Seasonal-to-decadal climate Prediction for the improvement of European Climate Services

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WP 5.3 *Calibration and Combination*

Deliverable 53.2

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		CO - Confidential, only for members of the consortium, including the Commission services		

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1.0	19/09/16	Richard Graham	Initial compilation
1.1	20/09/16	Caio Coelho	Edits and additions
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1.3	18/10/16	Richard Graham	Additions following review

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1. Executive summary

Calibration techniques are used to correct for systematic errors in forecasts and improve prediction skill and reliability. Combining forecasts from several prediction systems is known to improve prediction skill – with the so-called "multi-model" forecasts exhibiting, in general, skill that is equal to or better than the skill of the most skilful individual model in any region/season. As well as creating multi-model forecasts from several different dynamical prediction systems, forecasts from dynamical and statistical-empirical systems may also be combined – and this is of particular relevance at many Regional Climate Outlook Forums (RCOFs) where use of statistical methods is prominent and an objective means of incorporating information from the GPC systems is required. Forecasts which are both calibrated and the product of combined inputs can thus improve prediction skill and provide an optimised, consolidated, single probabilistic forecast product – reducing the multiplicity of forecast inputs that currently need to be considered by Regional Climate Centres (RCCs), RCOFs and National Meteorological and Hydrological Services (NMHSs) when preparing regional and national seasonal forecasts.

As part of WP5.3, different methodologies for calibrating and combining forecasts from Global Producing Centre (GPC) seasonal prediction systems have been developed, or existing systems upgraded. The methodologies used, including examples of skill improvements obtained, are described in the report for D53.1. Briefly, new or upgraded calibration/combining methodology includes those developed for:

- The EUROSIP multi-model which has global coverage and which is comprised of ECMWF System4, Met Office GloSea5, Météo-France System 5 and the NOAA NCEP CFSv2 system (ECMWF – Section 3.3);
- The EUROBRISA multi-model, with focus on the South American region. This system comprises a CPTEC/INPE empirical prediction model, ECMWF System 4, Météo-France System 5 and Met Office GloSea5 (CPTEC/INPE – Section 3.2)
- A multi-model using Canonical Correlation Analysis (CCA) methodology (referred to as the CCA-based multi-model), mainly deployed for the Greater Horn of Africa region but with flexibility for application elsewhere and including the Met Office GloSea5, ECMWF System 4, NOAA NCEP CFSv2 and the Canadian Meteorological Centre's CMC1-CanCM3 and CMC2-CanCM3 systems. (METOFFICE - Section 3.1)
- Objective combination of GPC forecasts with established statistical predictors used to prepare national seasonal forecasts in the Greater Horn of Africa. (METOFFICE – Section 3.1)

Under WP5.3, these systems have been used to enhance the quality of consolidated guidance from GPCs for preparation of regional and national seasonal forecasts at a wide range of RCOFs. Specific support has been provided to RCOF activities in Europe, the Greater Horn of Africa (GHA), North Africa, South America and India.

Delivery of combined/calibrated products has occurred both by upgrading of established web-based services and by in-person interaction with RCCs and RCOFs. The upgrades developed to the EUROBRISA system have fed directly into operational calibrated/combined products delivered routinely by monthly updating web pages. In addition, roll-out and dissemination of the upgraded EUROSIP and EUROBRISA products has been assisted by participation in, respectively, Mediterranean Climate Outlook Forums and RCOFs for Southern South America (SSA). Development and delivery of the CCA-based multi-model products has focused on close interaction with the IGAD Climate Prediction and Applications Centre (ICPAC) and participation by Met Office scientists at

Greater Horn of Africa Climate Outlook Forums (GHACOFs). Participation in GHACOFs has also been necessary to train personnel in the objective combining of GPC and statistical forecasts to prepare national outlooks.

To foster sustained and prudent use of GPC products in the regional forecast process, training in appreciation of the strengths and weaknesses of dynamical forecast systems is needed for some RCCs and RCOFs. Training in these areas have been provided as part of RCOF participation and an interactive spreadsheet training tool for familiarisation with the characteristics of ensemble forecast outputs has been developed. SPECS partners active in WP5.3 have participated in over 20 RCOFs during the course of the project to assist dissemination of products and to provide training in their use (see Table below).

