WCRP Global Drought Information System (GDIS) Workshop

August 2012

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ESA/ESRIN, Frascati, Italy

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I. Introduction

Among the key recommendations of a recent WCRP Workshop on Drought Predictability and Prediction in a Changing Climate, was the development of an experimental global drought information system (GDIS).

The timeliness of such an effort is evidenced by the wide array of relevant ongoing national and international (as well as regional and continental-scale) efforts to provide drought information, including the US[1] and North American[2] drought monitors, the European Drought Observatory[3], and various integrating activities such as the Group on Earth Observations (GEO) and the Global Drought Portal (GDP).[4]

In addition to the evolving drought information systems, there are a number of other emerging capabilities that could become important components of any GDIS. These include regional and global experimental hydrological forecasting capabilities and a number of national and international near real time global multi-model seasonal (short term climate) forecasting capabilities. Also relevant are two additional action items that arose from the WCRP drought workshop, namely to develop a drought catalogue, and to conduct coordinated research on specific high-profile case studies of past droughts.

In part as a response to the above recommendations, this workshop focused on the needs and the steps necessary for the development of an experimental GDIS. The workshop involved about 90 participants from more than 25 countries to discuss our understanding of drought worldwide, our current capabilities and needs for drought information, and how to move forward on the development of an experimental GDIS. The proceedings consisted of both oral (Appendix 1) and poster (Appendix 2) presentations.

The organizers greatly appreciate the support and/or sponsorship provided by the World Climate Research Programme (WCRP), the European Space Agency's centre for Earth observation (ESA-ESRIN), NASA, the National Integrated Drought Information System (NIDIS), NSF, NOAA, and GEO, with very special thanks to Ghassem Assrar (WCRP), Roger Pulwarty (NIDIS), Jared Entin (NASA), Mike Patterson (US CLIVAR), and Eric DeWeaver (NSF).

In the following we summarize the workshop discussions, the recommendations and action items, and outline a roadmap for moving forward.

[1] See: http://droughtmonitor.unl.edu/.
[2] See: http://www.ncdc.noaa.gov/temp-and-precip/drought/nadm/.
[3] See: http://desert.jrc.ec.europa.eu/action/php/index.php?action=view&id=201.
[4] See: http://www.drought.gov/portal/server.pt/community/global_drought.

II. Summary of Discussions

The discussions covering the first two days focused on gaps in our understanding and the mismatch between current capabilities and user needs.

Some key gaps in understanding included: the nature of drought over much of central Asia and other cold regions (e.g. Canada, the Arctic, and other permafrost regions); the footprint of drought linked to climate change; the nonstationarity of the relationships involving drought drivers; linking drought severity with particular impacts; and the lack of linearity in the strength of the forcing and the response. The importance (and lack of skill) of predicting the intensity, duration, and specific impacts of drought was emphasized, as well as the general lack of information regarding the prediction skill and predictability of drought at various time scales, including decadal. While it was noted that currently most of the skill in drought forecasting comes from knowledge of the land surface initial conditions and ENSO[5] sea surface temperature, there is potential for greater use of climate forecast information as subseasonal and seasonal forecasts improve (also at weekly time scales to exploit predictability inherent in weather forecasts).

The discussion on current capabilities centered on identifying the mismatch between capabilities and needs. An important issue concerns the connection between regional systems and regional drought information, and the type of information provided by a global drought information system. How do we insure consistency and how do we allow the regional information to inform the GDIS? Examples include the need for defining thresholds of drought indices that can serve to identify (trigger) the occurrence of drought in a particular region. These should be determined at the regional/local level to account for different socio-economics, policy structures, and cultural factors. A global system can and should focus on the indicators, not the triggers, so that national policies can be set.

The need for extension services, and other stakeholder partnerships and networks, to get stakeholder feedback and teach users how to use the information, was also discussed. A GDIS needs to be mindful of the wide array of different types of users. For example, what kind of GDIS can reach the nomadic populations? They are people most affected by drought in the central African region. It was noted that where there is a cellular phone network, then there are opportunities to disseminate information and collect feedback.

