

# Exploring applications of multi-year predictability of Sahel rainfall: Recommendations for further products

Neil Ward<sup>1</sup> and Declan Conway<sup>2</sup>

<sup>1</sup> Independent consultant. ([wardn626@gmail.com](mailto:wardn626@gmail.com))

<sup>2</sup> Grantham Research Institute on Climate Change and the Environment. London  
School of Economics and Political Science, Houghton Street, London, WC2A  
2AE, UK. ([d.conway@lse.ac.uk](mailto:d.conway@lse.ac.uk))

2019

This annex provides a list of follow-on activities to develop the work undertaken through the WISER project *Exploring applications of multi-year predictability of Sahel rainfall*. Actions are listed in order of potential for action now, and over the medium and longer-term future. Products 1 to 6 (termed generic climate products) primarily involve consultant technical work with the UKMO; Products 7 to 11 (termed Sudan applications) require collaboration with the Sudanese Meteorological Authority and other Sudan-based partners. Technical detail and time requirements are then provided for each Product.

## SUMMARY OF GENERIC CLIMATE PRODUCTS

### *Potential for Action Now – Products 1 - 2*

**1) Development of the current seasonal and multi-year forecast.** Building on the Sheen et al. analysis and drawing on UKMO model output, a tercile rainfall product for indices of the Sahel, West Sahel and East Sahel could likely be operationalized with a modest amount of additional applied-oriented research and development. The product could be for year-1 (extension of seasonal forecast) and years 2-5 (a multi-year forecast). A target could be to have information available ahead of the 2019 rainy season.

**2) Risk of extreme years within the 2-5 year period.** A small amount of additional diagnostic work could provide supporting diagnostic information on the risk of very dry / very wet years within a 2-5 year period, based on the predicted 2-5 year tercile. This information would address concern over what the 2-5 year forecast means in terms of within-period variability.

### *Potential for Action Medium Term – Products 3 - 5*

**3) Multi-model forecasts.** Building on the Sheen et al. analysis, and the role of UKMO as WMO lead center coordinating with forecasts from other centers, a pathway to a multi-model product may be envisioned with a possible timeline of 1-2 years. Considerable discussion, and methodological development would be needed along the way.

**4) Expression of forecast as simple Drought risk indices.** A fast-track option would be to generate diagnostics relating tercile rainfall forecasts to drought risk indices such as SPI, WRSI or other.

Supported by:



Fund Manager:



[A further project opportunity exists to couple climate forecasts with biophysical modelling across the Sahel. This has high likelihood of success (literature has already established the basis) but the work would require a multi-year project with appropriate modelling expertise).]

**5) Recent Multi-year rainfall anomalies / trends for context.** Contextualizing information on recent multi-year trends / anomalies. Products 4 and 5 would add value to the multi-year forecast for users, and require relatively modest inputs of time for development.

*Item with Longer-term Potential – Product 6*

**6) Regional forecasts through regional collaboration.** Moving to a regional multi-year product with a regional partner (such as ICPAC) may be considered as 1-2+ year target, initially extending the boreal summer work of Sheen et al (therefore only applicable to the northern part of the ICPAC domain), and ultimately, assuming new evaluations justify, to other seasons / regions as well.

## **SUMMARY OF SUDAN APPLICATIONS (All requiring coordination with and/or some inputs from SMA)**

*Potential for Action now - Products 7 - 9*

**7) Safety nets.** The workshop identified a demand for multi-year rainfall / drought forecast information to help inform actions associated with safety nets under a WFP programme. Combined with more general interest in using the multi-year information to help inform investments, this appears to create a framework for a quick-start collaboration to explore details of predictability and undertake experimental product development in the context of a clear demand for the information.

**8) Longer-lead seasonal rainfall forecast for agriculture planning.** Demand for the extended lead seasonal forecast was expressed by WFP. In some respects, this may be considered to have lower priority than Product 7 above, given the relatively lower skill of the product and less innovative application, but this would represent opportunity to develop further the existing seasonal forecast capacity (SMA) and

Supported by:



Fund Manager:



also, explore skill assessment with denser network of observations. It may be a valuable complement to Product 7 above.

**9) Other quick start applications of forecast products, but requiring some scoping.**

- i) Winter temperature focus, choose one or two targets from those discussed at the workshop, to drive some exploration of this under-explored aspect of climate risk in the Sahel. May have lower priority than Product 7, and may be more considered medium term for starting given some further discussions needed to choose target applications, but represents a clear outcome of the workshop to explore opportunity for both seasonal and multi-year forecasts, which can be expected to have good levels of skill that would allow relatively confident interventions based on these temperature forecasts.
- ii) Water availability, water harvesting. Further scoping is needed, although clear expression of demand was made for seasonal and multi-year information.
- iii) Fire management. Further scoping is needed, but represents a focused target of opportunity, an area that has been addressed in other fire risk areas.

