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Regional Drought and Crop Yield Information System to enhance drought monitoring and forecasting in Lower Mekong region

Asian Disaster Preparedness Center/SERVIR-Mekong

WHAT IS SERVIR?



Partnership between USAID and NASA



Establishes long-term regional hubs to get geo-spatial information and tools to decision makers



Identifies, addresses and resolves data and information challenges



Focuses on climate change and implications on land use, agriculture, biodiversity, disasters, forests, health, water and weather



**AGRICULTURE AND
FOOD SECURITY**



**LAND COVER / LAND USE
AND ECOSYSTEMS**



WEATHER AND CLIMATE



**WATER RESOURCES AND
DISASTERS**



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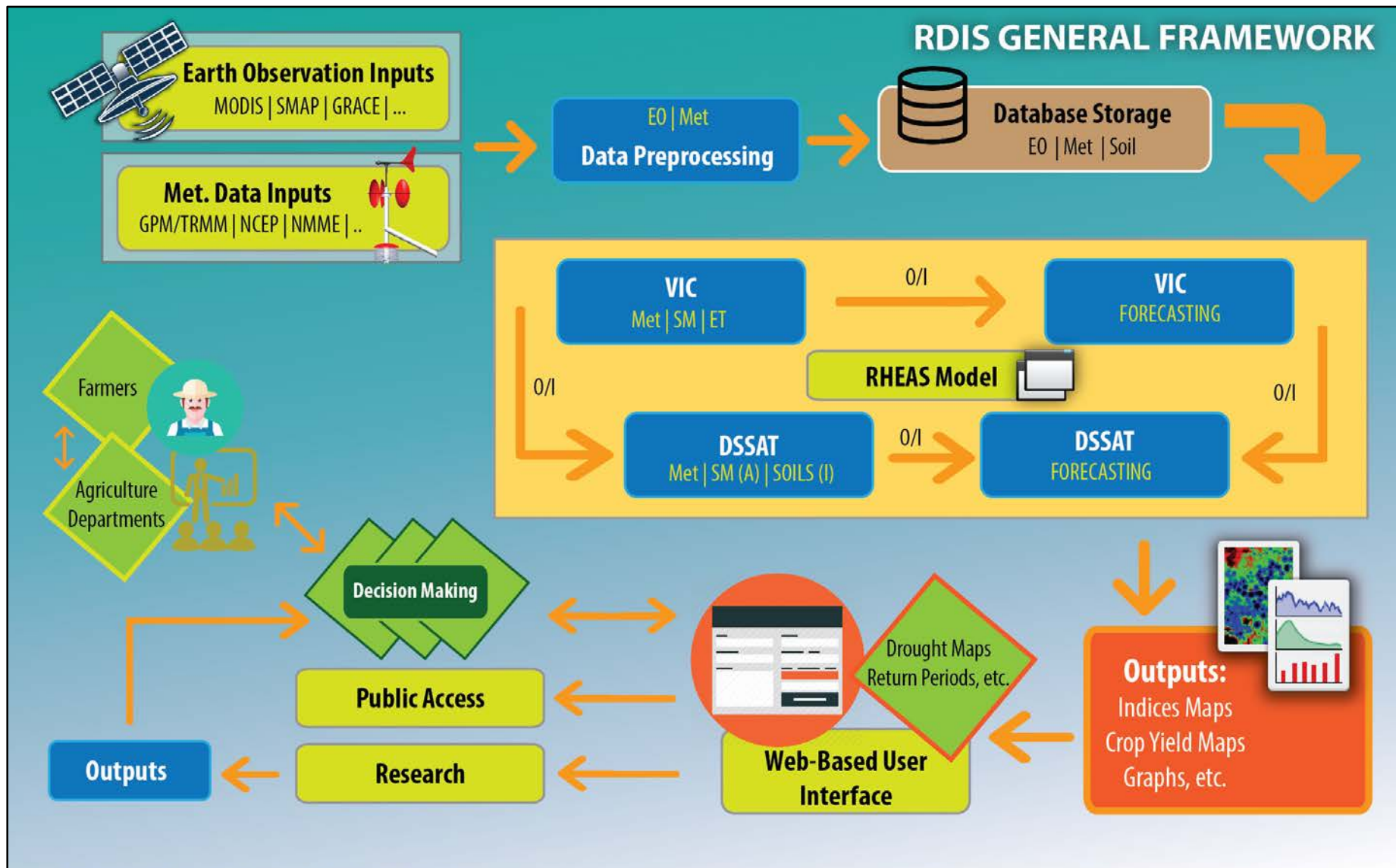
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Anticipated Results

- **Improved capacity of institutions** to use earth observation information and geospatial information technologies
- **Increased awareness by stakeholders** of geospatial data, tools, knowledge products, and services
- Increased provision of **user-tailored geospatial data, products, and tools** to inform decision making
- **ADPC strengthened** as a regional provider of geospatial data analyses, and capacity building services

Product Description of RDCYIS

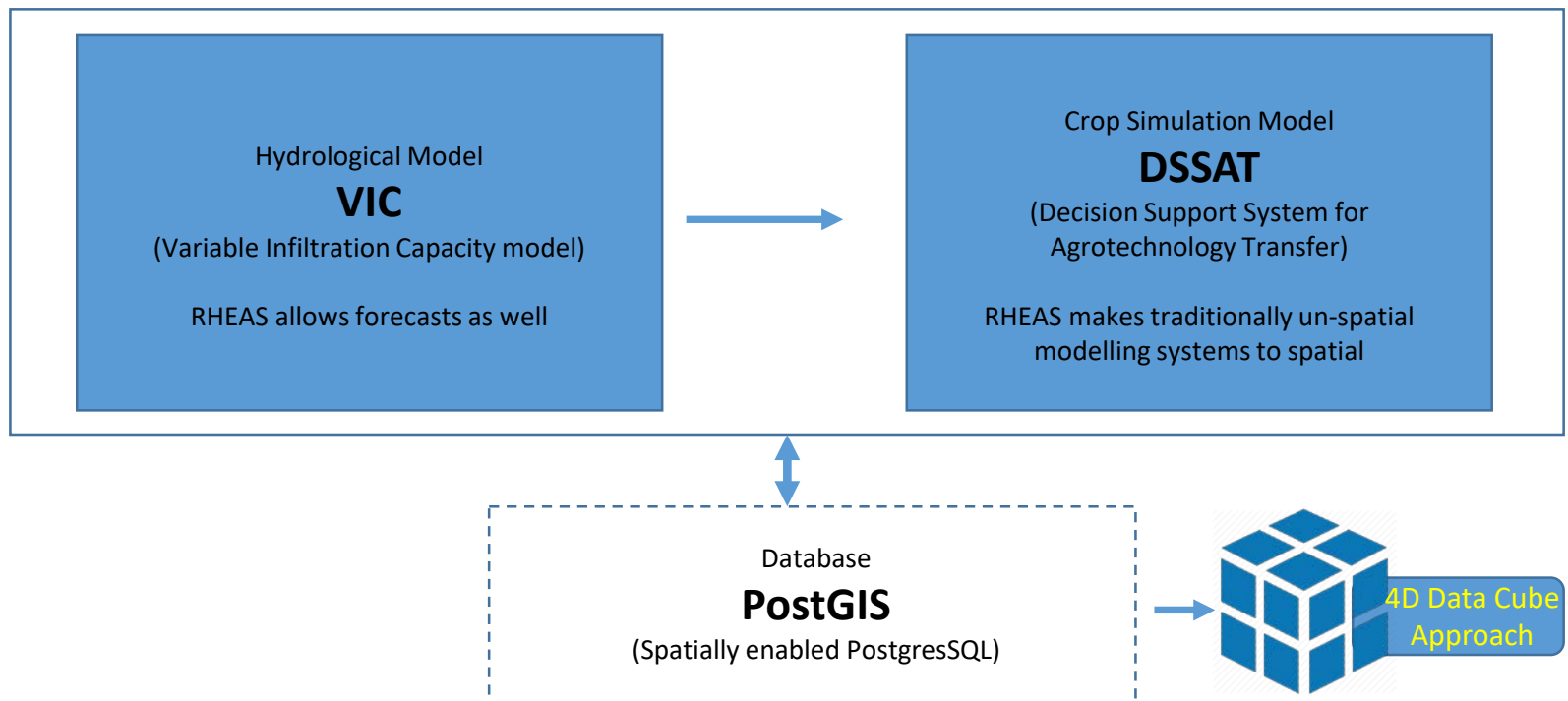
- The Regional Drought and Crop Yield Information System (RDCYIS) integrates drought monitoring and forecasting information as well as crop yield information that would allow decision makers in planning and preparedness during drought situations
- The system aims to help decision makers better prepare and respond towards droughts as well as helping the planning agencies and agricultural extension workers to disseminate drought related information to the farming communities creating awareness. As well as helping farming communities in considering various economic incentives, affordable coping strategies, and agricultural interventions coupled with social support services for the lower Mekong countries.
- Need assessments have been carried out based on country level consultations to identify end user needs. Consultations involved relevant government agencies and academic institutions