It was suggested that impact-related indicators are related to vulnerability, and that vulnerability should be built into the system. This leads to the issue of how to identify regional vulnerability – presumably through regional networks that are already developing vulnerability measures. The GDIS should use indicators that are on a common ground globally, and do not rely on local characteristics; they should be able to identify hotspots around the globe.

The afternoon of the third day was devoted to defining the steps necessary for developing an experimental GDIS. It was suggested to start with what might be an

[5] El Niño-Southern Oscillation

imperfect system, and to evolve it based on user/stakeholder feedback. The idea is to build on existing systems in a way that the combined, integrated system is much better than the sum of the individual parts. It is also important to clearly communicate what is research and what is operational in order to avoid inconsistencies in the products and confusion in the community. It was stressed, however, that a GDIS should be experimental to begin with and should provide tools that regions/countries/institutions can understand and use to enhance their own decision-making capability. The pilot phase should be geared at informing user groups what information is available and gauge if and how they want to use it. Pilots, or prototypes, allow for a flexible and iterative testing process.

The top-level view of the GDIS is provided in Figure 1. It consists of a drought catalogue containing information on drought mechanisms and characteristics throughout the world, a real time monitoring and prediction system, and a research component focused (among other drought research and development) on case studies with strong ties to user needs. In the next section we outline the recommendations, action items, and timeline for moving forward on the development of such a system.

