AGRICULTURAL DROUGHT IN THE PHILIPPINES ASSOCIATED WITH THE 2019 EL NIÑO

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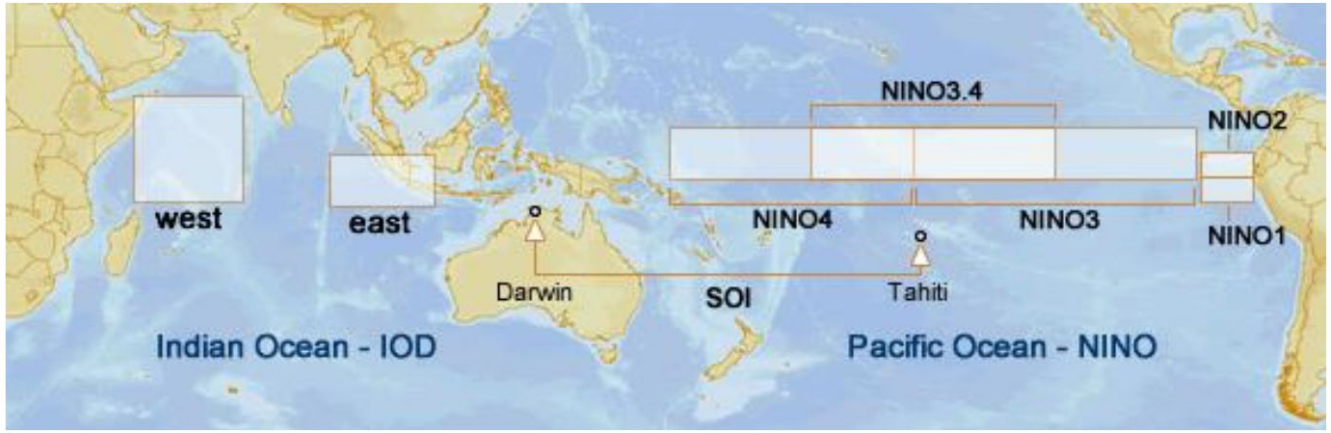
University of the Philippines Diliman

Land Use/Cover Changes, Environment and Emissions in South/Southeast Asia – An International Regional Science Meeting
Remote Sensing and Agricultural Land Use Session 3: Modeling and Decision Support Systems

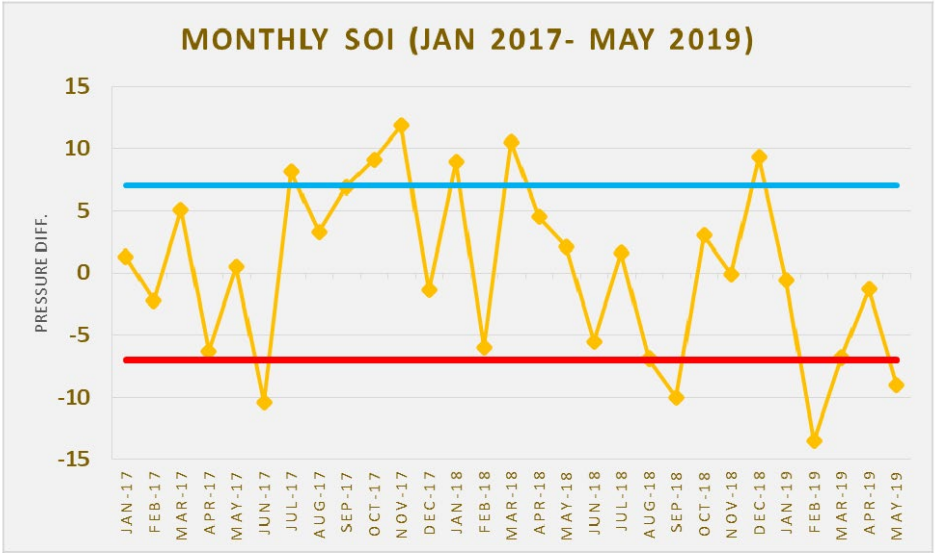
ENSO Indicators



PAGASA Climate Review

Atmospheric Indicator

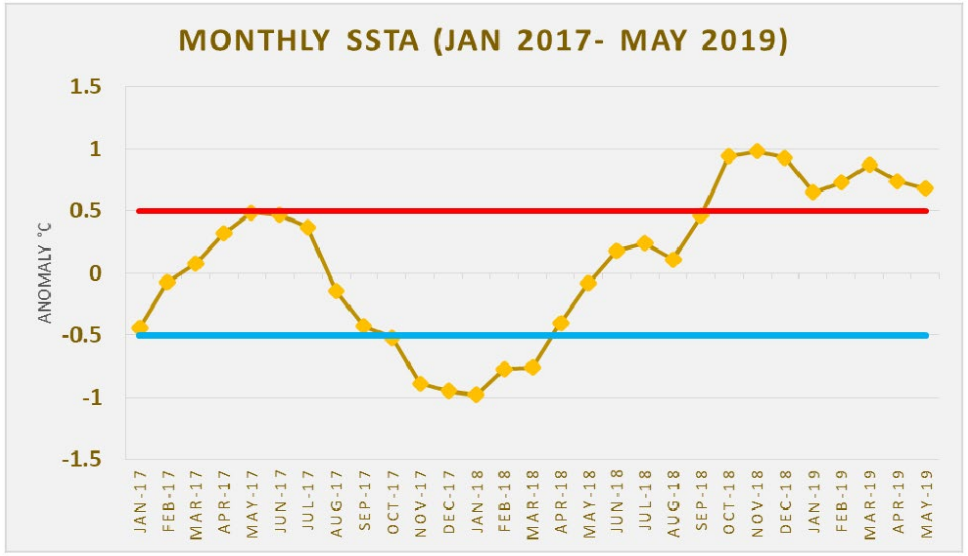
Southern Oscillation Index



Data Source: Bureau of Meteorology (BOM)