*Items with Longer-term Potential - Products 10 - 12*

**10) Reservoir management.** Perhaps the most substantial opportunity for further development. Integrating information from seasonal to multi-year in reservoir operations represents the potential for substantial improvements including in flood management, power generation, and irrigation efficiency.

**11) Index Insurance.** Initiatives in Sudan are clearly sensitive to climate, but the ways in which the forecasts may be effectively used remains challenging. There may be potential to connect to other initiatives addressing the forecast question explicitly.

**12) Extension into Regional application.** There is good potential to explore link-up with opportunities from the Sudan workshop with other regional application initiatives, e.g. food security.

Supported by:



Fund Manager:



# Technical and Practical Assessments of the Potential Products

*Products 1-6 cover some of the supporting details for work on generic climate products, while Products 7-12 cover supporting details for work on Sudan applications.*

## **Product 1. Development of the current seasonal and multi-year forecast model of Sheen et al. UKMO model (A basic tercile product)**

Assumption: It is assumed that the current real-time experimental products produced by UKMO are from a model that is identical or sufficiently compatible with the DePreSys3 that was used in Sheen et al. 2017.

Overview of envisioned product: Best-estimate tercile forecast for the regions used in Sheen et al. 2017 (Sahel, West Sahel, East Sahel), for year 1 rainy season and the average of rainfall for years 2-5. The timing of the existing experimental product is such that experiments are initialized each November, and made available in January <https://www.metoffice.gov.uk/research/climate/seasonal-to-decadal/long-range/decadal-fc>. Thus, the forecasts for 2019 Sahel rainy season and for 2020-2023 rainfall could be analyzed during early 2019 (see the possible steps below), and an experimental product could potentially be available before the 2019 Sahel rainy season.

Four steps are considered necessary to arrive at a quality real-time product:

**i) Establish tercile boundaries.** In principle, this is practical for the model since Sheen et al. results contain 20 forecast sets of years, each with 10-member ensemble, so there are 200 realizations to establish tercile boundaries. Here, and more generally, there will be need to focus on the choice of base-period for forecast presentation. The Sheen et al. results cover 1960-2014, but the terciles would not exactly correspond to this period, since runs were not made for all years in that period. This would need some discussion to arrive at a good operational compromise

Supported by:



Fund Manager:



for choice of base period, and for interpretation (given the terciles are calculated from de-trended data).

**ii) Establish and test strategy for de-trending of model results in real-time.** This may be tested on final few forecasts in Sheen et al. (say from 2008 onward) to check results are expected to be stable when the detrending is applied in real-time.

**iii) Some assessment of recent experimental real-time forecasts:**

<https://www.metoffice.gov.uk/research/climate/seasonal-to-decadal/long-range/decadal-fc>

This may take a number of forms, but seems sensible to at least take a look at these for context. May be best to generate tercile product for some of these past years for context (including testing detrending approach).

**iv) Establish preliminary methodology for physical diagnosis of the forecast.** (i.e. some assessment of what is driving the forecast rainfall anomalies). A prototype may develop diagnostic maps / summaries for (a) atmospheric stability anomalies, as associated with SST on interannual timescale in Sheen et al, (b) moisture flux anomalies (SST multi-year timescale in Sheen et al, (c) other major forcings operating during the forecast that stand out from those operating in the base period. This latter aspect may be the most difficult to handle. One option could be to initially ignore this issue, and just focus on the extent to which forecast anomalies may be attributed to (a) and (b). Another may be to just focus on “major other departures”, such as a major aerosol departure from the base period forcing and its possible role in the forecast rainfall anomalies.

#### *Practical Implementation Assessment*

**Extent to which the above is implementable now?** Yes, considered possible to launch now

**Timeline needed?** Could be fast-tracked to be ready for May/June 2019.

**Scenario for achieving the output:** technical consultant 20 days, oversee/applications consultant 2 days, other Met Office staff analysis / collaboration time.

**Product 2. Within the 2-5 year period risk of extreme years, back-to-back years etc.**

Supported by:



Fund Manager:



Considered a valuable add-on to the above. Novel, but valuable to have such analysis, given feedback at Sudan workshop. This option anticipates an obvious user concern on roll-out of the tercile product for years 2-5. Output: some key supporting diagnostics for the tercile 2-5 year product e.g. year 2-5 year dry tercile implies x% risk of a year below given threshold / wet tercile implies x% risk of year above given threshold etc.

#### *Practical Implementation Assessment*

**Extent to which is implementable now:** Yes, considered possible to launch now

**Time needed:** Initial assessment could be fast-tracked to be ready for May/June 2019

**Scenario for achieving the output:** technical consultant 5 days, other Met Office staff analysis / collaboration time (small).