Through strong links between SPECS investigators and WMO bodies, awareness of opportunities and challenges emerging from SPECS research and interactions with users has been raised in the global seasonal prediction community and has informed thinking and planning in WMO agenda-setting bodies such as the Commission for Climatology and the Commission for Basic Systems – adding to "pull through" and legacy of the research. This has occurred through meetings of WMO Expert Teams and two workshops on operational climate prediction with GPCs, RCCs, RCOFs and NMHSs. Key areas where progress has been made include agreeing Lead Centre facilities to aid RCCs, RCOFs and NMHSs to perform calibration on GPC output and raising awareness of the promising potential for prediction rainy season onset timing – of high importance to users, particularly in the agricultural sector.

RCOF	Date	Where	System	SPECS partner
MedCOF: Mediterranean Climate Outlook Forum				
MedCOF3	Nov. 2014	Antalya, Turkey	Upgraded EUROSIP	ECMWF
MedCOF4	Apr-May 2015	Online sessions	Upgraded EUROSIP	ECMWF
MedCOF5	Nov. 2015	Marrakech, Morocco	Upgraded EUROSIP	ECMWF
RCOF-SSA: RCOF for Southern South America				
RCOF-SSA40	May 2016	Santiago, Chile	EUROBRISA	CPTEC/INPE
RCOF-SSA38	May 2015	Mar del Plata, Argentina	EUROBRISA	CPTEC/INPE
RCOF-SSA37	Dec 2014	Montevideo, Uruguay	EUROBRISA	CPTEC/INPE
RCOF-SSA35	Jun 2013	Porto Alegre, Brazil	EUROBRISA	CPTEC/INPE
GHACOF: Greater Horn of Africa Climate Outlook Forum				
GHACOF33	Feb. 2013	Bujumbura, Burundi	CCA-based	METOFFICE
GHACOF34	May 2013	Addis Ababa, Ethiopia	CCA-based	METOFFICE
GHACOF35	Aug. 2013	Eldoret, Kenya	CCA-based	METOFFICE
GHACOF36	Feb. 2014	Entebbe, Uganda	CCA-based	METOFFICE
GHACOF38	Aug. 2014	Addis Ababa, Ethiopia	CCA-based	METOFFICE
GHACOF39	Feb. 2015	Nairobi, Kenya	CCA-based	METOFFICE
GHACOF40	May 2015	Djibouti, Djibouti	CCA-based	METOFFICE
GHACOF41	Aug. 2015	Dar es Salaam	CCA-based	METOFFICE
GHACOF42	Feb. 2016	Kigali, Rwanda	CCA-based	METOFFICE
GHACOF43	May 2016	Naivasha, Kenya	CCA-based	METOFFICE
PRESANORD: Northern Africa Climate Outlook Forum				
PRESANORD	Feb. 2013	Cairo, Egypt	CCA-based	METOFFICE
SASCOF: Southern Asia Climate Outlook Forum				
SASCOF8	April 2016	Colombo, Sri Lanka	CCA-based	METOFFICE
SASCOF9	Sept. 2016	Nay Pyi Taw, Myanmar	CCA-based	METOFFICE

2. Project objectives

With this deliverable, the project has contributed to the achievement of the following objectives (see DOW Section B.1.1.2):

No.	Objective	Yes	No
1.	To achieve an objective exhaustive *evaluation* of current forecast quality from dynamical, statistical, and consolidated systems to identify the factors limiting s2d predictive capability	X	
2.	To test specific hypotheses for the improvement of s2d predictions, including novel mechanisms responsible for high-impact events using a *process-based verification* approach	X	
3.	To develop innovative methods for a comprehensive *forecast quality assessment*, including the maximum skill currently attainable		X
4.	To facilitate the *integration of multidimensional observational data* of the atmosphere-ocean-cryosphere-land system as sources of initial conditions, and to validate and calibrate climate predictions		X
5.	To achieve an *improved forecast quality at regional scales* by better initialising the different components, an increase in the spatial resolution of the global forecast systems and the introduction of important new process descriptions		X
6.	To assess the best alternatives to characterise and deal with the *uncertainties in climate prediction* from both dynamical and statistical perspectives for the increase of forecast reliability		X
7.	*To achieve reliable and accurate local-to-regional predictions* via the combination and calibration of the information from different sources and a range of state-of-the-art regionalisation tools	X	
8.	*To illustrate the usefulness* of the improvements for specific applications and develop methodologies to better communicate actionable climate information to policy-makers, stakeholders and the public through peer-reviewed publications, e-based dissemination tools, multi-media, examples for specific stakeholders (energy and agriculture), stakeholder surveys, conferences and targeted workshops	X	
9.	*To support* the European contributions to *WMO research initiatives* on s2d prediction such as the GFCS and enhance the European role on the *provision of climate services* according to WMO protocols by creating examples of improved tailored forecast-based products for the GPCs and participating in their transfer to worldwide RCCs and NHMSs.	X	