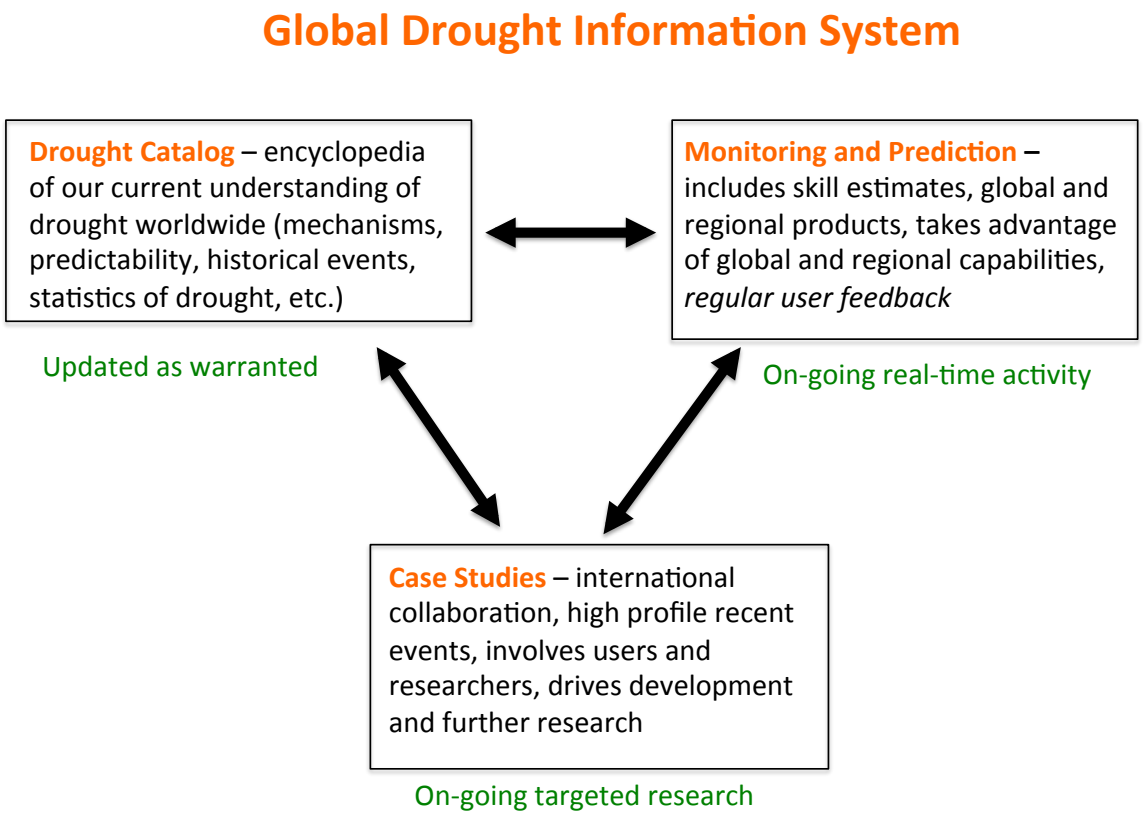

Figure 1: Overview of the components of the proposed Global Drought Information System

III. Recommendations/Action Items

The following outlines the recommendation for the initial implementation of the three components of the GDIS, and other related recommendations.

1a) Prediction and monitoring: It was recommended to implement the initial global system within the NIDIS Global Drought Portal (GDP) and at the NOAA/Climate Prediction Center (CPC), with pilot studies employing national/regional products focused on comparisons and validation. The implementation plan is outlined in Appendix 3. It was recommended that a follow-on user workshop be held once the initial system is in place.

1b) Drought Catalogue: It was recommended to use the presentations/posters as a starting point for a drought catalogue by placing them on the web at WCRP and the GDP. It was further recommended to organize a special collection on "Drought characterization and mechanisms world-wide", inviting key authors to ensure full coverage of the world. Also in a related recommendation, to organize a drought atlas (with links to data) based on reanalyses and observation, with regional input for evaluation/validation. This will require a full time person to help develop the catalogue and atlas (e.g. an early career scientist with funding sources to be determined)

1c) Case studies and other drought research: It was recommended to develop national and international collaborations to study the mechanisms and predictability of high profile drought and heat wave events, with strong links to the affected users. It was further recommended to pursue relevant international calls for proposals (e.g. Belmont Forum), and national programmes (e.g. NOAA, NASA and NSF in the US). A follow-on user workshop should be held, perhaps in conjunction with the initial evaluation of the experimental monitoring and prediction system (see above).

Other recommendations:

2) To further engage the Space Agencies (e.g. ESA and NASA), to help define/refine the needs for and uses of space-based observations for drought monitoring and prediction, especially within the context of the GDIS. What are the key parameters that need to be monitored? It was suggested that this be linked to relevant case study research efforts.

3) To carry out a coordinated assessment of predictability based on coupled models (perfect model), with a focus on the predictability of the hydrological cycle. This could include implications for land model predictions (e.g. initialize perfect model with only land initial conditions), and comparisons with observationally-based estimates of potential predictability. This is viewed as an essential effort for defining a baseline by which to judge improvements in predictive skill, and defining priorities for modeling, drought research and observational needs.

IV. Roadmap and Time Table

1) Initial experimental global monitoring and prediction system in place at NOAA/CPC by June of 2013 (see Appendix 3), with identified regional pilots for validation and to provide feedback on usefulness. Engage users as early as possible but ensure that by June 2013 we start up regular (monthly) interactions between users and providers.
2) Journal of Climate Drought Special collection (lead by Ron Stewart): due date for all articles December 2012, and expected publication of all articles by December 2013. An early career scientist will facilitate the development, tailoring, and summarizing of this information into the GDP, with links to publications, and in a way that it can be easily updated as the science advances. This should be completed by August 2013.
3) Build up global drought atlas within the GDP (build on Global Modeling and Assimilation Office, GMAO, effort), to be carried out by an early career scientist. Initial version completed by late 2013.
4) Case studies research, following a time frame as dictated by funding opportunities. Need to consider how to ensure these stay engaged with the GDIS evolution.
5) Follow-on workshop with users (requirements/initial evaluation of GDIS, facilitate cases studies activities) by Spring/Summer 2013.
6) Organize coordinated predictability assessment within WCRP: define plan by December 2012, engage relevant organizations, with goal of having initial results by December 2013.
7) Develop research proposals to further entrain ESA and NASA into GDIS evolution.
8) Write journal article summarizing the workshop and outlining the plans for the GDIS (draft by September 2012), authored by organizing committee and a few others (S. Schubert).

Appendix 1: Agenda

Wednesday April 11

8:30 – 9:00 Registration

Introduction

Chair: Pierre-Philippe Mathieu (Rapporteur: Catherine Beswick)

09:00 Maurice Borgeaud: WCRP Global Drought Information System Workshop

9:20 Siegfried Schubert: Overview of Workshop and Goals

9:40 Roger Pulwarty: Overview of GDIS activities and needs

Causes of Drought by Region (Summaries – time scales, mechanisms, etc.)

10:00 Brad Lyon: Advances in our Understanding of Drought in North and Central America

10:20 Sonia Seneviratne: Drought in Europe

10:40 Break

11:10 Belen Rodriguez-Fonseca and Roberto Mechoso: Drought in Africa

11:30 Wenju Cai: Drought in Australasia

11:50 Matt Barlow: Drought in Western Asia and the Middle East

12:10 Lixia Zhang and Tianun Zhou: Drought in Monsoonal East Asia

12:30 Hugo Berbery: Modeling Droughts in Southern South America

12:50 Short break

Case studies (mechanisms and predictability)

Chair: Michel Verstraete (Rapporteurs: Will Pozzi, Catherine Beswick)

1:05 Albert Van Dijk: Australia's Millennium Drought and the resulting development of a water information system

1:25 Christa Peters-Lidard, David Mocko, Sujay Kumar, Mike Ek, Youlong Xia, Jiarui Dong: Drought Monitoring for 3 North American Case Studies Based on the North American Land Data Assimilation System.

1:45 Lunch

2:45 Johan Malherbe and Willem Landman: Recent droughts in Africa:the Limpopo basin

3:05 Alice Grimm: A Recent South American Drought and Some Thoughts on Droughts and Interdecadal Variability

3:25 Ricardo Trigo: The 2010 Russian heat wave

3:45 Martin Beniston: The 2003 European Heat Wave

4:05 Break and discussion (Siegfried Schubert, Wenju Cai, Sonia Seneviratne)

6:00 Posters with refreshments

Thursday April 12

Drought Information Service Providers

Chair: Will Pozzi (Rapporteurs: Michel Verstraete, Pierre-Philippe Mathieu, Catherine Beswick)

9:00 Michael Hayes: Overview

9:20 Robert Stefanski: "Drought Management and Policies: Status of WMO Drought Initiations."

9:40 Douglas Cripe: GEO: International Framework for GDIS

10:00 Micha Werner, Sophie Vermooten, Juergen Vogt, and Ad de Roo:
DEWFORA: Forecasting droughts in Africa and linking to the EDO drought monitoring approach.

10:20 Break

10:50 Anna V. Mescherskaya: Historical drought catalogue for the former USSR agriculture regions

11:10 Cunjie Zhang: Drought Monitoring, Forecasting and Impacts Assessment in China.

11:30 Dasarath (Jaya) Jayasuriya: (BoM Water Program) Drought Monitoring and Forecasting in Australia Douglas Cripe: GEO: International Framework for GDIS

11:50 Dennis Lettenmaier: Hydrological forcasting

12:10 Short break

12:25 Gustavo Goncalves: South American drought monitoring and reconstruction of the drought record in South America

12:45 Abdou Ali: Drought Monitoring and Forecasting at AGHYMET, West Africa region

1:05 Franco Molteni: Rainfall predictions with the ECMWF monthly and seasonal forecast systems

1:25 Jared Entin and Deborah Belvedere: NASA Contributions to Global Drought Information