#### **Product 3. Multi-model forecasts**

Potentially 1, or 1+2 or 1+2+3 above may be repeated with a multi-model approach. This achieves the benefit of capturing issues of uncertainty that relate to using just one model for the forecast and produces a more robust product. However, there would be a number of issues to be resolved, making it likely a longer-term goal. Some of the questions include: access to other models to evaluate precipitation skill, access to other models for the fields to assess attribution of skill in historical runs and real-time products, how to combine the models – simple average not smart given it is known that some models systematically fail in the Sahel.

#### *Practical Implementation Assessment*

**Simplest output:** multi-model tercile forecast for Sahel regional index

**Extent to which implementable now?** No, needs assessment by UKMO / other model providers

**Time needed:** Likely time needed to check on access to data, develop methodology would be several months, then implement maybe a target of May 2020?

**Scenario for achieving output:** UKMO might be able to work through WMO-lead multi-year forecasting role to access fields, implementation potentially through use of technical consultant plus UKMO analysis / potentially small joint team with other model providers

#### **Product 4. Expression of forecast as simple Drought risk indices**

Supported by:

Fund Manager:





A fast-track option to generate diagnostics relating tercile rainfall forecasts to drought risk. This could be achievable with relatively small amount of diagnostic work, translating forecast to indices such as SPI, WRSI or other.

*Practical Implementation Assessment*

**Output:** Supporting key diagnostics to enable forecast to be interpreted in terms of drought risk

**Extent to which implementable now:** No, requires some discussion of forecast producer and drought community to arrive at methodology / choice of drought index.

**Time needed:** Could be set in motion with some initial discussion (consultant coordination) to arrive at work plan. Potentially implementable after a few months of discussion.

**Scenario for achieving output:** Initial discussion, then technical analysis, technical consultant 5 days, together with Met Office (small)

**Note:** There is also major project opportunity to couple with biophysical modelling, for which good literature establishing feasibility exists, and which may use the above drought index work as a baseline. Implementation would imply a multi-year project with appropriate modelling expertise (including land surface).

**Product 5. Recent Multi-year rainfall anomalies / trends for context.**

This would complement any experimental forecast product for the Sahel, by indicating the extent to which the forecast is consistent with or reverses recent trends. The timescale of comparison may be relatively short (say mean anomalies of the past 5 years relative to a previous period) or longer (say mean anomalies of the past 30 years, relative to previous 30 years) or linear trends over the last 30 years.

*Practical Implementation Assessment*

**Output:** Maps and/or statistics for the Sahel index

**Extent to which implementable now:** No, needs some discussion because it is a novel approach, but was requested at the Sudan workshop as natural companion with multi-year forecast, ideally to include some attribution for the recent anomalies / trends, although this makes the product more complex and may be best to not include at this point. Other challenge to implementation is choice of dataset.

**Time needed:** May initiate discussions and aim to target prototype products for May 2020?

Supported by:



Fund Manager:





**Scenario for achieving output:** Technical consultant (5 days) with UKMO to make connecting bridge to the forecast.

**Product 6. Regional forecasts through regional collaboration**

(includes capacity building component) – initial focus northeastern part of ICPAC for JJAS. Longer-term engagement to evaluate products for other seasons / ICPAC areas.

a) For Boreal Summer in northeastern area of ICPAC domain (primarily Sudan, Ethiopia, Eritrea)

*Practical Implementation Assessment*

**Output:** Experimental forecast product

**Extent to which implementable now:** No, needs discussion with ICPAC and methodology established. One challenge is whether this would need to move beyond existing East Sahel index – probably would need some index definition work in collaboration with ICPAC.

**Time needed:** 1-2+ years

**Scenario to deliver:** Needs implementation team to be constructed.

b) For other seasons in ICPAC domain

*Practical Implementation Assessment*

**Output:** Experimental forecast product

**Extent to which implementable now:** No, needs model evaluation, and discussion with UKMO / ICPAC and methodology established. Again, a challenge is whether need to stay with index forecasting, or whether to view moving to map product. Probably would need some index definition work in collaboration with ICPAC.

**Time needed:** 2+ years

**Scenario to deliver:** Needs implementation team to be constructed.

Supported by:



Fund Manager:



*The following Products 7 – 11 cover discussion of applications options, building from discussions at the workshop in Sudan. All of these options may be considered to have a capacity building component with the Sudanese Meteorological Authority (SMA), including; empowering understanding of the new forecast capabilities, evaluation of predictability using national datasets, and exploring product development. Estimates of consultant time has for now focused on technical implementation, and may need some adjustment depending on approaches to / involvement with capacity building dimensions. Product 12 has broader regional perspective, and implies regional capacity building.*

### **Product 7. Multi-year information for safety nets and guidance for investment.**

These were of interest to WFP, UNEP and DFID and may represent an effective way to make quick progress exploring application of the multi-year information in Sudan, while at the same time, gaining more knowledge on the nature of the information through validation in collaboration with SMA.