3. Detailed report on the deliverable

3.1 Contribution from the Met Office (METOFFICE)

With SPECS funding, the METOFFICE has made input to 12 Regional Climate Outlook Forums (RCOFs) since February 2013. We have focused on the Greater Horn of Africa Climate Outlook Forums (GHACOFs), coordinated by the IGAD Climate Predictions and Applications Centre (ICPAC), Nairobi. This choice of focus is for several reasons, including a) we have strong historical and ongoing collaborations with ICPAC – facilitating excellent engagement and progress; b) 3 GHACOFs are held each year, compared to 1 or 2 RCOFs in most other regions – this has provided more opportunity for trialling use of calibrated/combined GPC outputs; and c) ICPAC is in demonstration phase for designation as a WMO Regional Climate Centre – thus our SPECS activities have contributed to building capacity that is aligned with that aim. In 11 of the 12 GHACOFs held since the beginning of SPECS at least one METOFFICE staff has attended in person at both the workshop to prepare the regional consensus forecast – providing GPC products and training in their use - and the follow-up forum with forecast users (these two activities are referred to collectively as "the GHACOF process"). The model calibration/combining methodology developed has also been used to provide interpretation and guidance on dynamical seasonal forecast signals at similar forums held for the North Africa and Mediterranean region (PRESANOR) and for South Asia (SASCOF). At the GHACOFs our contributions have covered three areas:

a. *Delivery of calibrated and combined (multi-model) forecasts*: As part of D53.1 the METOFFICE has developed a procedure for calibrating and combining output from seasonal prediction systems – improving the local forecast skill of the "raw" uncalibrated outputs (Colman et al. 2016). In D53.2 the products have been trialled in real-time seasonal forecasting operations at over 12 Regional Climate Outlook Forums and progressively refined, including through feedback from ICPAC and GHACOF participants. These calibrated/combined products are described in detail, with an example real-time forecast, in the report for D53.1.

b. *Development and trial of methodology to assist in use of GPC forecasts in preparation of national seasonal forecasts*: The above activity (a) feeds mainly into preparation of the GHACOF regional consensus forecasts. In addition, the GHACOFs also serve an important function in providing tools and resources for NMHS representatives to formulate their corresponding national seasonal forecasts. In brief, the national forecasts are prepared by regressing station rainfall observations representative of sub-national climate zones (held by the participants) onto a pool of statistical predictors made available by ICPAC. Subjective use of GPC forecast maps is also used. By definition, the pool of statistical predictors relates to pre-season ocean and atmosphere conditions e.g. tropical Pacific SST in January to predict MAM rainfall over the GHA. The METOFFICE contribution to this activity has been to make available GPC forecast data to match the precedent predictors – e.g. continuing the last example, predicted MAM tropical Pacific SST. These GPC predictors are added to the pool of statistical predictors available to the workshop. In order to harmonise with the forecast production processes already established, the procedure follows several steps, listed below:

    i. *Preparation of GPC-based predictors to complement statistical (precedent conditions) predictors*: GPC hindcast and forecast data is made available in the form of time scores on the Principle Components (PCs) of predicted fields, specifically: SST, precipitation and zonal and meridional wind components. The GPC models used are those with hindcasts of at least 29 years length: ECMWF, NOAA NCEP CFSv2 and the Canadian Meteorological Centre's CMC1-CanCM3 and CMC2-CanCM4 models. Use of at least 29 years of

retrospective forecasts allows a more satisfactory merger with the established statistical methods which use observed data (including from re-analyses) back to 1961. PCs are mostly calculated over a "tropical" domain 40°S to 40°N; 0-360°E or over oceanic-scale subdomains within this region. PCs of zonal wind are calculated over north Indian Ocean and tropical Atlantic domains, matching corresponding EOF-based predictors calculated on precedent observations and made available by ICPAC.

ii. *Selection of the most skilful predictors*: The software package SYSTAT is an established tool at GHACOF and other African RCOFs. It is widely used to generate national-scale forecasts which are later blended to form an input to the regional consensus. Utilising familiarity with this tool, it has been used in this context to perform a stepwise regression on station rainfall data representative of national homogeneous climate zones, drawing on the pool of statistical and GPC-based predictors, to identify the most skilful set. In sample cases, the value of GPC-based predictors is clear from the high frequency of selection of GPC-based predictors (higher than expected by chance), relative to statistical predictors.

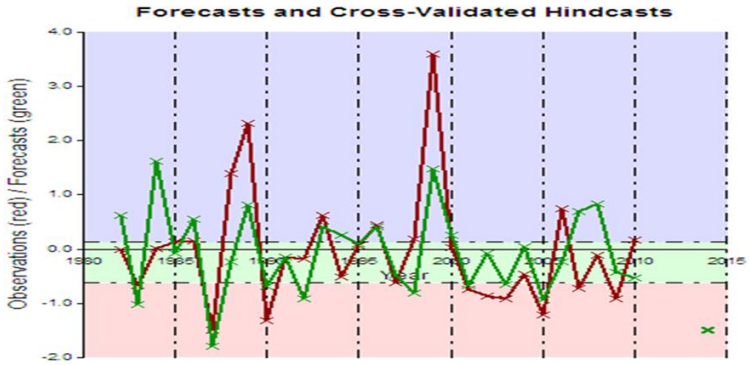


Figure 1: Hindcast (green) and observed (red) rainfall for a station representative of the Mbeya region of southwest Tanzania for MAM rainfall 1982-2010, generated using the method described in the text. The corresponding forecast for MAM 2014 is indicted by the green cross at right. Probabilities (not shown) for tercile categories are generated in CPT by constructing a probability distribution function with mean equal to the deterministic value and standard deviation equal to the standard error over the hindcast. The shaded plot areas indicate the tercile category ranges. (Courtesy Bibie Jaffer Lilla, Tanzania Meteorological Agency).

iii. *Generating a forecast using Principle Component Regression (PCR)*: The methodology used in SYSTAT when only statistical predictor are use is based on splitting the historical sample into separate training and validation periods (rather than on a cross validation approach). Inclusion of the GPC-based predictors, for which only a 29-year sample is available, substantially shortens the potential training samples from those used when only statistical predictors are considered. For this reason, a cross-validation approach is preferred when GPC-based predictors are included. Predictors selected in the previous step (ii) are used in a cross-validated PCR analysis using the Climate Predictability Tool (CPT) developed by the International Research Institute for Climate and Society (IRI). An example analysis for the MAM 2014 season using the above steps for the March-May season for the Mbeya region of southwest Tanzania is shown in Fig. 1. In this case the stepwise procedure selected exclusively GPC-based predictors, specifically PCs 1, 3 and 4 of CFSv2 ensemble mean SST for the tropical domain. The forecast gives a pronounced

dry signal and below normal rainfall was indeed observed over much of western Tanzania. Note: forecast probabilities (not shown) for tercile categories are generated by CPT by constructing a probability distribution function with mean equal to the deterministic forecast value and standard deviation equal to the standard error over the hindcast.

c. *Training in appreciation of dynamical seasonal forecast systems, tools for interpreting outputs and other resources for seasonal forecasting*: Statistical-empirical prediction methodology remains the backbone of operational forecasting at many RCCs and RCOFs and to foster sustained and prudent use of GPC products in the regional forecast process, appreciation of the strengths and weaknesses of dynamical forecasts is needed. As part of SPECS activities, METOFFICE has provided training – additional to that reported above - in these areas.

With part funding from SPECS a spreadsheet training tool has been developed which allows "hands on" experience with GPC ensemble hindcast and forecast data. The tool allows users to manipulate ensemble data to increase familiarity with concepts such as ensemble mean, ensemble spread, probability forecasts and statistical reliability and to validate GPC performance for a selected region using correlation, reliability and Relative Operating Characteristic (ROC) diagrams (Fig. 2).

