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The Drought Interest Group: Extreme events prediction from seasonal climate forecasting and distributed hydrological modeling simulations

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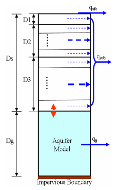
Abstract

Seasonal climate forecasting information can be utilized by water resource managers for planning activities reducing uncertainty with the additional predictive information. However, actual basin-scale use of this information is still limited due to limitations in accuracy and lead time. The aim of this study was to determine the predictability of extremely dry and wet conditions by looking into past extreme events and simulating at the basin-scale how well these extreme events can be reconstructed in the Pampanga river basin, Philippines. A 3-month seasonal climate forecast model derived from the MIROC-5 Ocean Atmosphere Global Circulation Models were used to drive the water and energy Budget-based Distributed Hydrological Model. Extremely dry and wet years in 1982-2000 were selected and integrated into the hydrological model WEB-DHM. The improved seasonal climate forecast system of the experimental season was constructed using the System for Prediction and Assimilation (SPAM) derived from the Ocean-Atmosphere global circulation model MIROC 5.0. This was used as input for the hydrometeorological parameters in the distributed hydrological model and incorporated to drive the basin simulations for the selected basin. Results showed that the SCFs were able to predict the severity of extreme events in the basin of up to 2 months. Accuracy in the prediction of extreme events such as floods and droughts are difficult. Basin-scale predictability of extreme events is important in local livelihoods and industries within the communities. Adaptation measures to address these extreme events were identified to minimize its negative impacts.

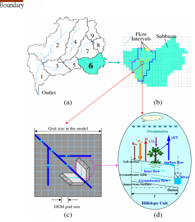
WEB-DHM

The distributed biosphere hydrological model, WEB-DHM (Wang et al., 2009a, 2009b, 2009c), enables continuous simulation of the exchanges of CO_2, water and energy during land-atmosphere interactions in the soil-vegetation-atmosphere transfer (SVAT) system, at the basin-scale.



Soil Model

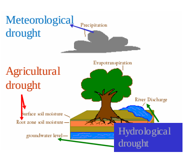
- Multi-layer soil;
- Lateral runoff;
- Groundwater;
- van Genuchten function.

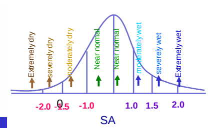


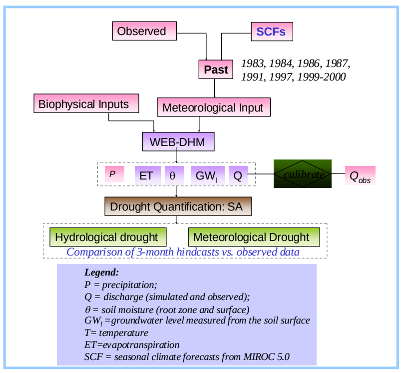
For this study:
large grid = 1 km
Smaller grid = 100 m

The Standard Anomaly Index (SA)

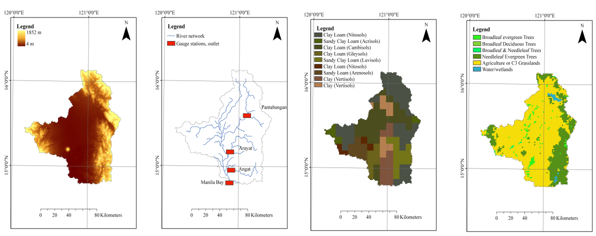
The SA fits a distribution pattern to the monthly hydrological parameter values from the inputs and outputs of the WEB-DHM simulations. This is then transformed to the normal distribution standardized by taking the anomaly (calculated as the difference of the parameter value from its climatic mean (long-term monthly mean)) and divided by the standard deviation of the transformed parameter.







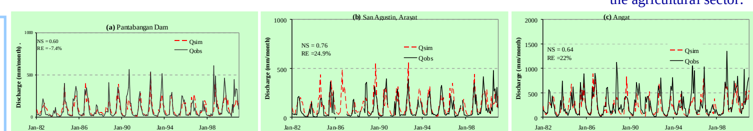
The Pampangga River Basin



The Pampanga River Basin supports around 97% of the domestic water requirements of Metro Manila. However, this basin is quite sensitive to the occurrence of extreme events such as floods and droughts.

It is also the rice bowl of the country hence, forecasting of extreme events is important in the agricultural sector.