#### *Practical Implementation Assessment*

**Output:** Assessment of 2-5 year rainfall season skill over Sahel latitudes of Sudan; assess product details that are required by stakeholders; capacity building in SMA to provide the guidance (potentially through collaboration); experimental product(s).

**Extent to which implementable now:** Likely yes, pending further confirmation of stakeholders. Framework is well established by the workshop.

**Time needed:** Potentially implementable after short additional stakeholder discussion, may target to run for 1.5 years, with informal discussion of available forecast information in 2019, and more formal experimental product construction in early 2020.

**Scenario for achieving output:** Consultants, climate technical 10 days, applications/oversee 10 days, Discussions of consultants with stakeholders in Sudan, input of Met Office and SMA.

### **Product 8. Longer-lead Early-warning for agriculture for upcoming season**

WFP recognized the longer-lead time of the seasonal forecast may be of substantial benefit in their early season assessments. This could be explored with the existing

Supported by:



Fund Manager:



model runs. A risk is the relatively lower-skill of the longer-lead information. One benefit is to address validation over Sudan of the model runs using more observations, addressing whether the interannual skill of  $r=0.33$  is lower due to poor observed gridded data.

#### *Practical Implementation Assessment*

**Output:** Assessment of 1 year ahead rainfall season skill over Sahel latitudes of Sudan; product details that are required by stakeholders; capacity building in SMA to provide the guidance (potentially through collaboration); experimental product(s).

**Extent to which implementable now:** Likely yes, pending further confirmation of stakeholders. Framework is well established by the workshop.

**Time needed:** Potentially implementable after short additional stakeholder discussion. Could focus first on multi-year opportunity and then turn to this possibility, e.g. to have some thinking ready for interpretation of information in early 2020 for 2020 rainy season.

**Scenario for achieving output:** Consultants, climate technical 10 days, applications/oversee 5 days, Discussions of consultants with stakeholders in Sudan, input of Met Office and SMA.

The following are also potentially quick-start, but are less-clearly framed from the workshop and would likely need more scoping.

#### **Product 9. Other relatively quick start applications of forecast products, but requiring some scoping**

(scoping (1 day consultant input per option) for any of these could be added as part of the more targeted initiatives above)

(i) Winter season temperature and wind speed applications. Of these three options (i-iii), this is the most clearly implementable with expected advances in the short-term. Once initial consultant scoping is undertaken to decide on the target forecast information, then the development of predictability assessment and pilot products could be achieved relatively quickly and with modest consultant and other collaborator time input (to be determined once the scoping is undertaken).

Supported by:



Fund Manager:



- (ii) Water harvesting (rainwater harvesting research center) and other water availability (Wadi)
- (ii) FAO project on Fire monitoring/prediction

### **Product 10. Applications with Reservoir Management**

Enhanced reservoir management (for flood, energy and irrigation purposes) described by the water group, which could broaden beyond Sudan. The discussion identified good potential and high demand for the existing short-lead seasonal forecast to be explored further in this context, in addition to possible enhanced management through the newly emerging longer-lead forecast and multi-year forecast products.

Assessment: This would need the mapping of stakeholders and construction of implementation team.

### **Product 11. Applications with index Insurance**

From the safety nets discussion group, the potential of index insurance may be highlighted for future use of forecasts, although the methodology for how to use the forecast information may be a generic issue for such index insurance initiatives.

Assessment: Needs further scoping and exploration of potential other initiatives to connect with. Specific questions to consider include whether there are projects looking generically at implications of multi-year forecasts for the many index insurance initiatives that are now underway, and for which, the progress made in the Sudan workshop may lead to useful case studies?

### **Product 12. Scope potential for regional applications of Products 7 – 11**

Assessment: Needs further scoping and exploration of potential interest and priorities of relevant regional organisations.

Supported by:



Fund Manager:



## **Note: Comments on the Day Estimates for Achieving the Products**

Assuming the existing consultants (or ones with the similar knowledge and skills), the scenarios give an initial approximate assessment of consultant time needed. This may need some modest adjusting once the implementation and collaboration modes are established.

A qualitative indication of feasibility and overall time needed to achieve some of the products is offered in the scenarios, but no attempt to assess specific work-time needs of collaborators is attempted at this stage (e.g. SMA).

Some revision of consultant time needed may also result if specific combinations of options are selected for implementation – for example, if the generic products are not acted upon, the technical consultant time needed for the applications options (e.g. products 7 and 8) would increase, since those actions are implemented more efficient by processing data for the generic products in parallel.

Supported by:



Fund Manager:

