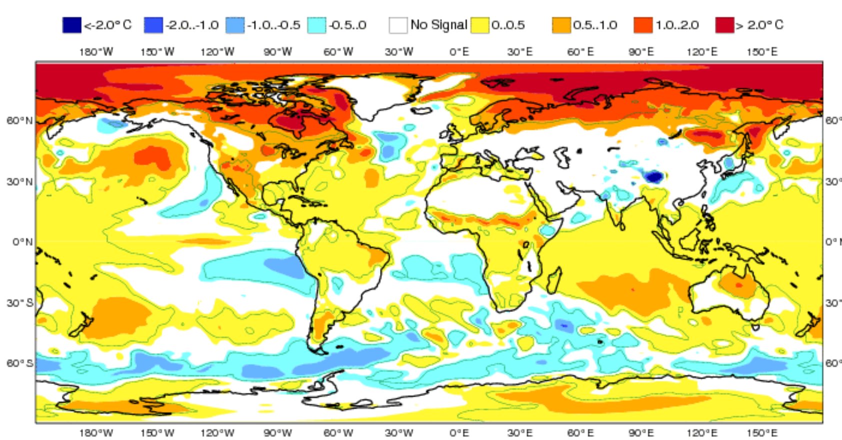
El Nino 1982/83

DJF 2014 : 2m temp anomalies



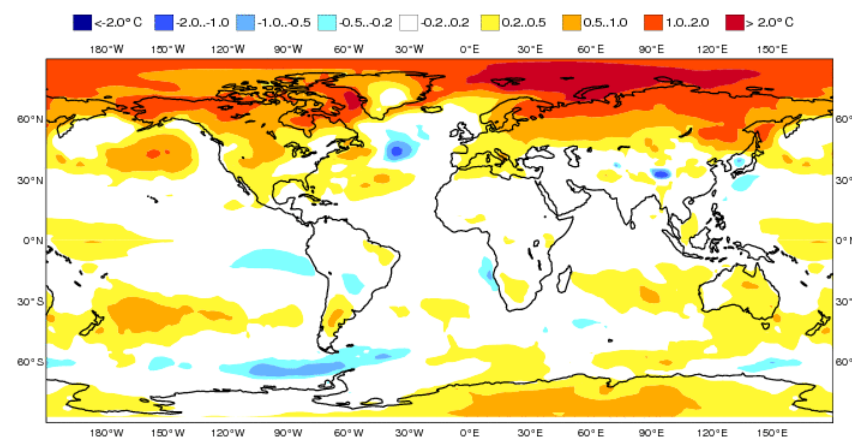
ECMWF Seasonal Forecast
Mean 2m temperature anomaly
Forecast start reference is 01/11/13
Ensemble size = 51, climate size = 450