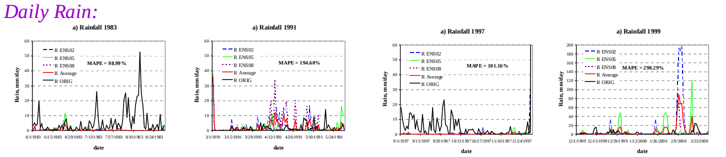
Monthly Flow Calibrations:



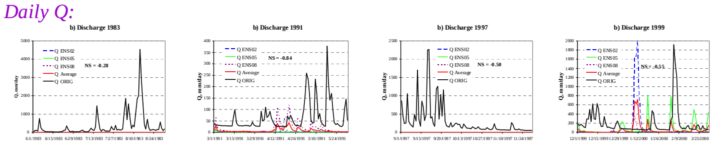
Droughts records for study period 1982-2000: 1982, 1983, 1987, 1989, 1990, 1991, 1992, 1993, 1994, 1995, 1997 and 1998.

Jun - Aug 1983 **Mar - May 1991** **Sep - Oct 1997** **Dec 1999 - Feb 2000**

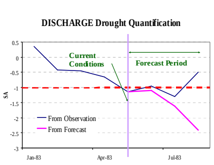
Daily Rain:



Daily Q:



El Niño **Mild to normal** **El Niño** **La Niña**



Months	1st		2nd		3rd	
Year	Observed	SFC	Observed	SCF	Observed	SCF
1983						
1991						
1997						
1999-2000						

ARROW Legends: red= drought; green=normal; blue=wet

e.g. increase towards drought conditions

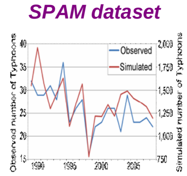
WEB-DHM details:

Static Inputs (biophysical)	Dynamic Inputs	Inputs and Outputs used for drought analysis
DEM: Aster GDEM 50m regridded to 1km x 1km	Meteorological: JRA-25: Japan Reanalysis datra	Rainfall: Meteorological Drought
Land use: USGS landuse map	Rainfall: APHRODITE-gridded rainfall dataset (MA)	Discharge: Hydrological drought
Soil: FAO Soil Map	LAI/FPAR: AVHRR, 16km x 16 km	

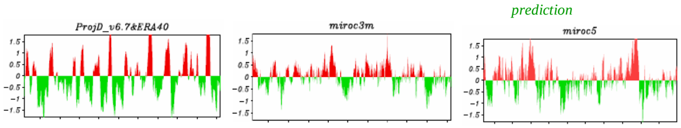
2-step forecast method used for developing SPAM datasets

STEP 1:	*STEP II:*
Coupled models resolution version of MIROC	*Coupled models: High resolution version of CCSR/NIES/FRCGC AGCM*
Atmosphere: horizontal 40T 42 (300 km lattice) perpendicular layers	*Atmosphere: The horizontal 56 T106 (110km lattice corresponding) perpendicular layers*
Ocean: 1.4 degrees and perpendicular 1.4 degree in longitude direction 0.5 degree (low latitudes) 44 layers in latitude direction	*Initial value: Re-analysis JRA-25 long-term average (temperature, zonal wind velocity and relative humidity)*
Assimilation technique: Three dimension variation method	*Forecast Ensemble: [Step1] with the Ensemble boundary value that is combined*

SPAM dataset



Improvements in typhoon prediction



ENSO is one of the main causes of abnormal weather generation in the world. In MIROC 3.2, the amplitude of ENSO was weak so in MIROC 4.2 and 5.0 (Watanabe, et al., 2010), the physical processes was improved (Chikara and Sugiyama, 2010) and it had come to reproduce by the same degree of the amplitude as the observation of the current year (Kim et al., 2011).

Figures were reproduced from Kimoto, et al. presentation 2010.

Dataset: MIROC (SPAM) by CCSR MIROC by NIES-JAMSTEC

Seasonal climate forecasting information can be used by decision-makers for profit-related or risk-related decisions by reducing uncertainty with the additional information it provides keeping in mind 1.) accuracy, 2.) relevance, and 3.) lead time. In this study, there is potential for SCF information to be used in reducing uncertainty in water resource management during droughts by utilizing SCF predictions and incorporating into WEB-DHM for more comprehensive basin-scale information that can be used by water resources managers in decision making especially on the first 2 months of the seasonal forecast.

Currently, MIROC 5 seasonal forecasts are available in 3-month time slices and is available as hindcasts. Efforts are being made for the assimilation of future predictions.

CONCLUSIONS AND CURRENT STATUS:

The information provided by meteorological (3-months SPAM) and hydrological (outputs of the hydrological model) data especially in basins strongly affected by El Niño, in predicting when the drought signals occur can be used in basin management. For the case of agricultural basins such as the Pampanga River basin, prior knowledge of droughts even for the first 2 months duirng the planting season can minimize crop losses by putting into place appropriate soft and hard structures that can supplement possible water deficiency during drought. However, We recognize that the SPAM forecast data will need further calibration to improve its quantitative accuracy.

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