1:45 Lunch

2:45 Kingtse Mo: NOAA/NCEP/CPC Drought outlooks

3:05 Eric Wood: Experimental Hydrological Monitoring and Forecasting with a focus on the US and Africa

3:25 Jin Huang: Global MME forecasts – US, ECMWF, APCC

3:45 Break

User Needs and Capabilities (Regional and larger scales)

Chair: Douglas Cripe (Rapporteurs: Kingtse Mo, Catherine Beswick)

4:15 Liliana Nunez: Monitoring drought in Argentina

4:35 Jinlong Fan: Dought monitoring with remote sensing

4:55 Michel Verstraete: The European Drought Observatory (EDO)

5:15 Gideon Galu: FEWSNET agricultural drought domain and monitoring technology: quantifying lead time requirements

5:35 Posters

7:30 Group Dinner (Don Wilhite is the guest speaker: Managing Drought in a Changing Climate: Future Prospects) - at Grand Hotel Villa Fiorio – Grottaferrata (non-hosted)

Friday April 13

User Needs and Capabilities (Regional and larger scales) (cont.)

9:00 Margaret Nicholson: assessing drought vulnerability to agricultural and social sectors

9:20 Wu Bingfang: Drought Monitoring Information System for China and its Application

9:40 Oscar Rojas and Felix Remboud: FAO/MARS Agricultural Monitoring

10:10 Break

10:40 Ben Lloyd-Hughes: Global Drought impacts upon the business community

10:55 Discussion (Michael Hayes, Cunjie Zhang, Margaret Nicholson)

Developing an Experimental GDIS

Chair: Michael Hayes (Rapporteurs: Siegfried Schubert, Catherine Beswick)

11:50 Will Pozzi: Elements of an Experimental Global Drought Information System

12:25 Richard Heim/Mike Brewer: Global Drought Monitor web portal

12:40 Rogier Westerhoff and the GLOWASIS Consortium: GLOWASIS - A collaborative project for pre-validation of a GMES Global Water Scarcity Information Service

12:55 Discussion, panel (Kingtse Mo, Will Pozzi, Michael Hayes, Doug Cripe, Franco Molteni, Robert Stefanski)

1:50 Lunch

2:50 Vikram Mehta: A coordinated case study approach – Overview and a prototype system

3:20 Annarita Mariotti: NOAA drought task force: an example of coordinated research on case studies

3:35 Ron Stewart: drought characterization/catalogue and links to case studies

3:50 Discussion, panel (Siegfried Schubert, Michel Verstraete, Pierre-Philippe Mathieu, Vikram Mehta, Ron Stewart)

5:00 Wrap up (Siegfried Schubert and Pierre-Philippe Mathieu)

5:30 Adjourn

Appendix 2: List of Posters

Some posters are available for download at:
http://www.clivar.org/organization/extremes/activities/292/posters

Day 1: Wednesday *6:00pm Posters with refreshments* *Big Hall (Building 14)*

Causes of Drought by Region

1 Suraj Pandey, P K Joshi: *Modeling drought prediction for agricultural growth in the Indo-gangetic plains of India under climate change scenario.*

2 Yaohui Li, Liang Zhang: *Using a land surface model monitoring drought in China.*

3 Charles Ichoku and Luke Ellison: *Researching the link between biomass burning and drought across the Northern sub-Saharan African Savanna/Sahel belt.*

4 Sumant Nigam, Alfredo Ruiz-Barradas, Bin Guan, Yongjing Zhao: *Key role of the Atlantic Multidecadal Oscillation in 20th Century drought and wet periods over the Great Plains*.

5 Teresa Losada, R. Suárez-Moreno, E. Mohino, B. Rodríguez-Fonseca: *Non stationary impacts of the tropical oceans of the West African Monsoon. Predictability implications*.

Case studies

1 Valeriy Khokhlov, Natalia Yermolenko, Andrey Ivanov: *Spatiotemporal features of droughts in Ukraine under climate change.*

2 Sahana Bose: *Assessing drought vulnerability in Gangetic Bengal of India, its impact on agriculture and rural masses*.