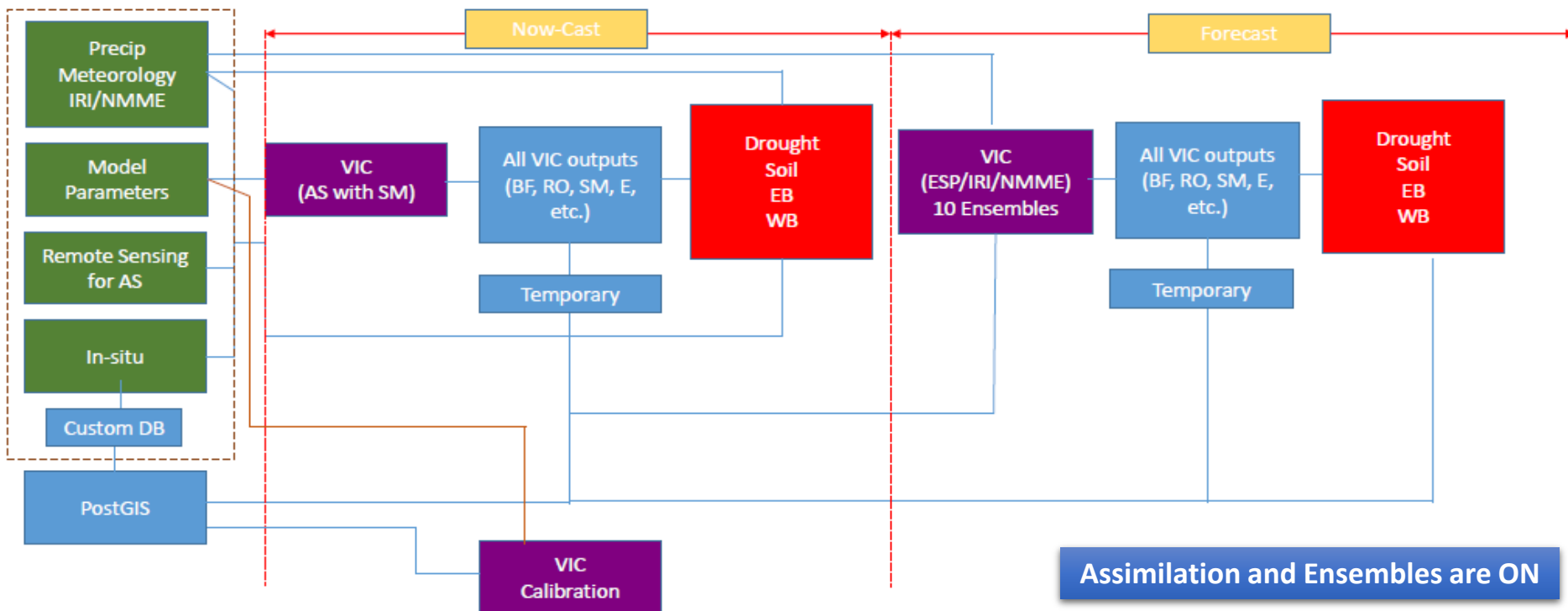
RHEAS

RHEAS (Regional Hydrologic Extremes Assessment System)

- A hydrologic now-cast and forecast framework
- Developed by NASA Jet Propulsion Laboratory



Nowcast & Forecast Configuration at SERVIR Mekong



AS: Assimilation, SM: Soil moisture; BF: Base Flow; RO: Runoff; E: Evaporation; EB: Energy Balance; WB: Water Balance; ESP: Ensemble Streamflow Prediction;

Data Inputs

Variable	Dataset	Tim. Cov.	Temp. Res	Spat. Res	Spatial Coverage	Table	Mode
Precipitation	CHIRPS	1981-	Daily	5km	Global	precip.chirps	IN
Precipitation	TRMM	1998-	Daily	0.25 °	Global	precip.trmm	IN
Precipitation	RFE2	2001-	Daily	0.10 °	Africa	precip.rfe2	IN
Precipitation	CMORPH	1998-	Daily	0.25 °	Global	precip.cmorph	IN
Precipitation	GPM	2014-	Daily	0.10 °	Global	precip.gpm	IN
Temp/Wind	NCEP	1981-	Daily	1.875 °	Global	*.ncep	IN
Temp/Wind	PRISM	1981-	Daily	4km	CONUS	*.prism	IN
Soil moisture	AMSR-E	2002-2011	Daily	0.25 °	Global	soilm.amsre	AS
Soil moisture	SMOS	2009-	Daily	~40km	Global	soilm.smos	AS
Soil moisture	SMAP	2015-	Daily	3/9km	Global	soilm.smap	AS
Evapotranspiration	MOD16	2000-	8 days	1km	Global	evap.modis	AS
Water storage	GRACE	2002-	Monthly	1.0 °	Global	twsg.grace	AS
Snow cover	MOD10	2001-	Daily	1km	Global	snow.mod10	AS
Snow cover	MODSCAG	2001-	Daily	1km	Global	snow.modscag	AS
Leaf Area Index	MCD15	2002-	8 days	1km	Global	lai.modis	AS
Meteorology	IRI	2000-	Monthly	2.5 °	Global	*.iri	FC
Meteorology	NMME	2000-	Daily	0.5 °	Global	*.nmme	FC

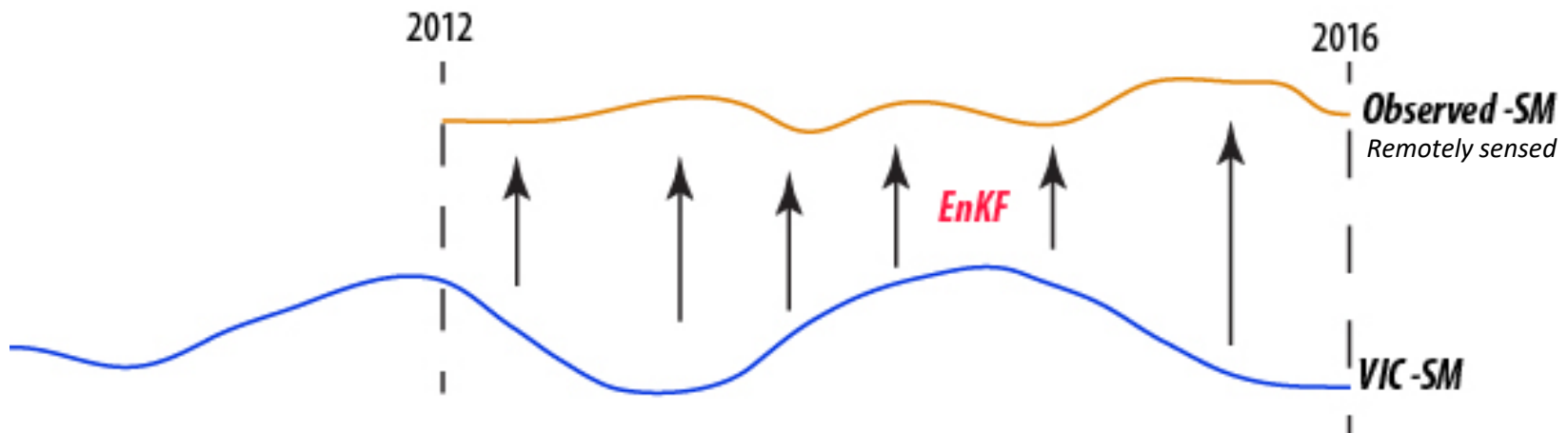
Data Inputs

Variable	Dataset	Tim. Cov.	Temp. Res	Spat. Res	Spatial Coverage	Table	Mode
Precipitation	CHIRPS	1981-	Daily	5km	Global	precip.chirps	IN
Temp/Wind	NCEP	1981-	Daily	1.875 °	Global	*.ncep	IN
Soil moisture	SMOS/SMAP	2009-	Daily	~40km	Global	soilm.smos	AS
Meteorology	NMME	2000-	Daily	0.5 °	Global	*.nmme	FC

Nowcast Approach: Assimilation

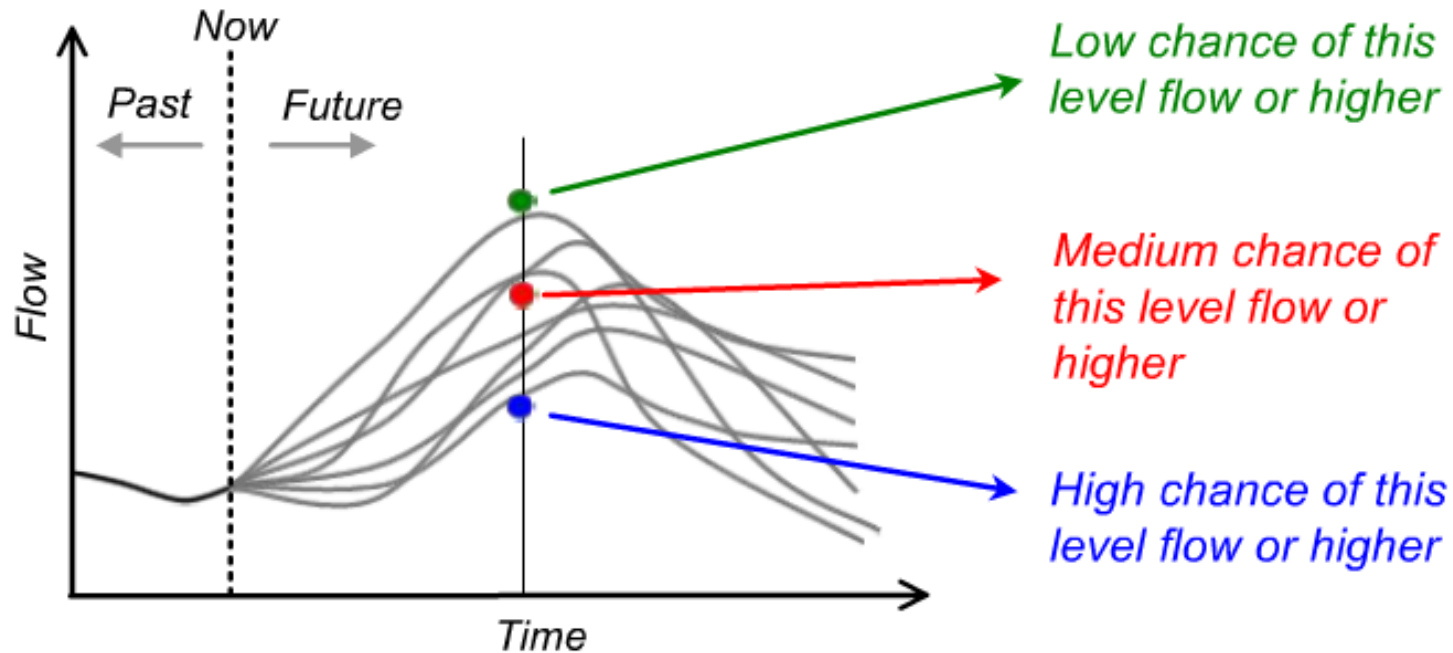
Assimilation is on

- **SMOS**
 - **SMAP**
 - **AMSRE**
- Sources for Observed SM



- **LAI**
 - **ET**
 - **SNOW**
- Options for SM

Nowcast/Forecast Approach: Ensemble Runs (10 runs)



Nowcast/Forecast Approach Currently Being Used

- **Nowcast**

- Continues run since 1981 in daily time scale

- **ESP/Seasonal Forecast (iri/nmme)**

- (Ensemble Streamflow Prediction approach that resamples the climatology)
- (resample climatologies based on the probabilities in IRI/NMME meteorological forcing)
- Forecast for 90 days with 10 ensembles

Nowcast and Forecast Outputs

Resolution of the output products is 25km

Drought:

SPI (1,3,6,12): Standardized Precipitation Index^M

SRI (1,3,6,12): Standardized Runoff Index^H

SMDI: Soil Moisture Deficit Index^A

Dry Spells: Number of dry spell events with at least 2-week duration^A

RZSM: Root Zone Soil Moisture^A

Drought Severity^A

Soil:

Soil temperature for each soil layer (3 layers: 0-10cm, 10-40cm and 40-100cm)

Soil total moisture content [mm] for each soil layer (3 layers: 0-10cm, 10-40cm and 40-100cm)



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Nowcast and Forecast Outputs

Resolution of the output products is 25km

Water Balance:

Baseflow

Runoff

Rainfall

Total net evaporation

Energy Balance:

Surface temperature

Net downward shortwave flux

Net downward longwave flux

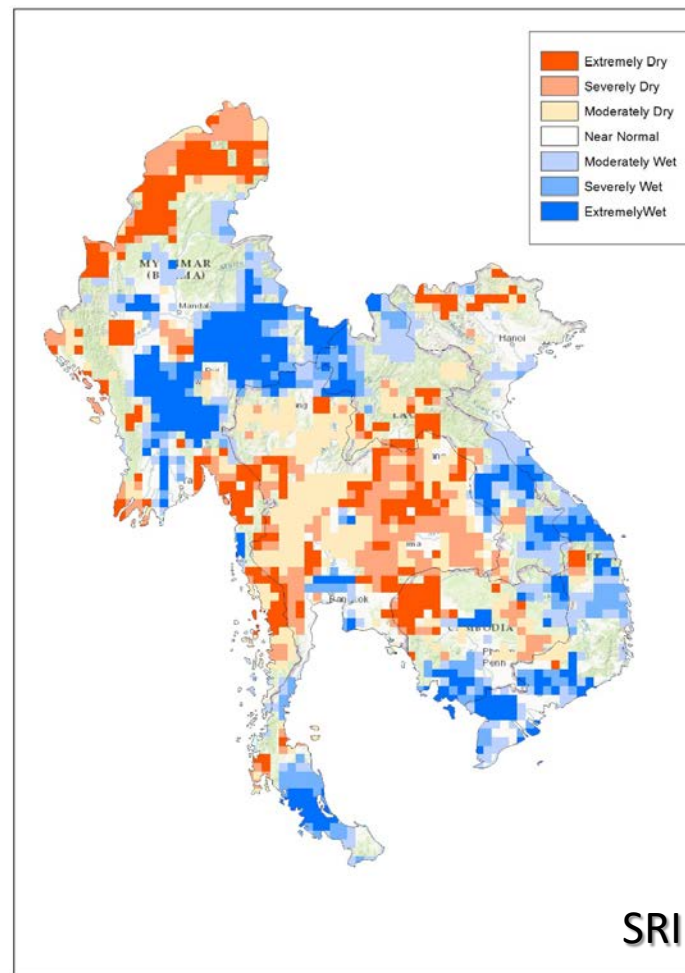
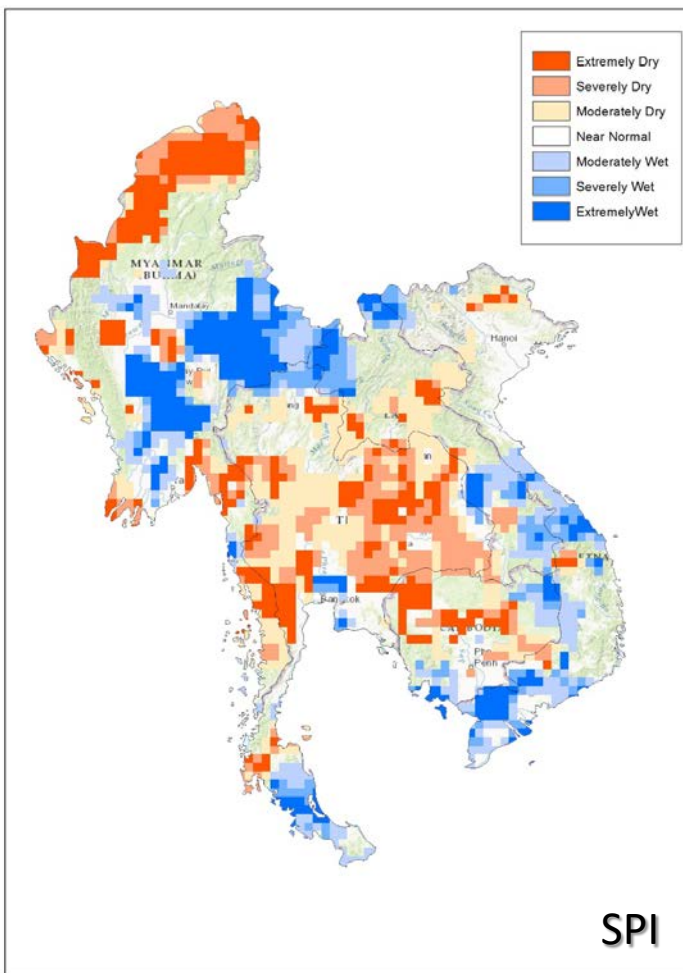
Net upward latent heat flux

Net upward sensible heat flux

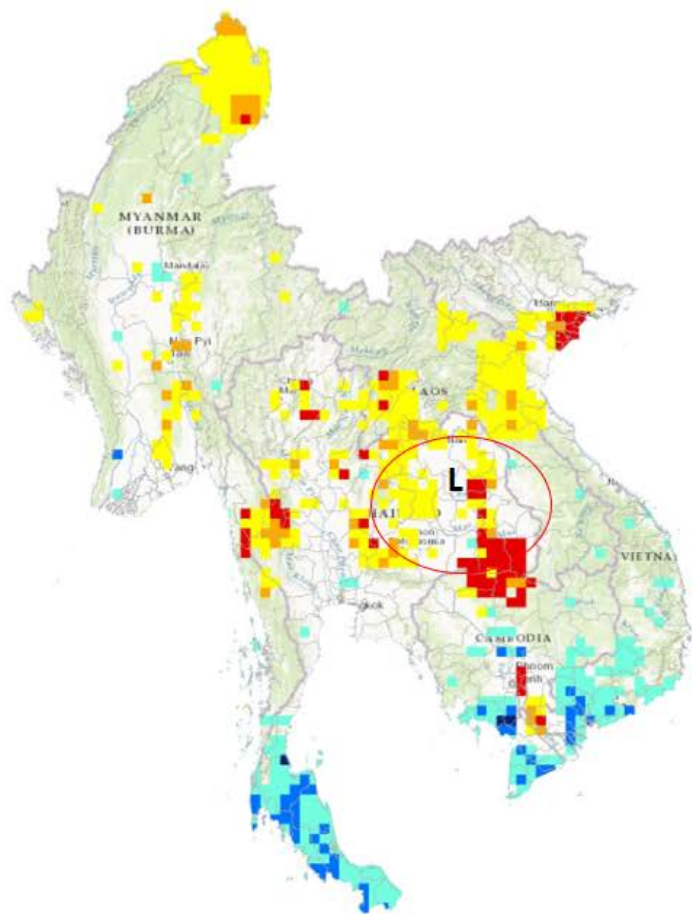
Net heat flux into ground

Drought Products (SPI and SRI)

Forecast : January 2017

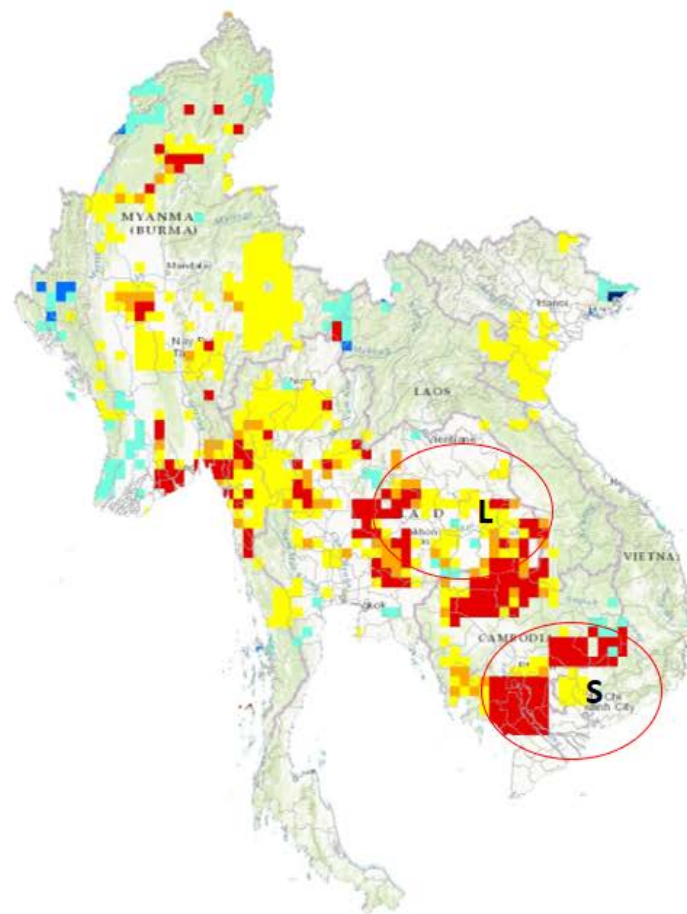


Ensemble Drought Forecasts (SPI and SRI)