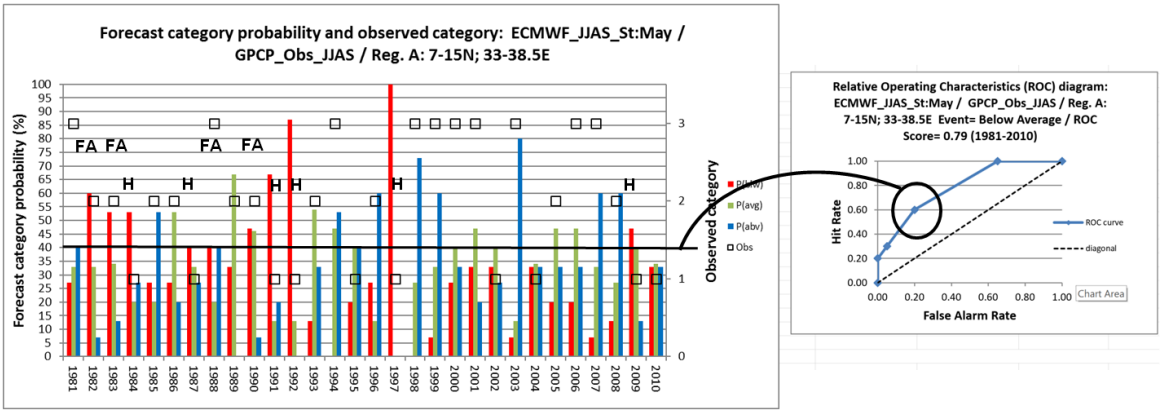


Figure 2: Interactively generated graphics from the spreadsheet training tool illustrating the construction of ROC diagrams. The example is from ECMWF System 4 rainfall hindcasts for the JJAS season in western Ethiopia. The left panel shows hindcast probabilities for the below (red), average (green) and above (blue) tercile categories. The open squares show the observed category with reference to the right-hand vertical axis (1=below, 2=average, 3=above). Hits and False Alarms for the 40% probability threshold are indicated and connected to the associated point on the ROC curve (right-hand panel).

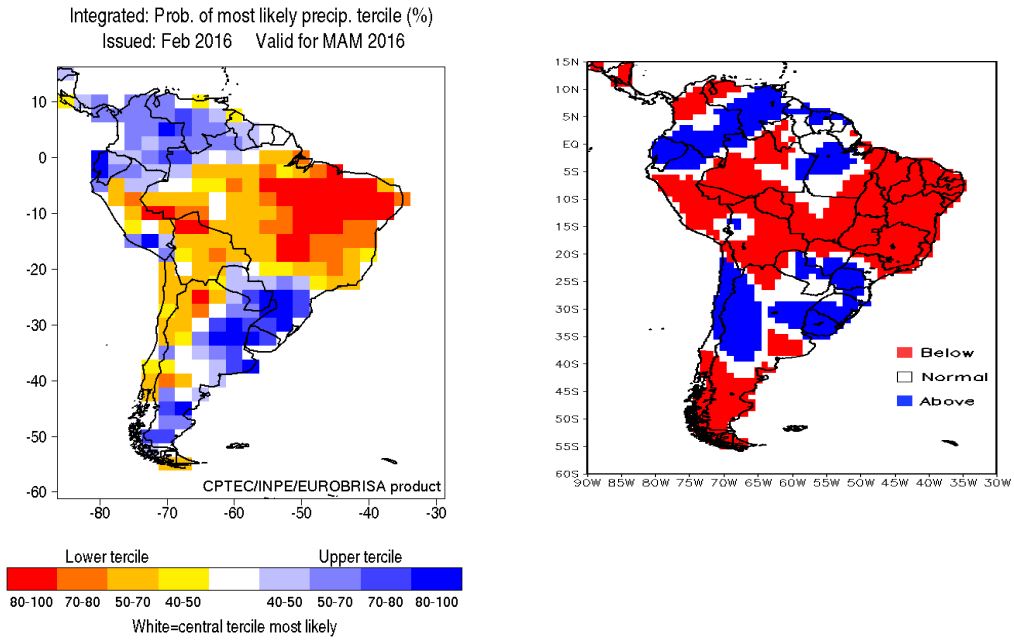
In addition training has been provided on more advanced processing of GPC outputs using the CPT software – particularly the Principle Component Analysis (PCR) and Canonical Correlation Analysis (CCA) modules.

As part of METOFFICE participation in generation of the GHACOF consensus forecasts, predictions from the Met Office statistical predictions for SOND season (Mutai et al. 1998 and see: http://www.metoffice.gov.uk/research/climate/seasonal-to-decadal/long-range/east-african-rainfall) have also been provided, in person, together with the calibrated and uncalibrated products from the GloSea5 dynamical system and other European and international dynamical systems.