3 Lincoln Alves, Jose A. Marengo, Iracema Cavalcanti, Guillermo O. Obregón: *Statistical analysis of extreme events in long-time series from Amazon Basin*.

4 Joris Timmermans, M. Gökmen, U. Eden, M. Abou Ali, Z. Vekerdy and Z. Su: *Drought monitoring by remotely sensed products over North-East Africa.*

5 Patricia Ann Jaranilla-Sanchez, Lei Wang, Katsunori Tamagawa, Izumi Hasegawa, Hiroki Yamamoto and Toshio Koike: *Drought forecasting with SPAM in Pampanga River Basin, Philippines.*

6 Nasab Alrawashdeh, Sawsan Attla Al Oran and Jawad Albakri: *Effect of climate change on the spatial distribution of plant biodiversity in Wadi Shuieb area/Jordan.*

7 Ricardo Trigo, Célia M. Gouveia, David Barriopedro: *The intense 2007-2009 drought in the Fertile Crescent: Impacts and associated atmospheric circulation.*

Day 2 Thursday *5:35pm – Posters* *Big Hall (Building 14)*

Drought Information Service Providers

1 Gabriel Diaz, Ignacio Sánchez-Cohen; Rafael A. Guajardo-Panes; Ana L. Del Ángel-Pérez; Ariel Ruíz-Corral; Guillermo Medina García, Danie I.*: Mapping of the aridity index and its population distribution in Mexico.*

2 Mark Svoboda, Michael J. Hayes and Brian Fuch: *Drought as a focal point for climate services: NDMC activities toward a Global Drought Early Warning and Information System.*

3 Xiangming Xiao, Pavel Dorovskoy, Chandrashekhar Biradar and Eli Bridge*: Global geo-referenced field photo library.*

4 Ramona Magno, Pasqui Massimiliano, Guarnieri Francesca, Gaetani Marco: *Use of the multiple time scales SPI index for monitoring and forecasting drought events over the Mediterranean Basin.*

5 David Fereday, Emily Hamilton, Graham Weedon, Alberto Arribas, Adam Scaife, Jeff Knight, Anna Maidens, Richard Graham: *Impact of soil moisture initialisation on extremes in the GloSea4 seasonal forecast system.*

6 Michael Ek, Youlong Xia and Jesse Meng: *Development and application of NCEP operational land data assimilation systems for drought.*

7 Amir AghaKouchak: *A drought GeoServer for real-time drought monitoring and analysis.*

8 Carolina Neri and Víctor Magaña: *Handling climate information and drought risk management: a proposal of Drought Early Warning System for México.*

9 Brian Fuchs: *A new national drought risk atlas for the United States from the National Drought Mitigation Center.*

10 *Arlindo Meque and Babatunde Abiodun: Improving seasonal forecast of drought over Southern Africa using non-hydrostatic global model with adaptive grid*

User Needs and Capabilities

1 Boris Orlowsky and S. I. Seneviratne: *Future droughts in Global Climate Models and adaptation strategies from regional present-day analogues.*

Appendix 3: Outline of Implementation Plan of the Experimental Real Time Global Drought Monitoring and Prediction System

The initial (phase 1) implementation of an experimental Global Drought Information System (GDIS) will build on existing systems that are already producing global products on a real time basis, or are capable of doing so. These include both global land data assimilation systems (GLDAS) and predictions from various hydroclimate forecast systems based on coupled climate models that are currently running at the major modeling centers and the ensemble streamflow prediction based on observations.

During phase 2, national/regional capabilities will be implemented as part of a small number of pilot studies focused on validation of the global products and other comparisons to assess consistencies between the various products. Rigorous and ongoing validation (as exemplified by the pilot projects) based on both in-situ and remotely sensed data will be critical for evolving the GDIS to where it is capable of providing global products that can satisfy the various demands for drought information throughout the world.