S: Short term dryness
L: Long term dryness

Forecast situation in December 2016



Forecast situation during Dec – Feb 2017



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adpc

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REGIONAL DROUGHT AND CROP YIELD INFORMATION SYSTEM

HOME MAP HOW TO USE DOCUMENT FEEDBACK

Drought

Area

Close All Admin Layers

Select Index

Drought Index

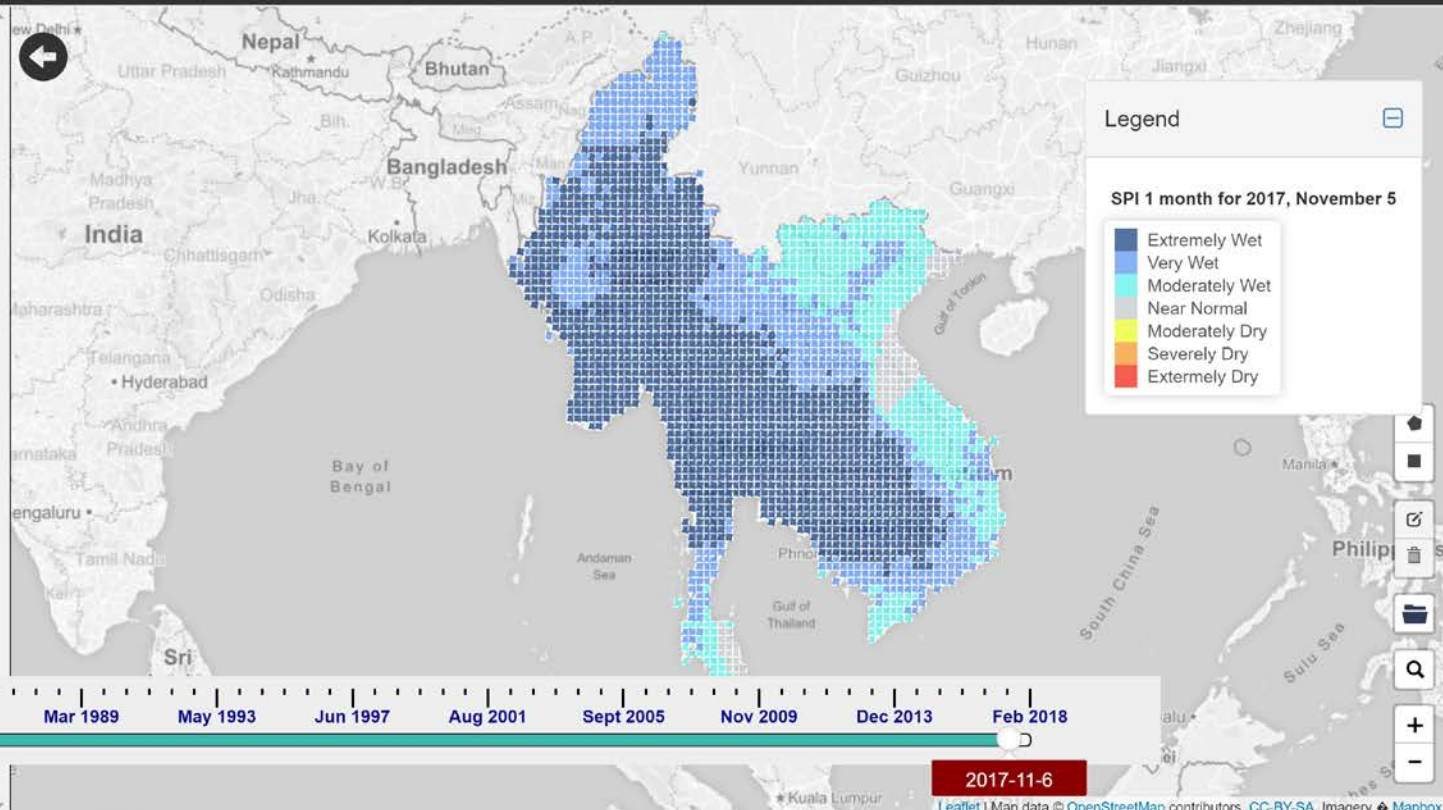
Select Variables

SPI 1 month

Show in Map

Show Chart

Crop Yield



<https://rdcyis-servir.adpc.net>

Charts and Graphs



Average SPI 1 month Value



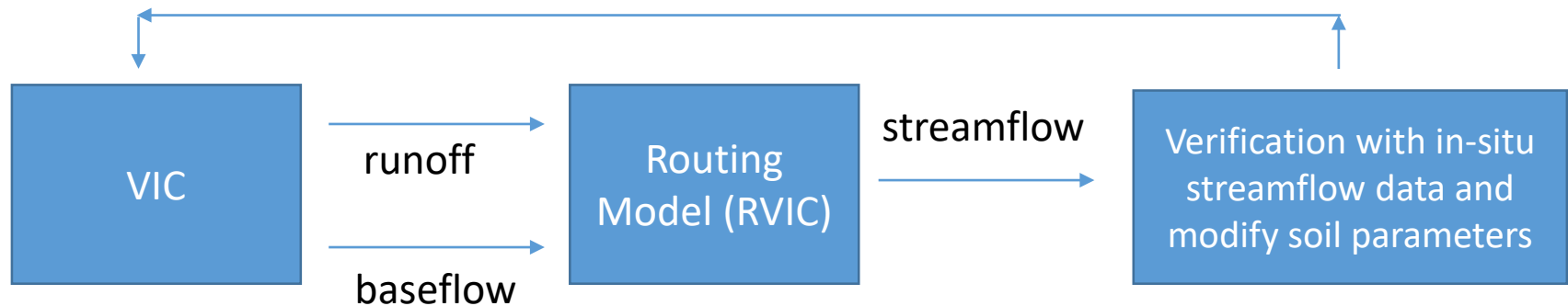
Highcharts.com

How to Improve RHEAS outputs

1. Bias correction of input data
2. Data assimilation [SM (SMOS, SMAP, AMSRE), LAI, ET, SNOW]
3. Ensemble runs [ex: 10/40 runs]
4. Calibration of VIC and DSSAT models

VIC Calibration Approach

Calibration with streamflow (most common observation) and/or soil moisture and/or ET.



Soil Parameters: most often adjusted during calibration of the VIC model include, [b_infilt](#) (parameter used to describe the Variable Infiltration Curve), [Ds](#) (represents the fraction of the Dsmax parameter at which non-linear base-flow occurs), [Ws](#) (fraction of maximum soil moisture where non-linear baseflow occurs), [Dsmax](#) (maximum velocity of baseflow for each grid cell) and [soil depth](#).



Initiative of Faisal, Lee, et al, 2017

- GSOD (Global Summary of the Day) by NCDC (National Climatic Data Center) via WMO
- Soil data from the Harmonized Land database (12.5km resolution)

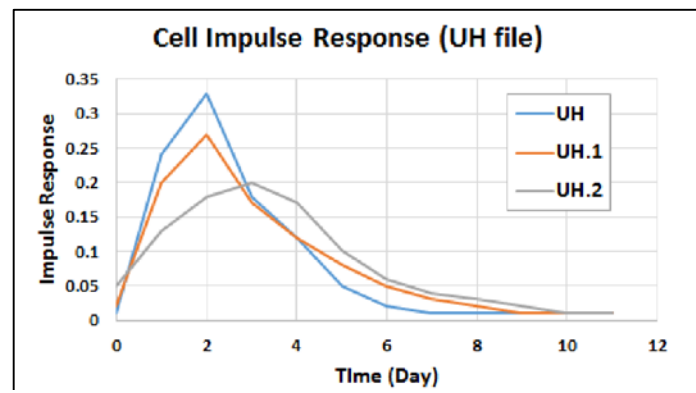
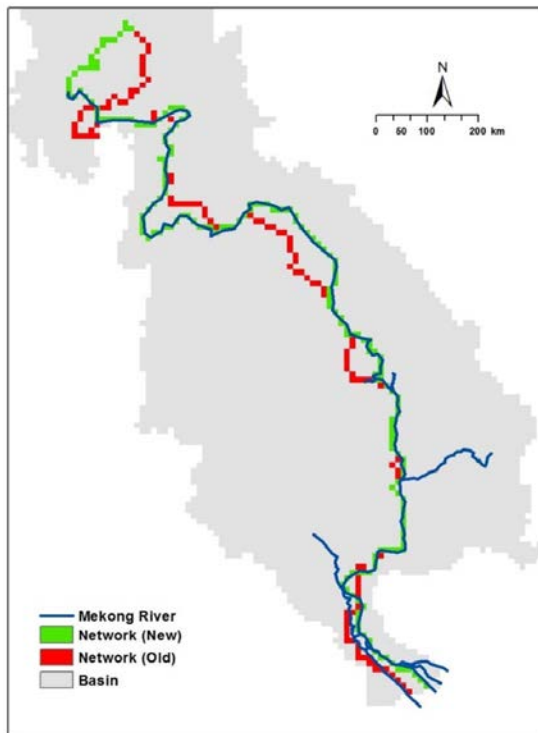
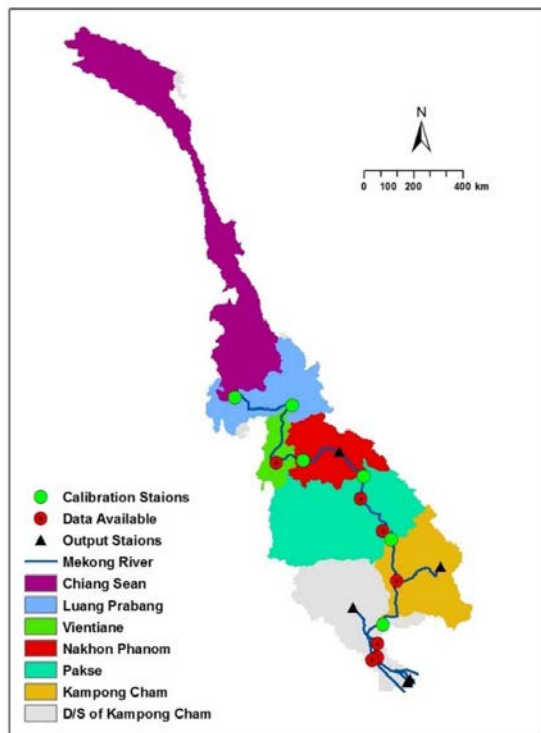


Table 1: Calibrated model parameters of each sub-basin.

Sub-basin	INFILT (b_{inf})	Ds	Ds_MAX (mm/day)	Ws
Chiang Sean	0.1	0.3	No change	1
Luang Prabang	0.1	0.3	No change	1
Vientiane	0.1	0.3	No change	1
Nakhon Phanom	0.2	1	5	0.1
Pakse	0.1	0.8	No change	1
Kampong Cham	0.4	1	2	0.1
Kampong Down	0.4	1	2	0.1

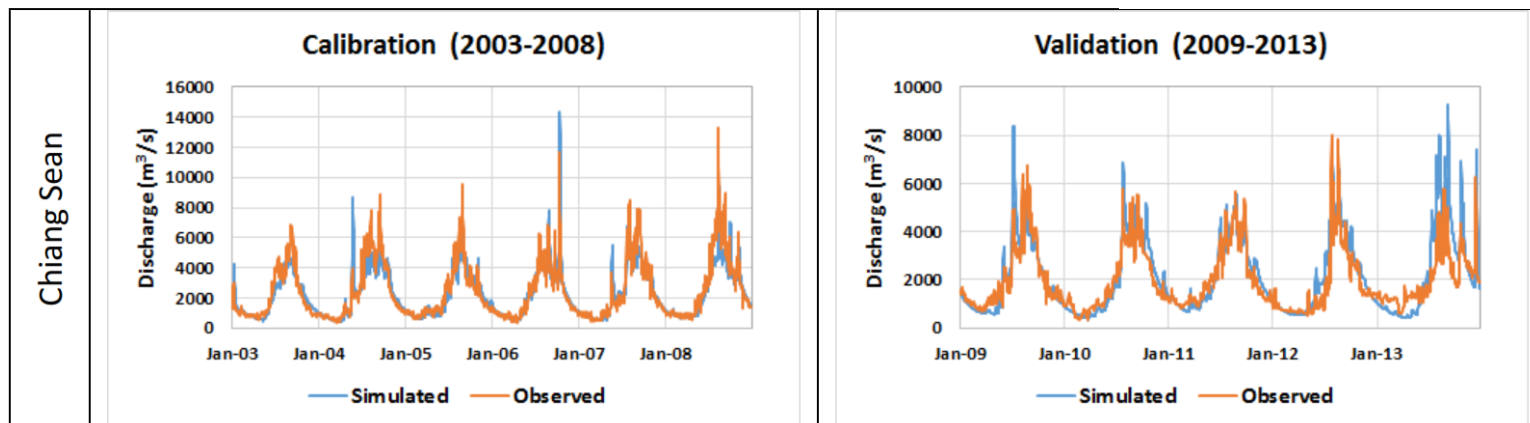
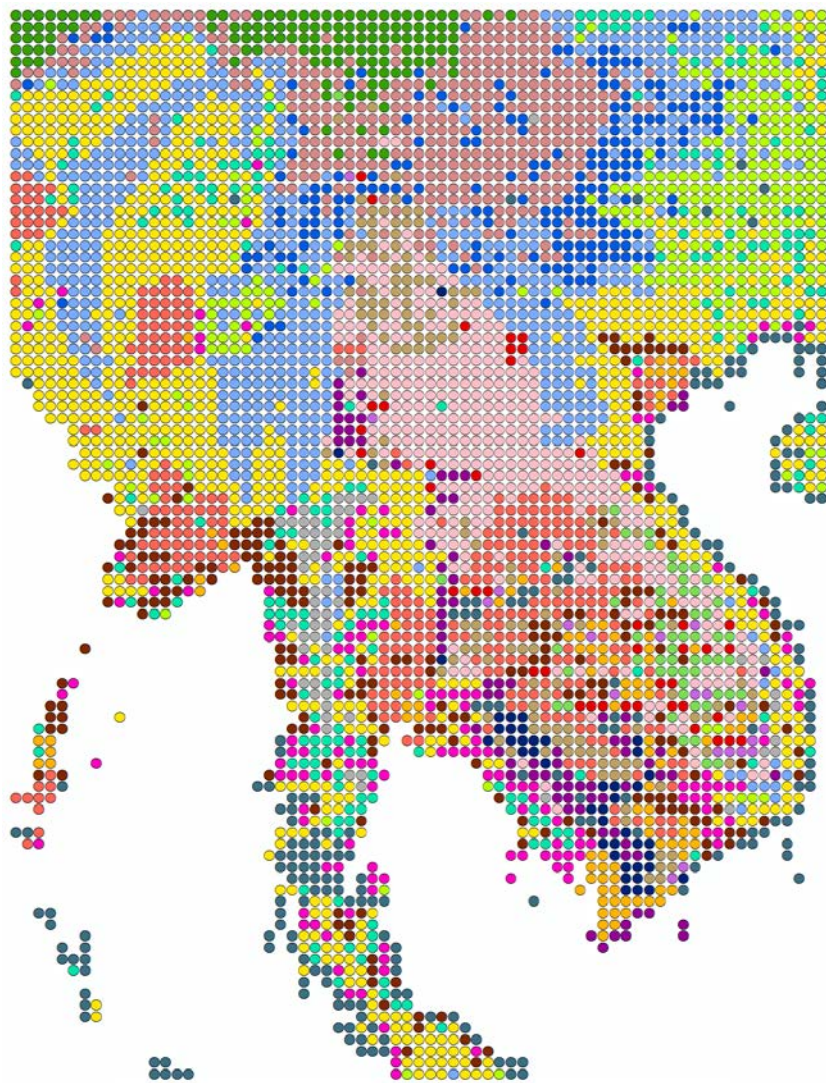


Table 2: Performance metrics of the simulated discharge before (i.e., base) and after calibration. Validation is over the independent period of 2009-2013.

Basin	Category	Mean Error (cms)	NRMSE (%)	Efficiency	Correlation
Chiang Sean	Base	-1274	70.6	0.64	0.80
	Calibration	-152	35.5	0.80	0.90
	Validation	171	42.5	0.57	0.87
Luang Prabang	Base	-1270	63.1	0.69	0.84
	Calibration	225	37.5	0.84	0.92
	Validation	792	52.8	0.70	0.92
Vientiane	Base	-1822	63.3	0.71	0.84
	Calibration	-206	35.3	0.84	0.92
	Validation	564	41.3	0.78	0.92
Nakhon Phanom	Base	-1822	63.3	0.71	0.84
	Calibration	-2536	52.4	0.78	0.93
	Validation	-1454	36.3	0.88	0.95
Pakse	Base	-1822	63.3	0.71	0.84
	Calibration	-316	38.7	0.86	0.93
	Validation	760	34.2	0.89	0.95
Kampong Cham	Base	-1822	63.3	0.71	0.84
	Calibration	-2349	45.3	0.84	0.93
	Validation	-597	40.9	0.85	0.92

Note: Base (2003-2008) is the model efficiency before calibration;

Calibration period is from 2003 to 2008 and Validation period is from 2009 to 2013

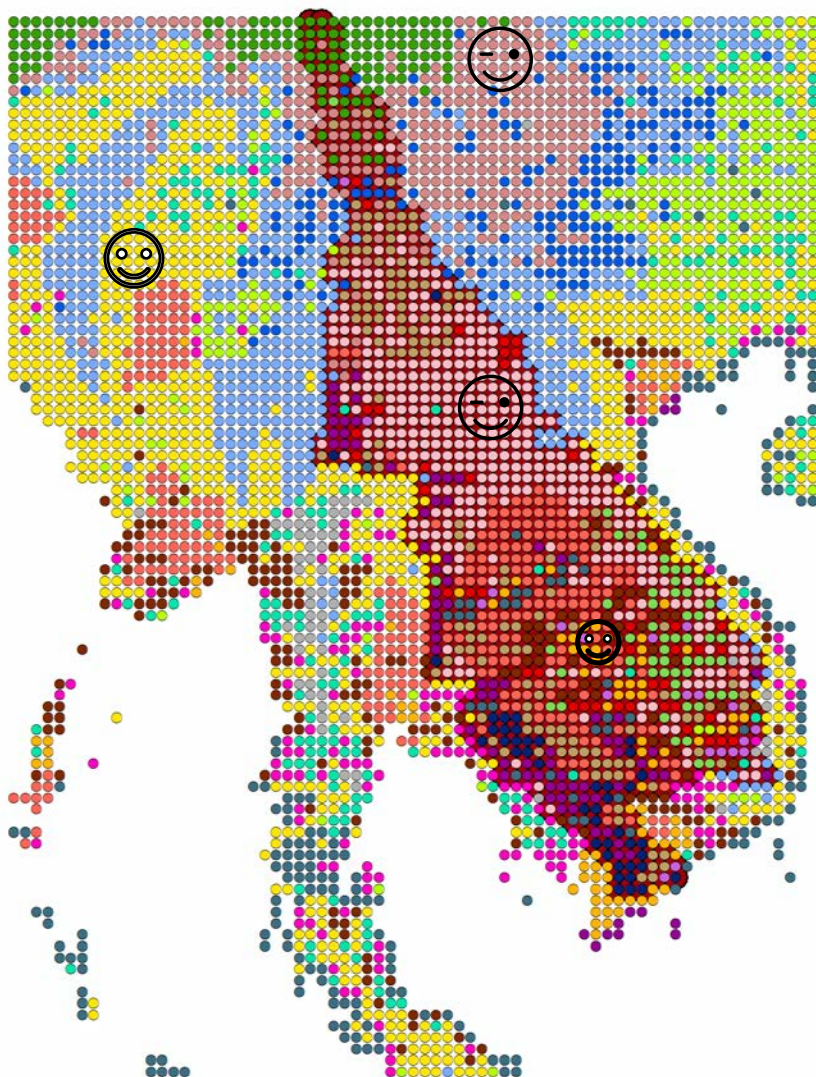


Clustering based on:

- Elevation
- Bulk Density
- % Clay (Top Clay)
- % Sand (Top Sand)
- Landuse
- LAI

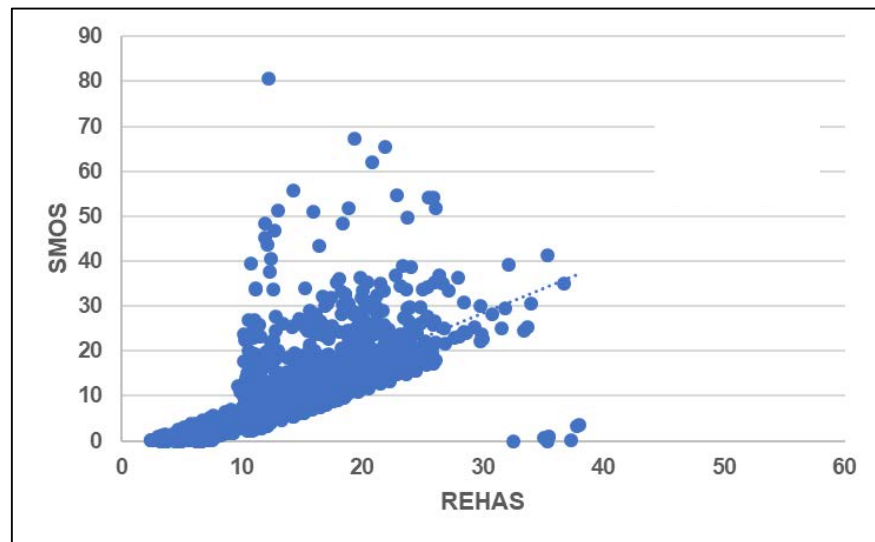
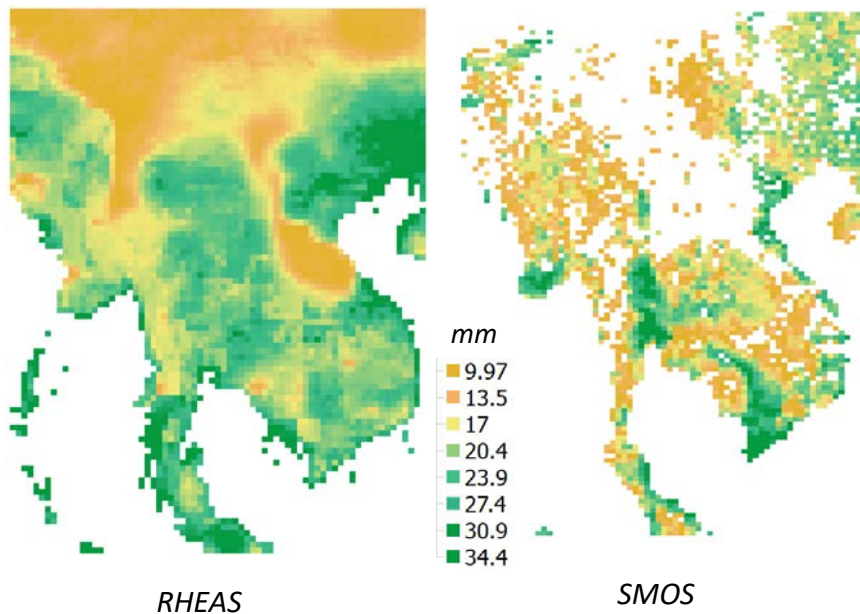
HWSD

To effectively use the subset of calibrated VIC parameters, we need to identify optimal number of pedo-transfer functions. The pedo-transfer functions are selected for this study that generally influence the evolution of calibrated VIC parameters related to above parameters.



- Perform cluster analysis using the above mentioned pedo-transfer function to both Mekong River Basin area and the whole study area (LMR) to identify the areas that are similar in geophysical characteristics.
- RHEAS executed in open-loop
- Comparison of soil moisture products between RHEAS and SMAP/SMOS
- Expected correlation is about 75%.
- Procedure would be repeated (changing number of clusters) if the expected correlation gets less than 75%.

Comparison Results (2010-03)



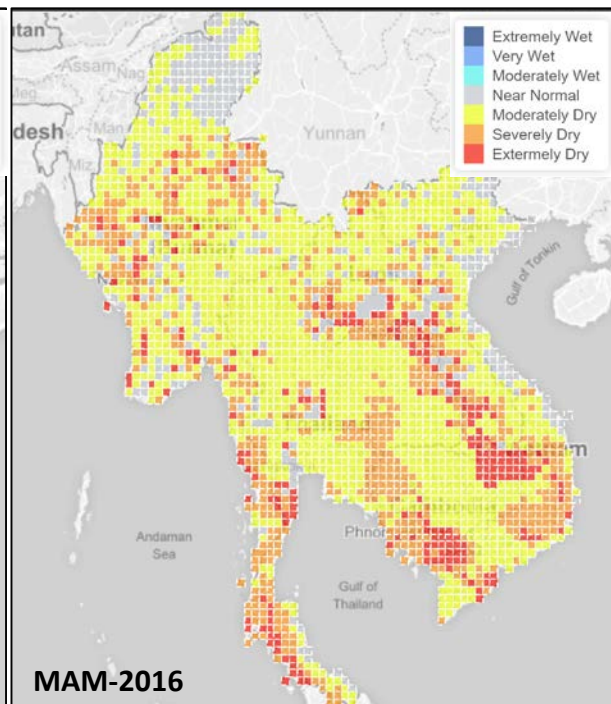
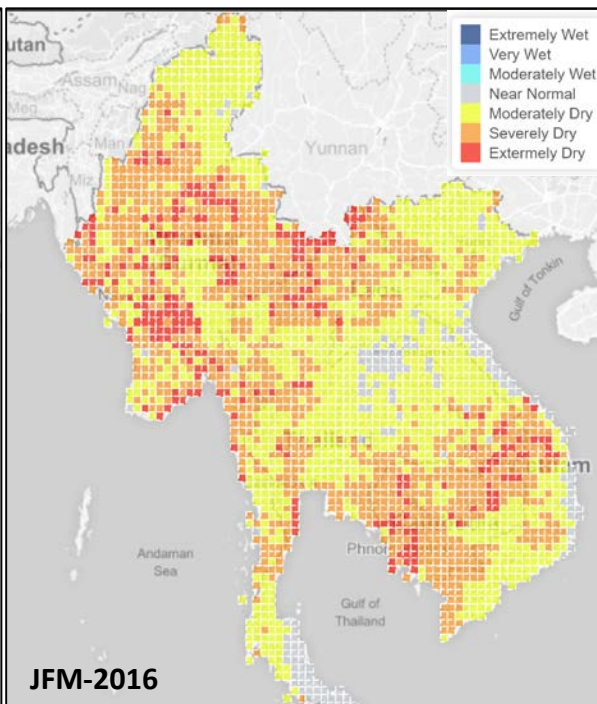
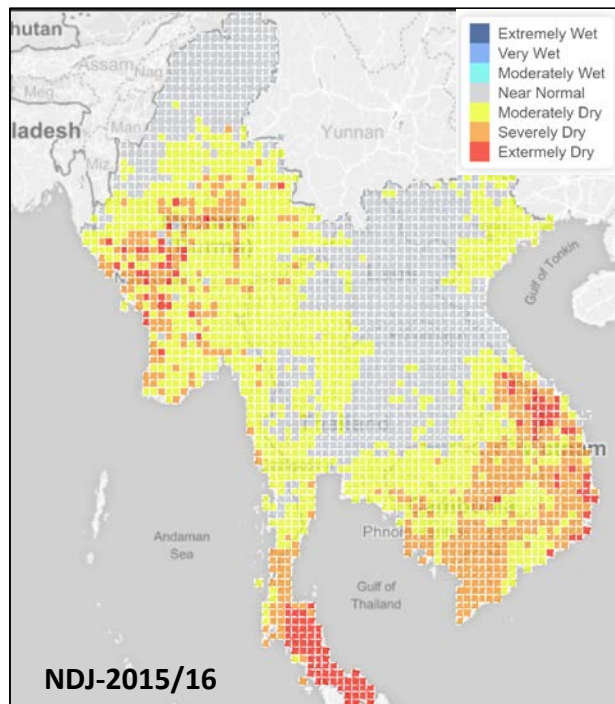
Bias	3.19
RMSE	5.59
R (Correlation)	0.63
NSE (Nash–Sutcliffe model efficiency coefficient)	0.40

Comparison Results (2015 and 2016): RHEAS SM and SMAP

Month	Correlation	NSE	Month	Correlation	NSE
Jan-2015			Jan-2016	0.78	0.5
Feb-2015			Feb-2016	0.76	0.5
Mar-2015			Mar-2016	0.81	0.6
Apr-2015	0.79	0.5	Apr-2016	0.78	0.5
May-2015	0.79	0.5	May-2016	0.79	0.5
Jun-2015	0.75	0.4	Jun-2016	0.76	0.4
Jul-2015	0.74	0.4	Jul-2016	0.75	0.4
Aug-2015	0.74	0.4	Aug-2016	0.76	0.4
Sep-2015	0.76	0.5	Sep-2016	0.77	0.5
Oct-2015	0.79	0.5	Oct-2016	0.79	0.5
Nov-2015	0.78	0.5	Nov-2016	0.79	0.5
Dec-2015	0.80	0.6	Dec-2016	0.81	0.6

Simulating the Drought Event in 2015/16

ENSO Type														
	Season		JJA	JAS	ASO	SON	OND	NDJ	DJF	JFM	FMA	MAM	AMJ	MJJ
WE	2014	- 2015	0.1	0.0	0.2	0.4	0.6	0.7	0.6	0.6	0.6	0.8	1.0	1.2
VSE	2015	- 2016	1.5	1.8	2.1	2.4	2.5	2.6	2.5	2.2	1.7	1.0	0.5	0.0



SPI 3 months

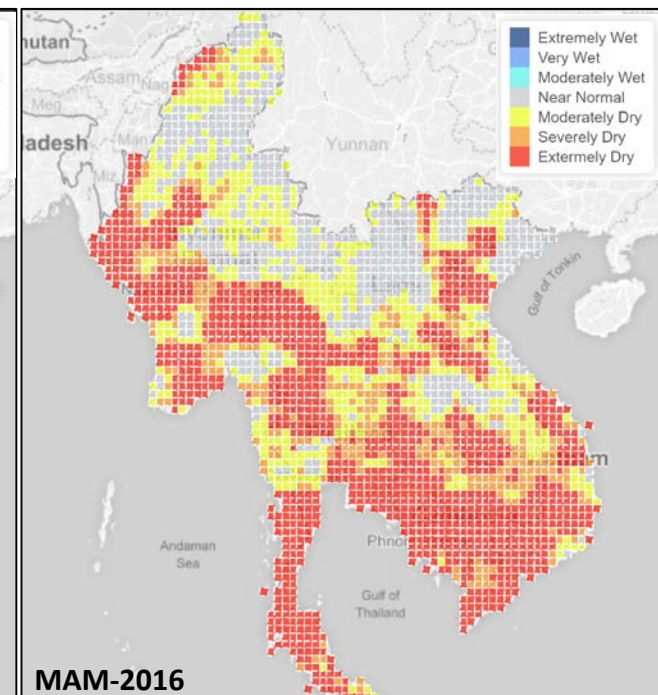
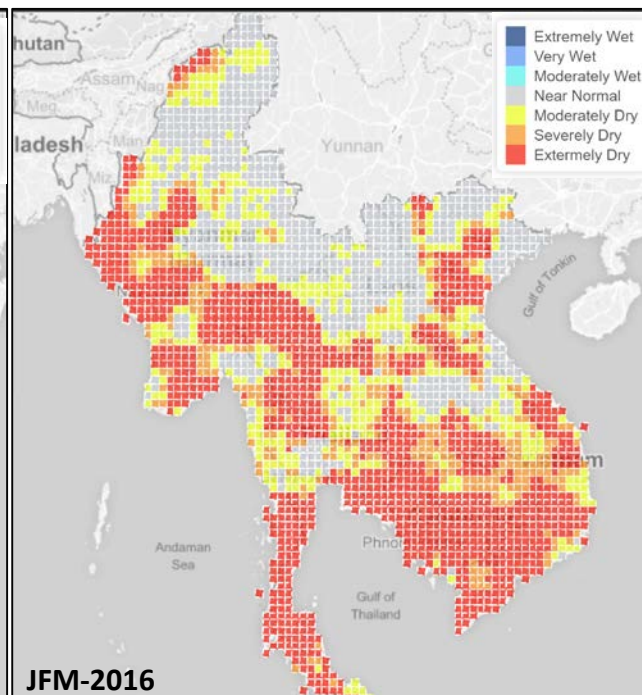
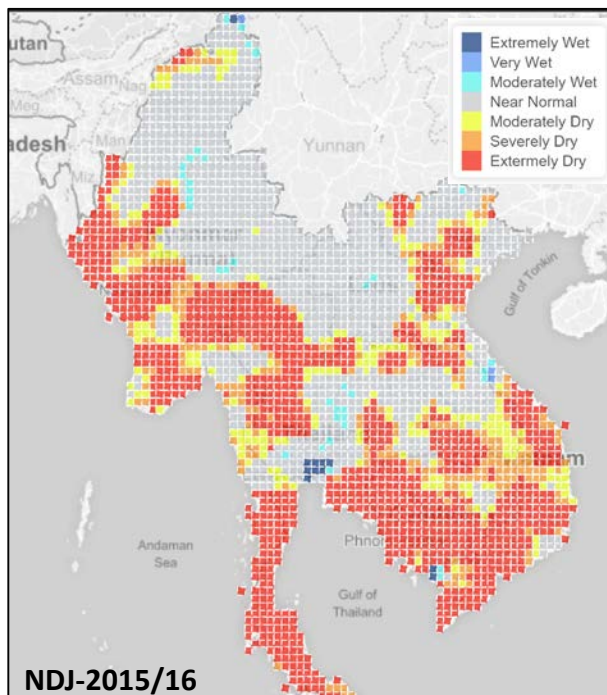
Simulating the Drought Event in 2015/16

Charts and Graphs



Highcharts.com

Simulating the Drought Event in 2015/16



SMDI

Charts and Graphs

Average SMDI Value (Regional)



Highcharts.com

Capacity Building on RHEAS Modeling



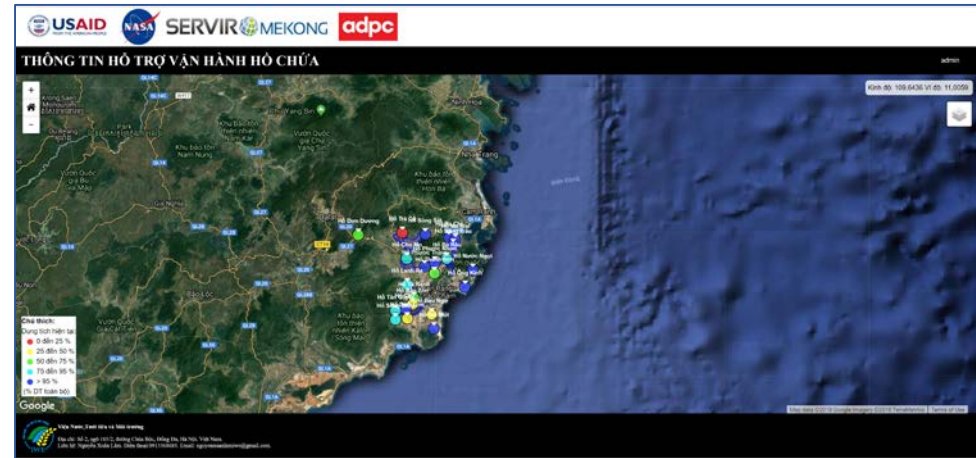
Vietnam Academy of Water
Resources (VAWR)
19-23 June and 2-6 Oct 2017



Co-development Engagements

Vietnam Academy of Water Resources (VAWR):

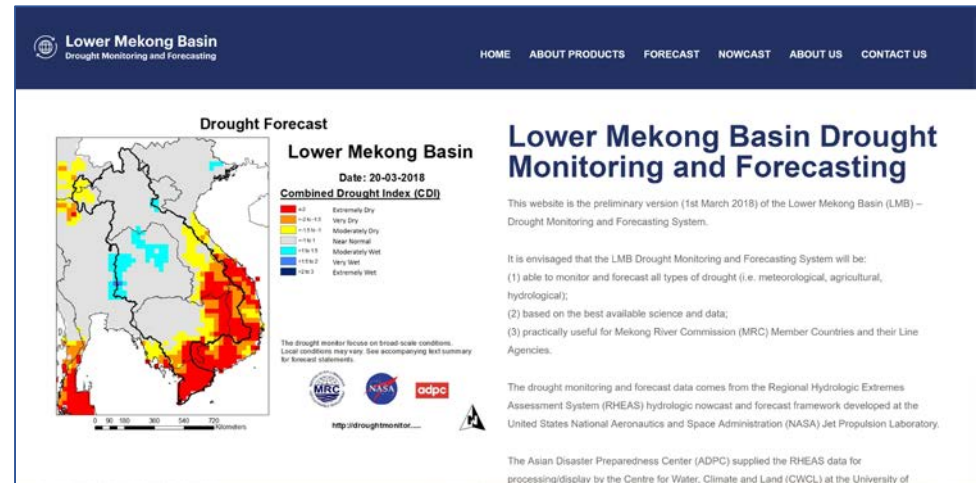
- Two pilot sites (Ninh Thuan and Binh Dinh provinces) for initial testing



Reservoir Operation Tool (http://hochua.com/index.php#popup_tab-22)

Mekong River Commission (MRC):

- Providing all drought related products generated by RHEAS
- Technical support for developing drought portal



Future Developments

- Implement PostGIS database in Data Cube approach
- Generate time series graphs for user AOIs
- Add more statistics
- Include crop yield information for maize and rice crops
- Increase output data resolution to 5km
- Add customized and new indices/variables
- Include climate projections data
- Add Text bulletins



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Thank You!!

 **SEI** STOCKHOLM
ENVIRONMENT
INSTITUTE


Spatial Informatics Group

Deltares
Enabling Delta Life 

Let's Explore the Tool Now!!!

- <https://servir.adpc.net>



- <https://rdcyis-servir.adpc.net>