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

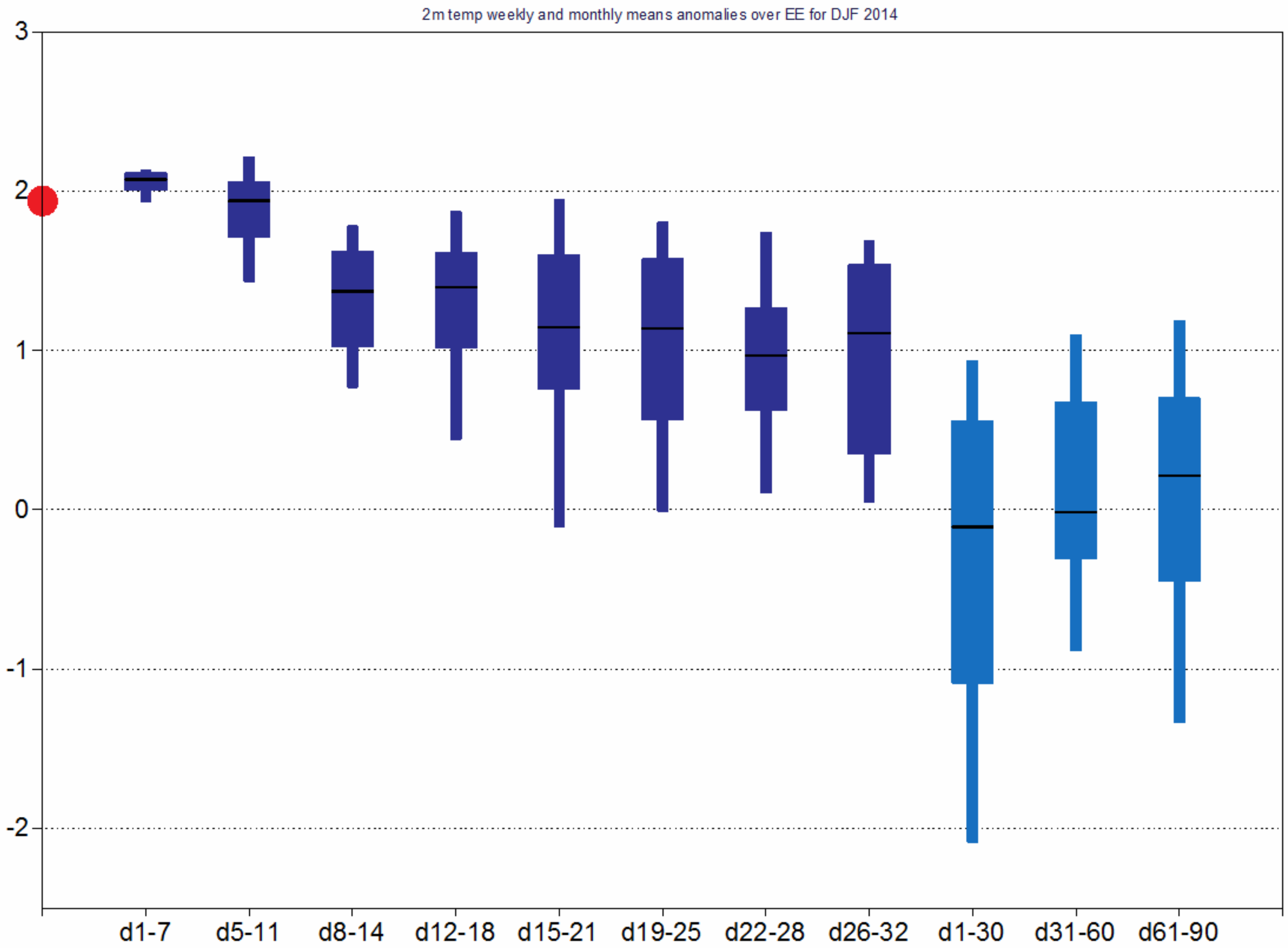


EUROSIP multi-model seasonal forecast
Mean 2m temperature anomaly
Forecast start reference is 01/11/13
Variance-standardized mean

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



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

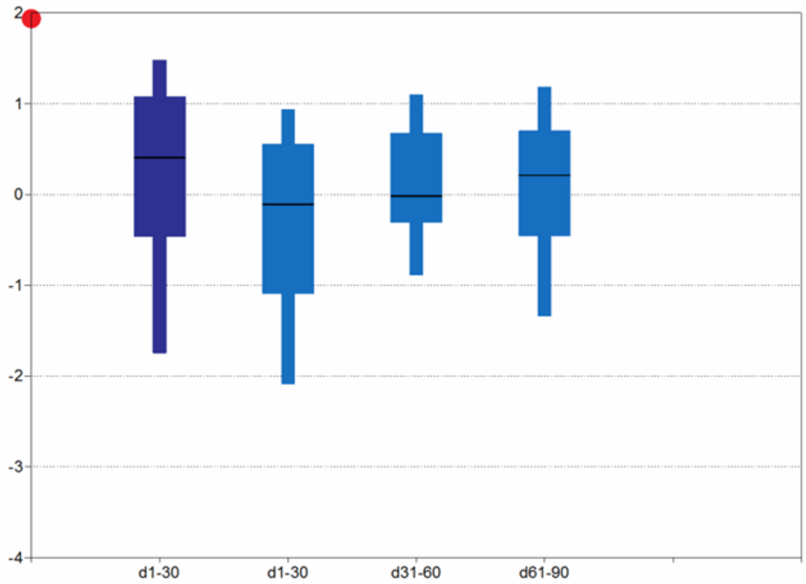


Predictability of seasonal mean anomalies:

Monthly system versus Seasonal system

2m temp. anomalies for DJF 2014 averaged over:

Eastern Europe



North America