Once the experimental GIDIS system is set up and evaluated, the products will be distributed (phase 3) to users via the global drought portal. The drought portal will also serve as the interface for providing the synthesis of current drought development and for user feedback.

In the following we outline the basic components and products of the initial real time GDIS monitoring, prediction and validation efforts.

a) Global drought monitoring:

The global drought monitoring will include the following basic products:

1 Precipitation anomalies and drought indices (SPI).

2 Ensemble GLDAS products: soil moisture (SM) percentiles and anomalies, runoff products (SRI), snow water equivalent (SWE), and evapotranspiration (ET).

Data sources:

- Global Land Data Assimilation System (GLDAS), from the Environmental Modeling Center/National Centers for Environmental Prediction (EMC/NCEP), University of Washington, and Princeton systems.
- Global Modeling and Assimilation Office (GMAO) New-Merra SM from the reanalysis products.
- European Centre for Medium-Range Weather Forecasts (ECMWF) interim-reanalysis (need to confirm).

Work needed:

- Verification and intercomparison of various precipitation analyses and model based precipitation products.
- Examine the uncertainties of the GLDAS or SPI.
- Compare with regional products.

b) Global drought prediction

It is anticipated that the global drought predictions will include the following products:

1 US National Multi-Model Ensemble (NMME): SPI predictions.

2 University of Washington ensemble streamflow forecasts (ESP).

3 Hydroclimate prediction based on NMME (Princeton System: use MME to derive forcing to drive a land/hydrology model to produce SM, ET, SWE and runoff).

4 GMAO: SM, runoff, SWE from their seasonal coupled model forecasts.

5 ECMWF: see if they are able to produce SM and runoff prediction from their model.

6 APEC Climate Center (APCC): can they produce drought related products?

Work needed:

- Assess the basic skill of hydroclimate prediction- where the skill is high and where drought is just not predictable.
- Produce ESP products and verification.
- Compare with regional products.
- Compare ESP and MME_VIC and persistence for SM.

c) Regional Pilots

Products needed for near real time: It is not necessary to have the digital files in real time; image files will be fine. It will, however, be extremely helpful to have historical data for verification of global products (precipitation anomalies and SPI, soil moisture percentiles, streamflow anomalies, snow water equivalent). An agreement or MOU will be worked out in due course covering institutions that participate. Common indices and products will be agreed upon for regional products.

Regional pilots should include links to National Weather Services (NWS) in different countries and the World Meteorological Organisation (WMO).

Areas considered (will need to get commitments at institutional levels), also leverage International Research Institute (IRI) regional activities:

1 Australia (ABARES, CSIRO, BoM)

2 China (CMA Institute of Arid Meteorology, CMA National Climate Center, Institute of Atmospheric Physics)

3 South America (CPTEC, others)

4 Africa (DEWFORA, GIEWS, AGRHYMET, FEWSNET)

5 Europe (European Drought Observatory)

6 USA (link to NIDIS pilots, NOAA drought task force)

d) Benefits

- The GDIS will provide systematic and coherent products for monitoring and prediction of drought for the NIDIS international pilots.
- The GDIS will support the CPC international desk functions, global monsoon monitoring and prediction and international hazards.
- The GDIS will link and provide support to other international drought initiatives such as the Integrated Drought Management Programme and the WMO-led effort to encourage the development of National Drought Policies.
- The GDIS will provide a natural platform for communication on a variety of drought-related issues, much like the US Drought Monitor does within the United States.
- The GDIS will be able to provide critical information for non-governmental organizations (NGOs) working on food security issues.
- Regional inputs and GDIS products can be used to study the attribution and physical mechanisms that trigger, maintain and lead to the improvement of global drought conditions.
- Validation of the global systems in different climate regimes:
    - to assess the transferability of the system; and
    - to involve regional producers and users in drought verification.
- The GDIS will contribute to the global risk assessment of drought.