3.2 Contribution from the Centre for Weather Forecasting and Climate Studies, National Institute for Space Research, Brazil (CPTEC/INPE)

CPTEC/INPE routinely delivered during the SPECS project period (2012-2016) combined and calibrated seasonal precipitation forecasts for South America at the World Meteorological Organization (WMO) Regional Climate Outlook Fora for Southern South America (RCOF-SSA). The most recent delivery was made during the 40th RCOF-SSA held in Santiago, Chile, 2-3 May 2016. This delivery was made within the context of EUROBRISA (A EURO-BRazilian Initiative for improving South American seasonal forecasts), which was previously supported by the São Paulo State Research Foundation (FAPESP, Brazil) and the Leverhulme Trust (UK), and is now supported by SPECS.

The EUROBRISA system is composed by an empirical model and three coupled ocean-atmosphere dynamical models. The final probabilistic forecast product, known as the integrated forecast, combines and calibrates the forecasts from these four models using the state-of-the art statistical method known as forecast assimilation. The empirical model uses the previous month Pacific and Atlantic sea surface temperatures as predictor for the next season South American precipitation. The dynamical models currently used in the EUROBRISA system are from the following Global Producing Centres (GPCs): the new versions of the UK Met Office (GloSea5 GC2) and the Météo-France (System 5) models, and the ECMWF (System 4) model. Previous versions of the EUROBRISA system used earlier versions of the UK Met Office GloSea model (namely GloSea4 and GloSea5) and of the Météo-France model (namely System 3 and System 4).



(a) **(b)**

Figure 3: a) EUROBRISA combined and calibrated (integrated) precipitation forecast for MAM 2016 issued in the previous February 2016. This forecast is produced using the state-of-the art statistical method known as forecast assimilation that combines and calibrates the forecast of three dynamical models (GloSea5 GC2, Météo-France System 4 and ECMWF System 4) and an empirical model. b) Observed precipitation tercile category in MAM 2016. Blue regions indicate that above normal precipitation was observed (i.e. precipitation above the upper tercile). Red regions indicate that below normal precipitation was observed (i.e. precipitation below the lower tercile). White regions indicate that normal precipitation was observed (i.e. precipitation between the upper and the lower tercile).

EUROBRISA combined and calibrated (integrated) forecasts and the associated verification products were generated every month and disseminated via the web portal http://eurobrisa.cptec.inpe.br during the SPECS project period (2012-2016). A link to the EUROBRISA web portal was also made available at the SPECS web portal at http://www.specs-fp7.eu/Products. Figure 3a shows an example of combined and calibrated (integrated) probabilistic seasonal precipitation forecast for MAM 2016 issued in February 2016 by the EUROBRISA system during the recently observed El Niño event in the equatorial Pacific. The forecast provides an indication of the most likely tercile category. Figure 3b shows the corresponding observed categories in MAM 2016. The EUROBRISA integrated seasonal forecast, produced by combining and calibrating the state-of-the-art European dynamical models listed above with the empirical model also mentioned above, indicated higher probabilities for rainfall to be observed in the below normal category in North and Northeast Brazil and higher probabilities for rainfall to be observed in the above normal category in southern Brazil, Uruguay, northeastern Argentina and Ecuador, in accordance with the expected El Niño teleconnection response over South America. The comparison of Figures 3a and 3b reveals that for most of these regions (except in eastern Amazon in northern Brazil) there was good correspondence between the forecast most likely category and the category that was observed.

3.3 Contribution from ECMWF

ECMWF has been working on a new/re-structured/re-engineered software suite, described in more detail in the WP5.3 2nd periodical report, Milestone 5.3 – Prototype of optimally combined European GPC products and D53.1 - Methodologies for calibration and combination of global and downscaled s2d predictions for Europe and South-America. The suite contains in-house-developed calibration and combination techniques for multi-model products and was initially tested on the participating models of the EUROSIP multi-model seasonal forecasts to form an upgraded EUROSIP product. The dissemination of this upgraded EUROSIP product was handled by a representative of ECMWF (D. Decremer), who attended and participated in 3 Mediterranean Climate Outlook Fora (http://medcof.aemet.es), more particularly, MedCOF3, held in Antalya, Turkey (Nov 17th~18th 2014), MedCOF4, as online-only meeting (Apr 17th ~ May 26th 2015) and MedCOF5 (Nov 23rd~26th), held in Marrakech, Morocco, where this new EUROSIP multi-model product was presented. The goal of MedCOF, SEECOF and PRESANORD (jointly organised) is to create a consensus forecast for the coming season in Mediterranean region, including regions of North-Africa and the Balkan Peninsula. Inclusion of the new EUROSIP product into MedCOF's forecasts analysis prior to the consensus proved useful and was met with great interest from the attendees. As for future plans, there will be no attendance to the next MedCOF as this will fall after the SPECS project's termination. However, MedCOF's participants will continue to incorporate operational EUROSIP products into their future consensus forecasts. The future application, dissemination and development of the multi-model combination techniques developed in WP5.3 on EUROSIP products will be handled by the Copernicus Climate Change Service (https://climate.copernicus.eu).

4. References

Colman, A, Graham, R and Davey, M. 2016: Calibrating and Combining Seasonal Rainfall Forecasts from Dynamical Models for the Greater Horn of Africa. In preparation

Mutai, C.C., Ward, M.N. and Colman, A.W. 1998: Towards the prediction of the East African short rains based on sea-surface temperature-atmosphere coupling. Int. J. Climatol., 18, 975-997.

Acknowledgements
The METOFFICE thank Dr J Mutemi and Mr B. Mohamed for discussions on the approach and assisting in the trialling of the multi-model in the GHACOF process and current and former directors of ICPAC, Dr G. Artan and Prof. L. Ogallo for continued collaboration. Simon Mason and other IRI colleagues are thanked for assistance and discussions with CPT software.

5. List of publications

METOFFICE: None for this deliverable.

INPE: None for this deliverable.

ECMWF: None for this deliverable

Peer reviewed articles:

METOFFICE: None for this deliverable.
INPE: None for this deliverable
ECMWF: None for this deliverable

Plan for future publication:

METOFFICE:
Colman, A., Graham, R., and Davey, M. 2016: Calibrating and Combining Seasonal Rainfall Forecasts from Dynamical Models for the Greater Horn of Africa. In preparation

INPE:
Coelho CAS, MAF Firpo, AHN Maia, C MacLachlan, 2016: Exploring the feasibility of empirical, dynamical and combined probabilistic rainy season onset forecasts for São Paulo, Brazil. Under review in the International Journal of Climatology

6. Efforts for this deliverable

Partner	Person-months (actual)	Person-months (in-kind)	Period covered
2. INPE	0	6	M06 – M48
14. METOFFICE	6	3	M06 – M48
19. ECMWF	1.42	0	M06 – M46
Total	7.42	9	M06 – M48

7. Sustainability

Prospects for sustaining the advances made in delivery to RCOFs have been enhanced by activities to incorporate the improved calibration and combining methodology developed into operational multi-model products – this has been completed for EUROBRISA and will be completed for EUROSIP as part of the Copernicus Climate Change Service. Assistance in using the calibrated/combined products through participation of GPC personnel at RCOFs is still needed, in some cases, to accelerate optimum use of GPC outputs and to extract full benefits. This will require future funding sources – as will continued development of methods for calibration and combination.

A useful area of future research would be an inter-comparison of the differing approaches for calibration/combination that have been developed taking into account the challenging task of re-calibrating the systems every month when incorporating models with on-the-fly hindcast production.

Another challenging topic of great interest for RCOFs and RCCs is rainy season onset predictions. The application of methods for investigating the feasibility of probabilistic rainy season onset predictions combining information of different models is an activity likely to produce relevant outputs useful for supporting a number of application sectors.

SPECS investigators at METOFFICE and CPTEC are active on the WMO Expert Team on Operational Predictions from Sub-seasonal to Longer-Time Scales (ET-OPSLS) and ECMWF are also represented. Through these strong links, awareness of opportunities and challenges emerging from SPECS research and interactions with users has been raised in the global seasonal prediction community and has informed thinking and planning in WMO agenda-setting bodies such as the Commission for Climatology and the Commission for Basic Systems. This has occurred through meetings of the ET-OPSLS and two workshops on operational climate prediction with GPCs, RCCs, RCOFs and NMHSs. Particular areas of influence include: calibration of GPC forecast outputs – from interventions by CPTEC and METOFFICE the LC-LRFMME will now provide data format conversion software on its website to aid RCCs and RCOFs perform calibration and downscaling of forecasts; prediction of rainy season onset timing – awareness of the promising potential for useful prediction has been raised and other centres encouraged to investigate skill with their own systems. The additional potential for prediction of onset with subseasonal forecast systems has also been raised.