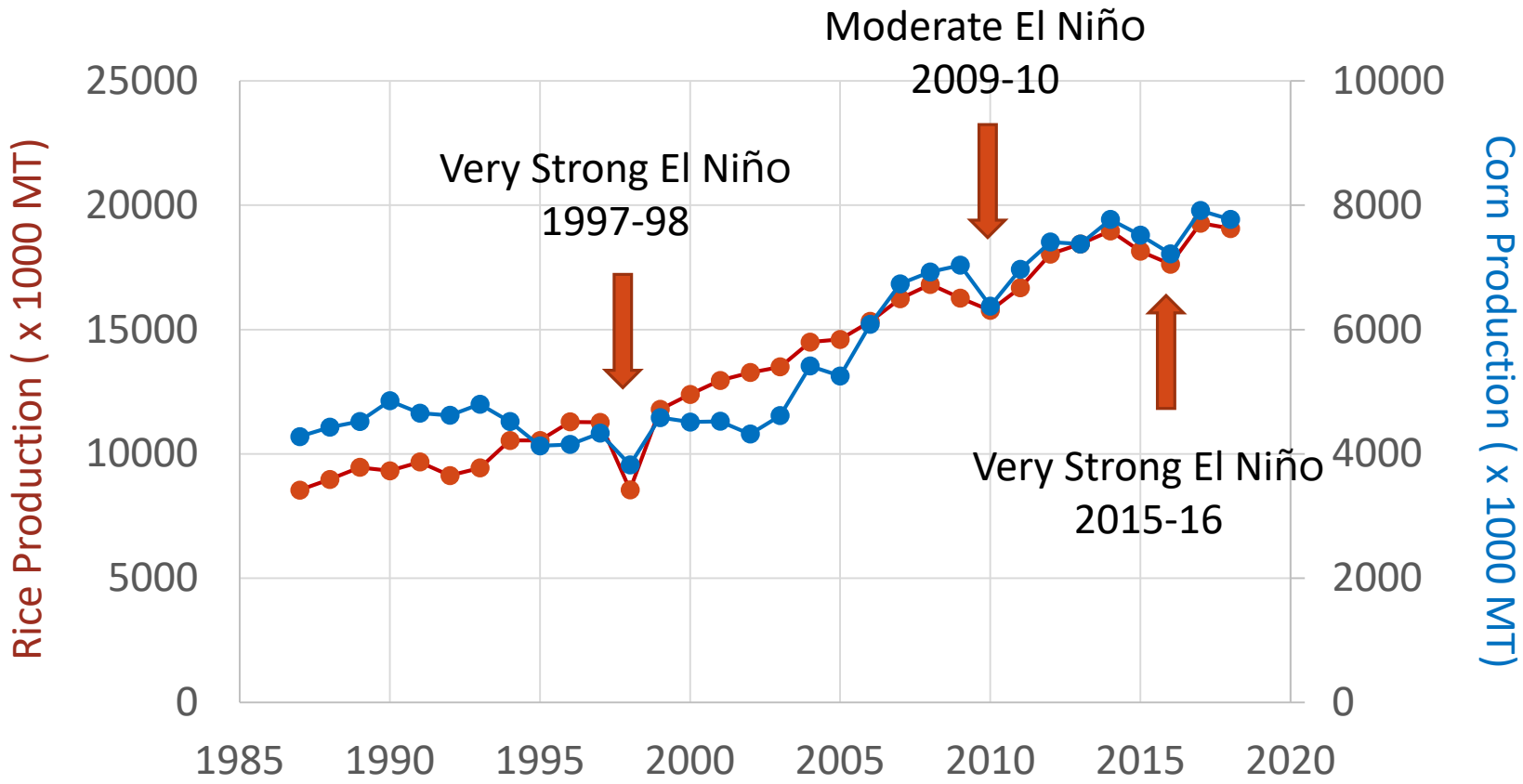
Oceanic Indicator

Extended Reconstructed Sea Surface Temperature (ERSST)



Data Source: Climate Prediction Center (CPC)

El Niño Impacts on Crop Production



Data Source: Philippine Statistics Authority

2019 El Niño impacts in the Philippines

Source: Youtube (CNN Philippines)

https://www.rappler.com/business/229052-el-nino-damage-agriculture-as-of-april-25-2019

https://www.philstar.com/headlines/2019/04/09/1908536/metro-manila-heat-index-reaches-404c

WATER SHORTAGE:
Critical dam levels due to lack of precipitation

AGRICULTURAL DAMAGE:
Damage to crops due to low levels of soil moisture

INCREASING TEMPERATURE:
heat index reaching up to 40°C

Objective

Monitor agricultural drought development during the 2019 El Niño in the Philippines

1. Examine spatiotemporal variation of drought in the Philippines using several drought indices
2. Compare drought indices with satellite soil moisture data
3. Examine viability of drought indices for damage assessment

Drought indicators used in the study

Parameters	Acronym	Equation	Sensor(s)	Resolution
Rainfall	RF	-	TRMM	25 km
Land Surface Temperature	LST	-	MODIS	5 km, 1 km
Soil Moisture	SM	$m_s(t) = \frac{\sigma^0(t) - \sigma^0_{dry}(t)}{\sigma^0_{wet}(t) - \sigma^0_{dry}(t)} * 100,$	Sentinel-1, SMAP	10 m, 9 km
Normalized Difference Vegetation Index	NDVI	$NDVI = \frac{NIR - RED}{NIR + RED}$	MODIS, Sentinel-2	250 m, 10 m

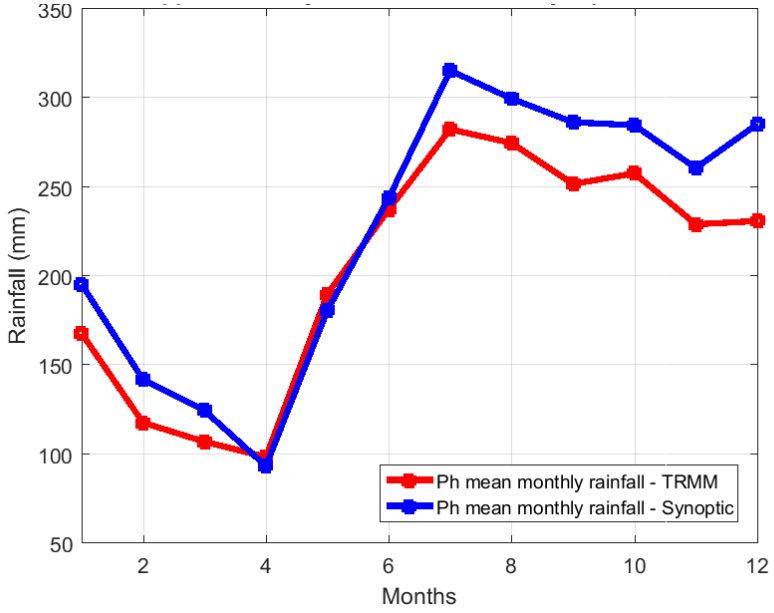
Drought indices used in the study

Category		Drought index	Acronym	Equation	Input and sensor	Resolution
Meteorological drought		Standardized Precipitation Index-1	SPI-1	$SPI = \frac{RF - \overline{RF}}{\sigma_{RF}}$	TRMM	25 km
Agricultural drought	Temperature and vegetation-based	Standardized Vegetation Temperature Ratio	SVTR	$SVTR = \frac{R_i - \bar{R}_i}{\sigma_R}$	MODIS	5 km
		Vegetation Health Index	VHI	$VHI = \alpha VCI + (1 - \alpha)TCI$	MODIS	5 km
		Temperature Vegetation Dryness Index	TVDI	$TVDI = \frac{T_s - T_{s_{min}}}{a + bNDVI - T_{s_{min}}}$	MODIS	5 km
	Rainfall-based	Standardized Precipitation Index-3	SPI-3	$SPI = \frac{RF - \overline{RF}}{\sigma_{RF}}$	TRMM	25 km

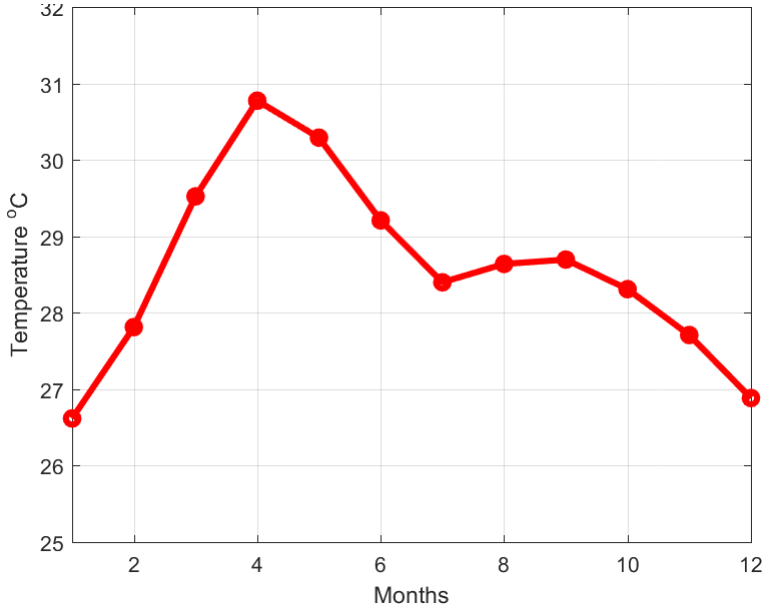
From the several choices, there is a need to understand how each index represents drought in the Philippines

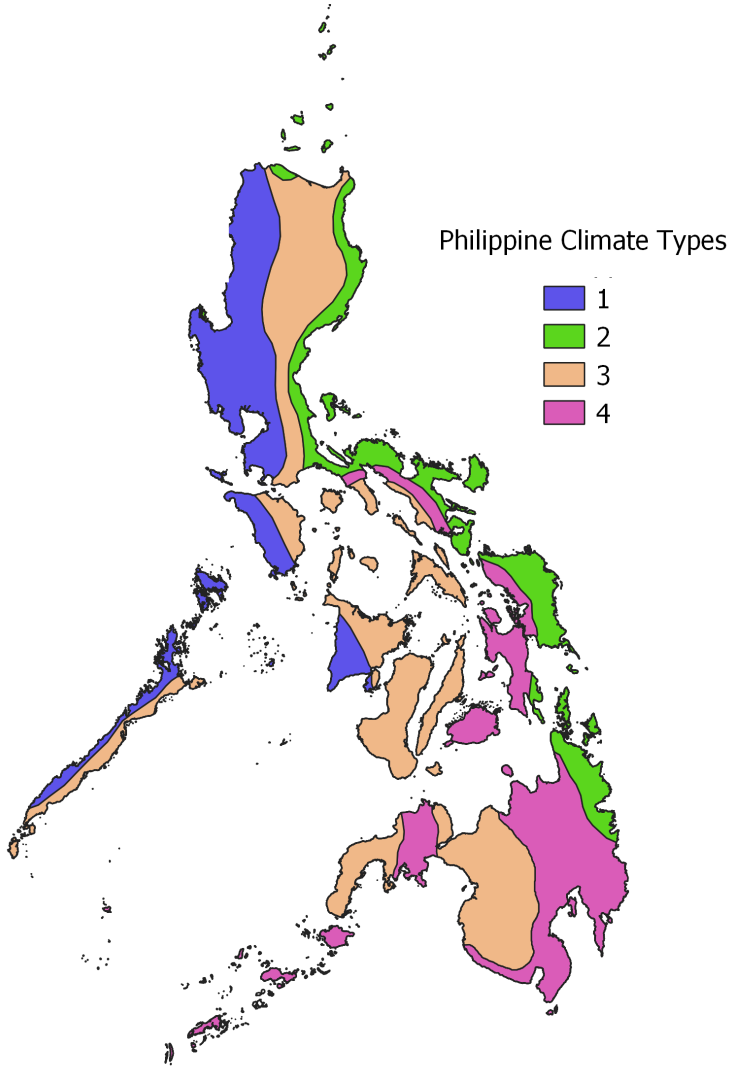
The Philippine Climate

Rainfall Climatology from TRMM and rain gauges

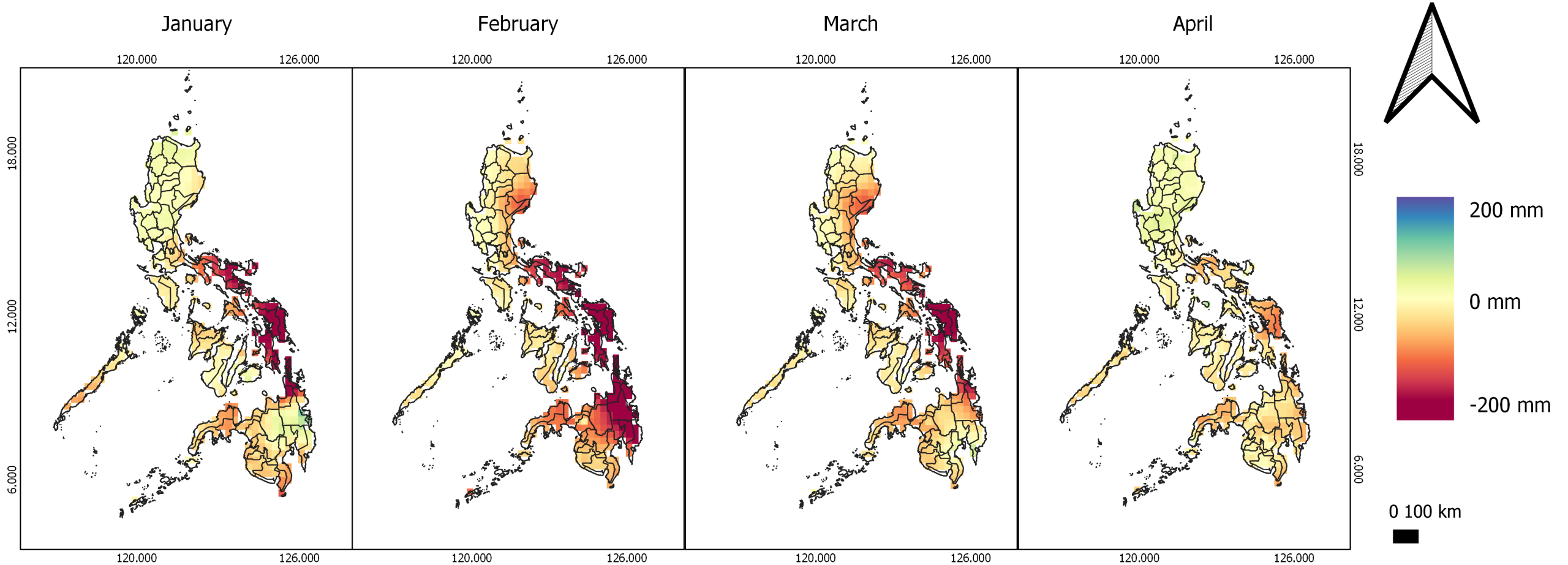


Temperature Climatology from MODIS

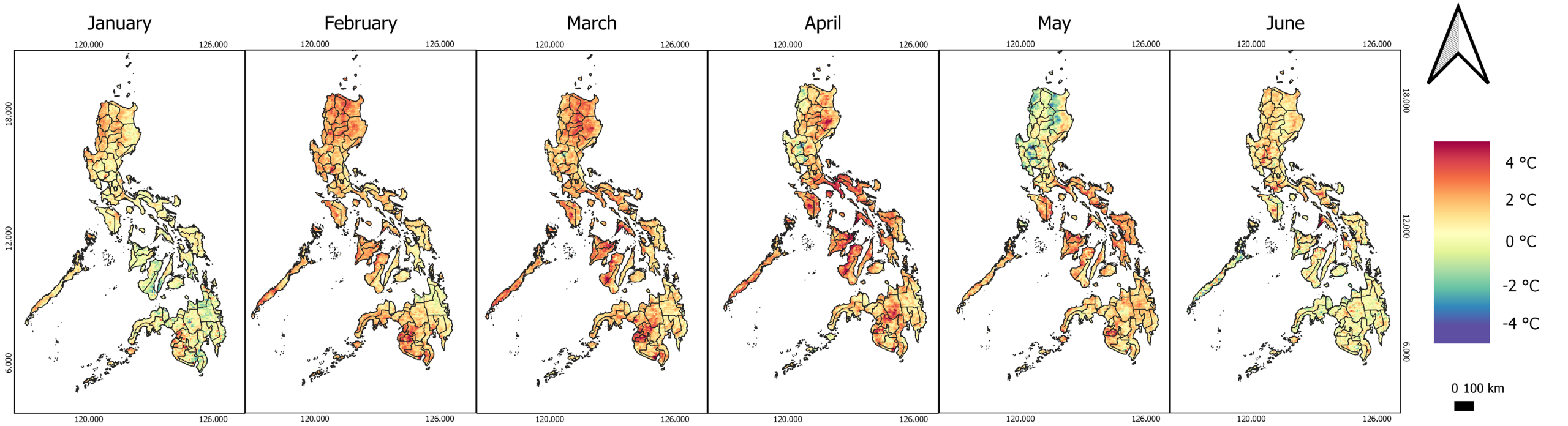




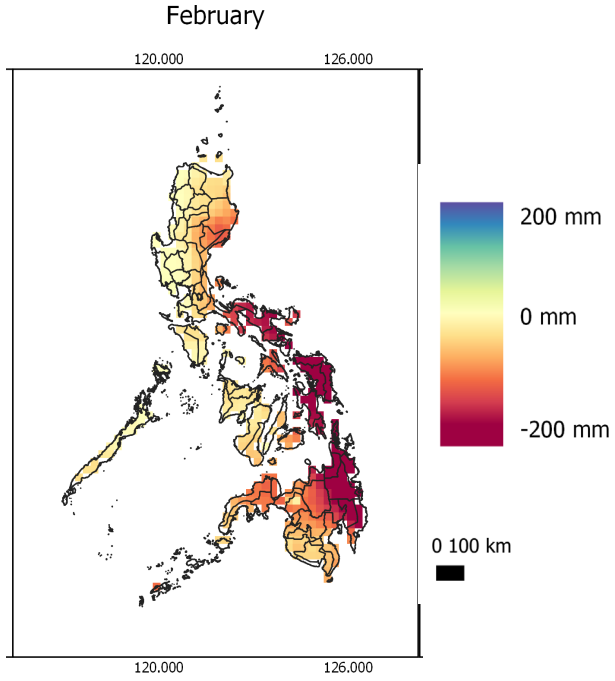
Drought Driver: Precipitation Anomaly



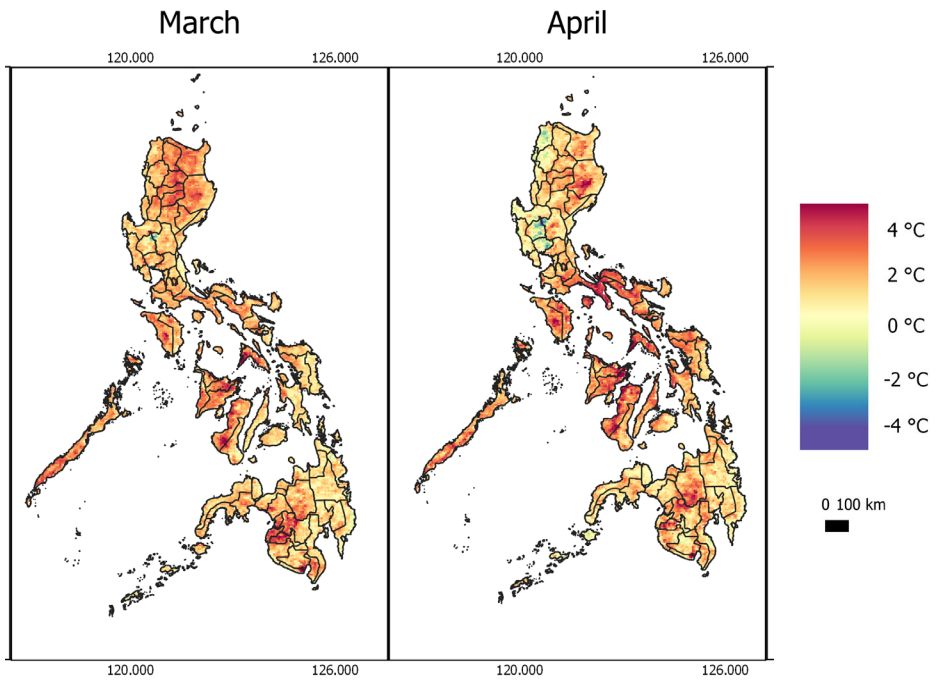
Drought Driver: Temperature Anomaly



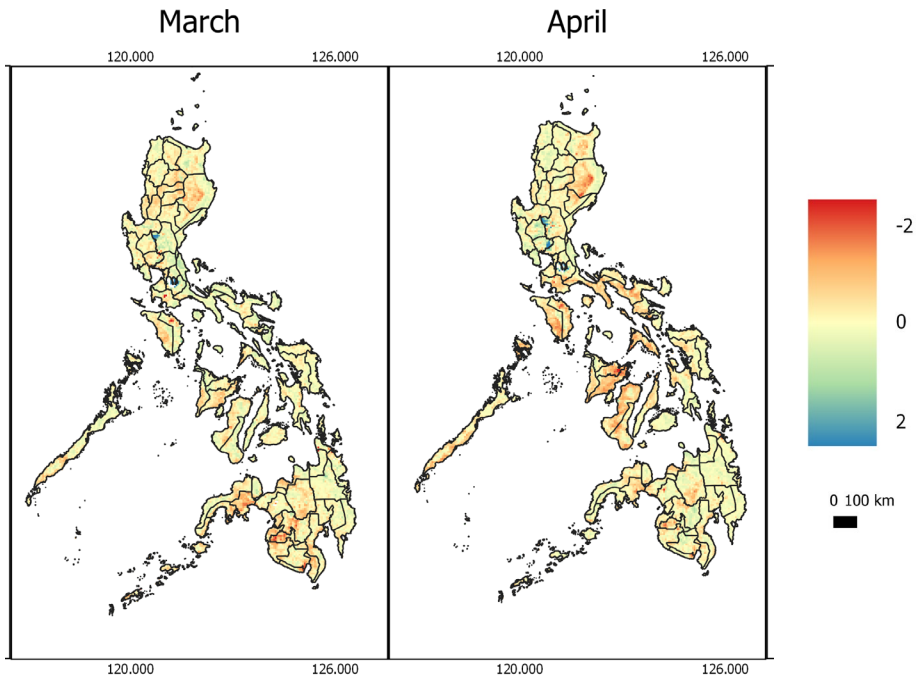
Agricultural Drought Indicator



Precipitation Anomaly

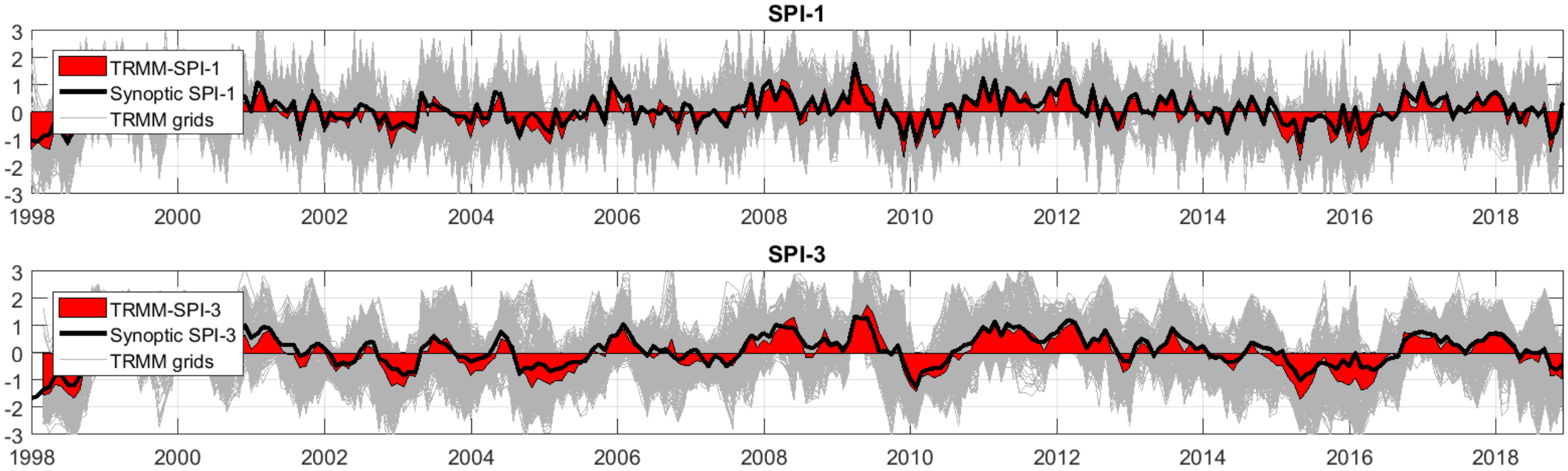


Temperature Anomaly

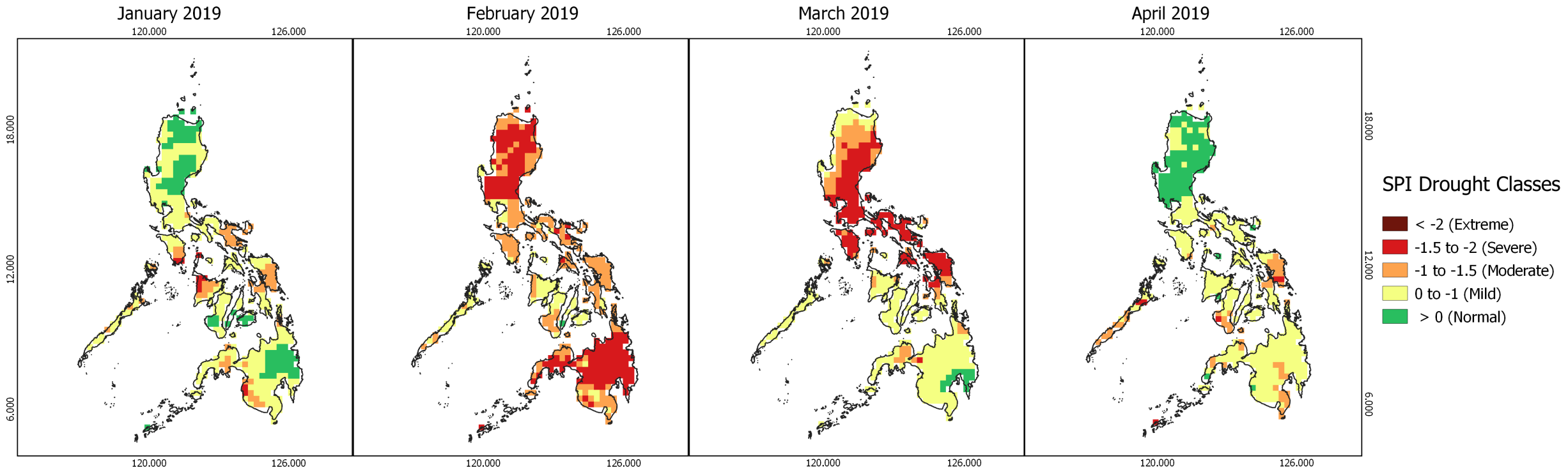


NDVI Anomaly

SPI-1 and SPI-3: Historical Perspective

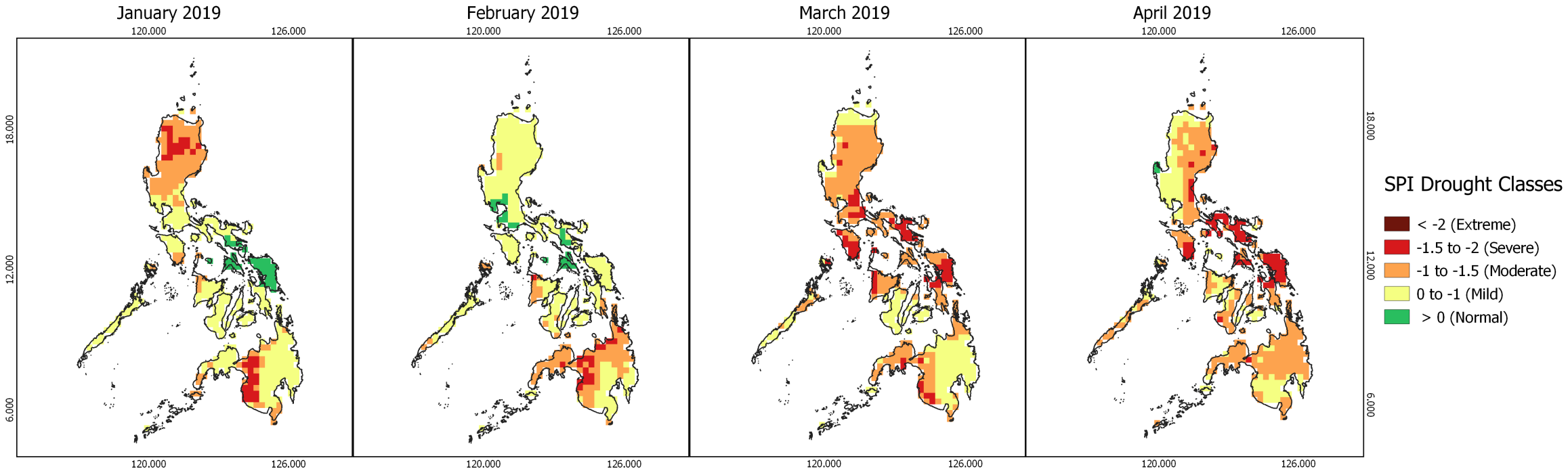


DROUGHT INDICES MAPS: SPI-1



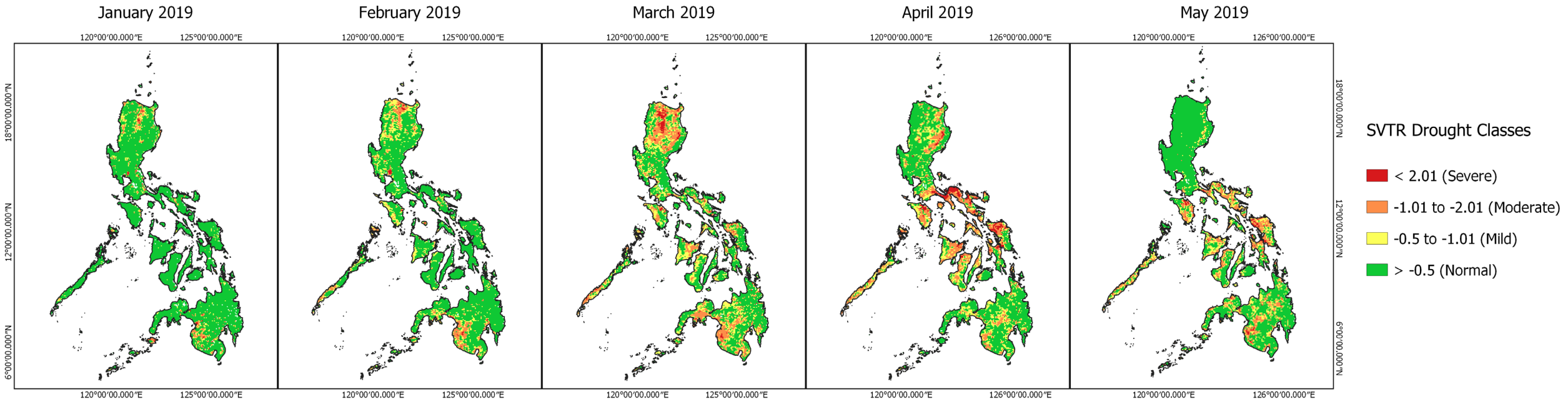
Meteorological drought peak during February

DROUGHT INDICES MAPS: SPI-3



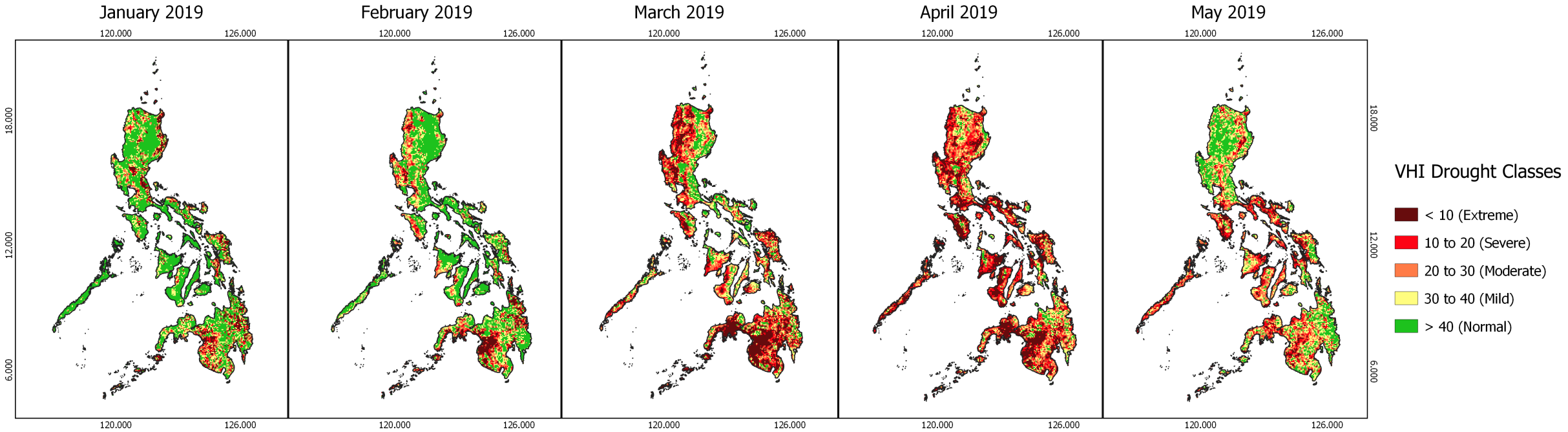
- Agricultural drought peak during March/April
- Drought signals starts in areas with climate type 1 and 3, with pronounced dry season

DROUGHT INDICES MAPS: SVTR



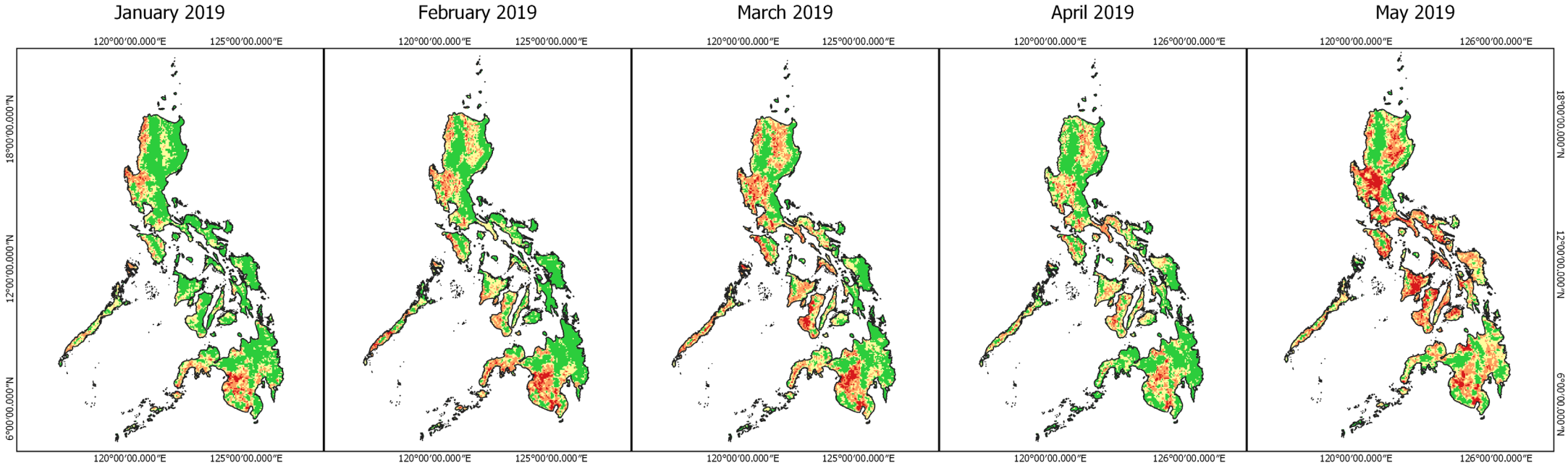
- Drought signals started in the west then became widespread around March to April
- Follows the climate type-based drought pattern of SPI-3

DROUGHT INDICES MAPS: VHI



- Drought signals started in the eastern part of the country
- Drought peak observed during March

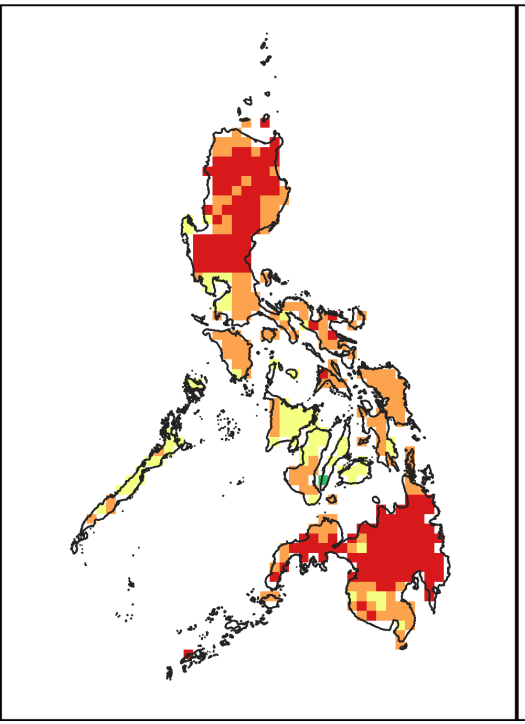
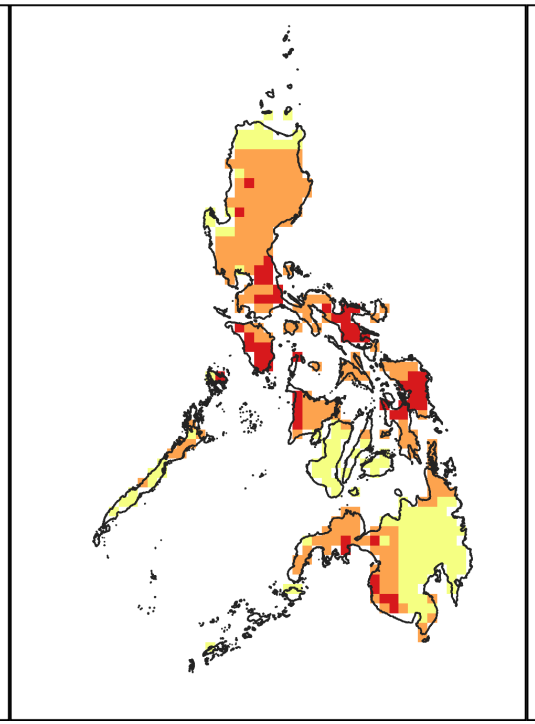
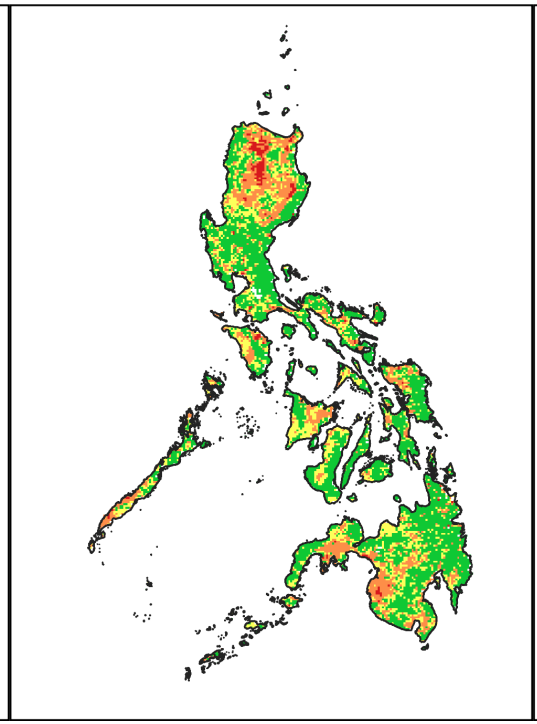
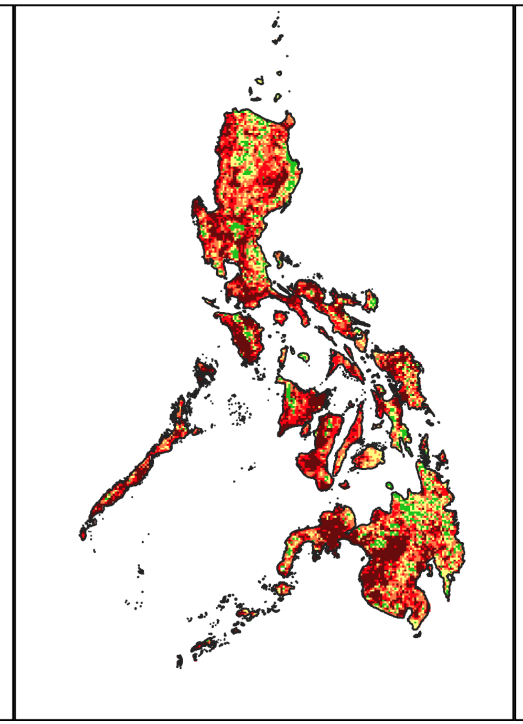
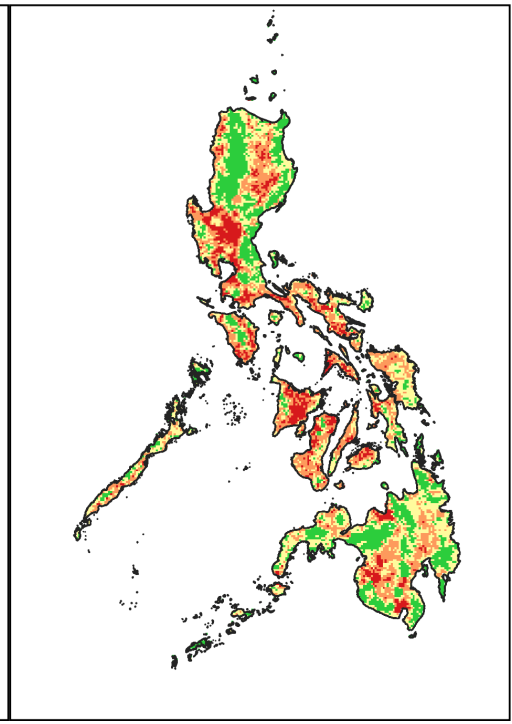
DROUGHT INDICES MAPS: TVDI



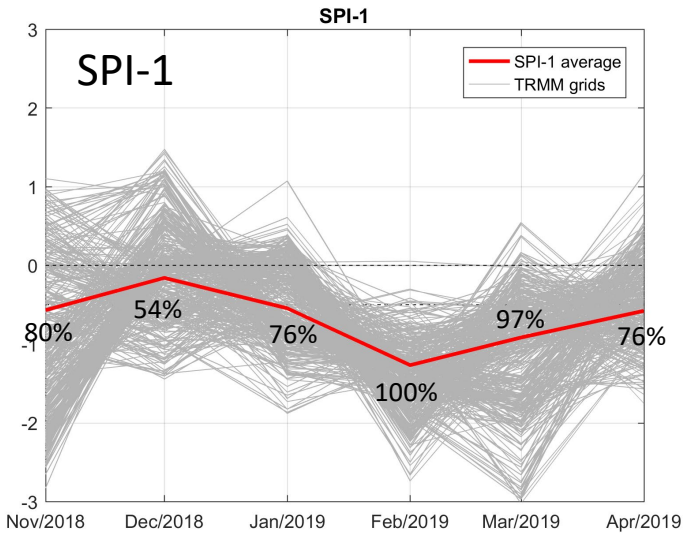
- Drought signals were consistent in the western part of the country
- Drought peak observed during May

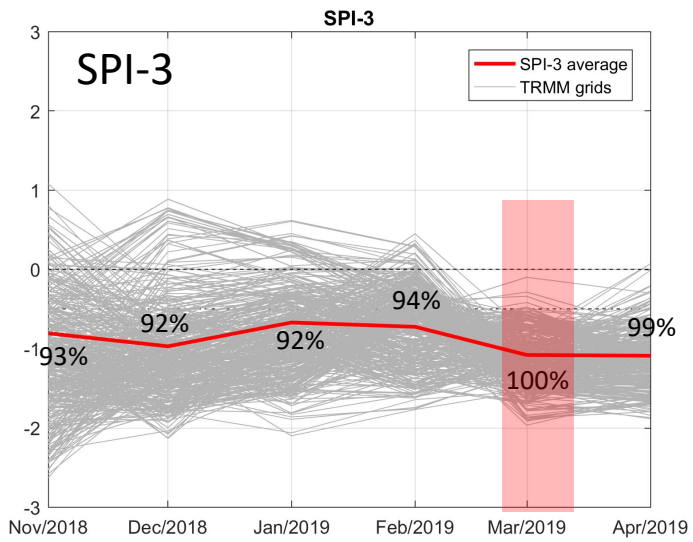
DROUGHT INDICES MAPS

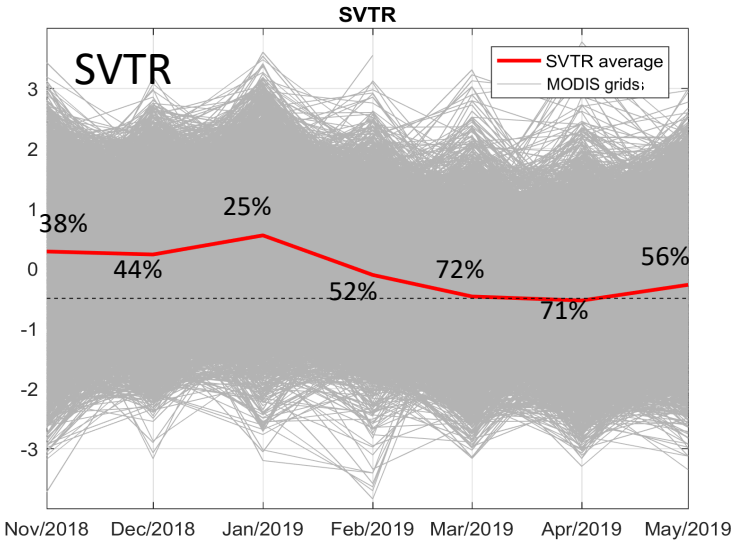
Months of drought peak

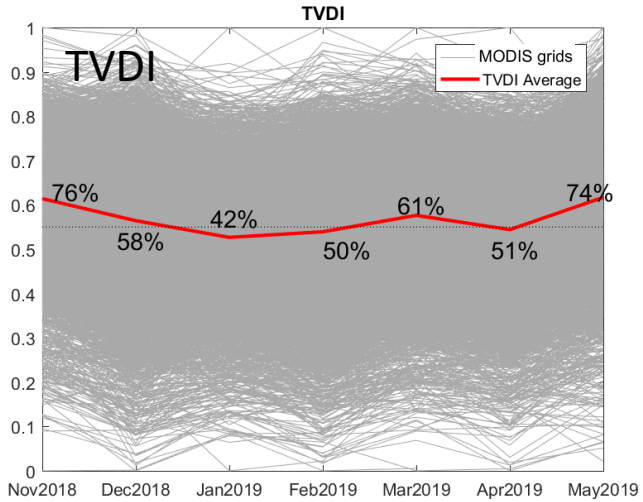
SPI-1	SPI-3	SVTR	VHI	TVDI
				
February	March: 100% April: 99%	March: 72% April: 71%	April	May

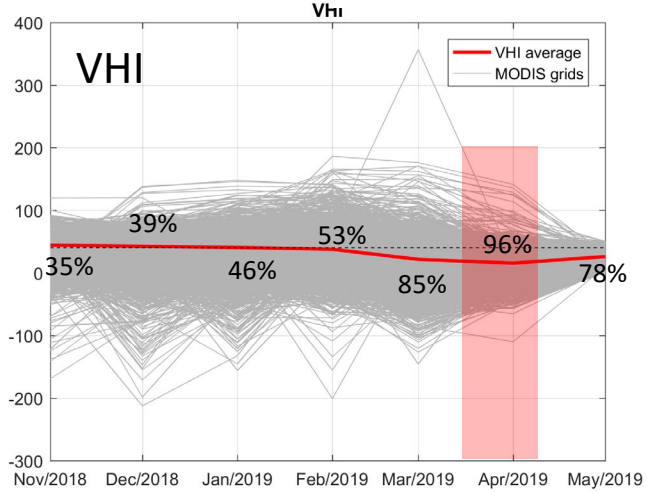
TIME SERIES OF DROUGHT INDICES







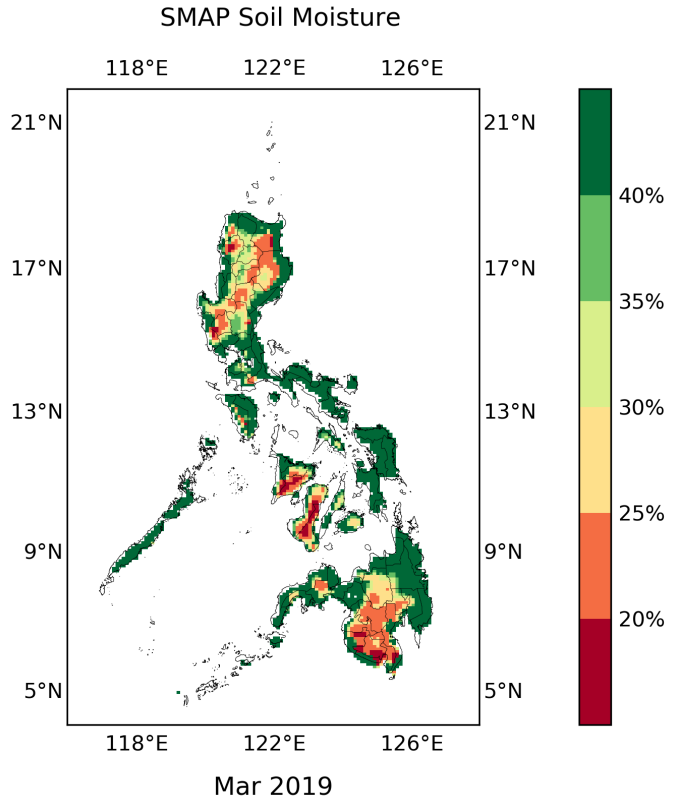




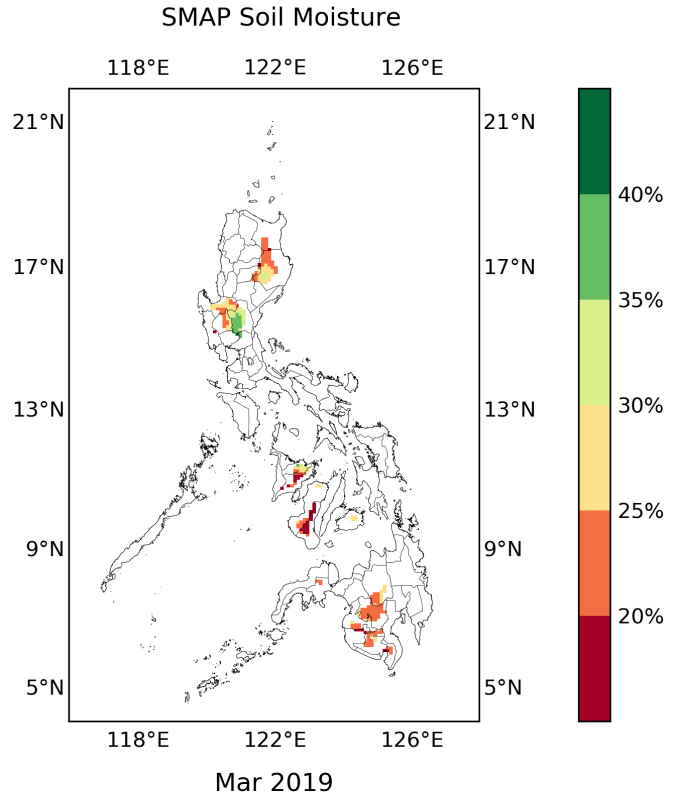
SVTR, SPI-3, and VHI peaked around March/April

Overall pattern showed **increasing number of affected land area** from January up to May

Soil moisture derived SMAP observations

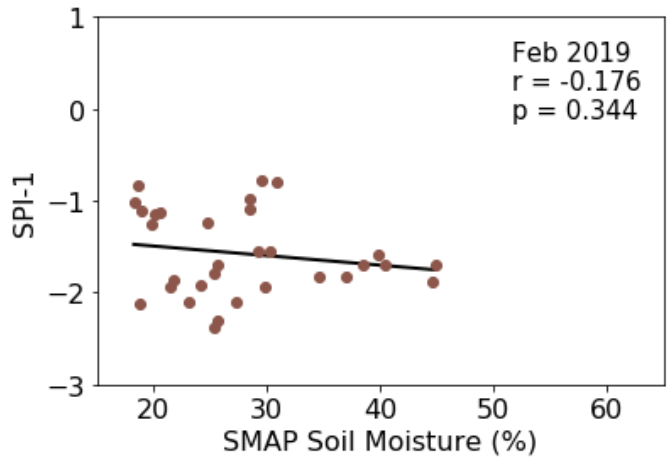


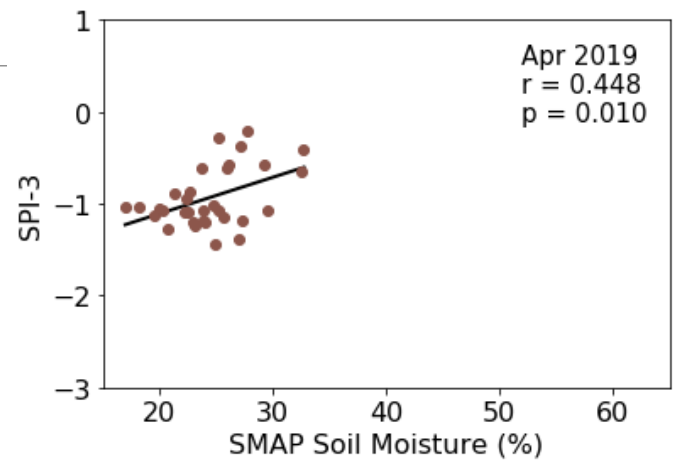
Before QA

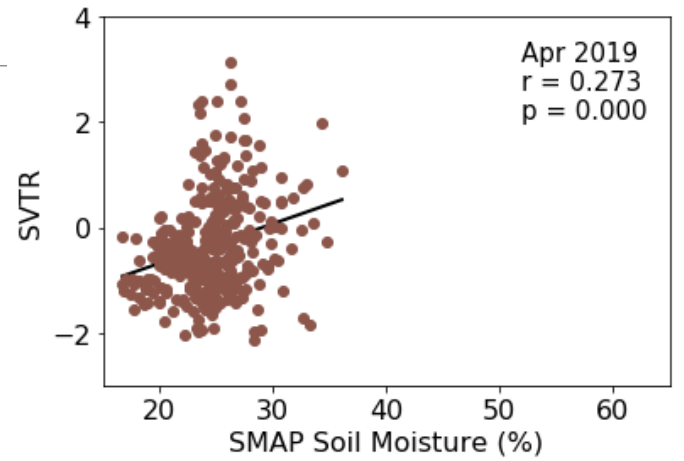


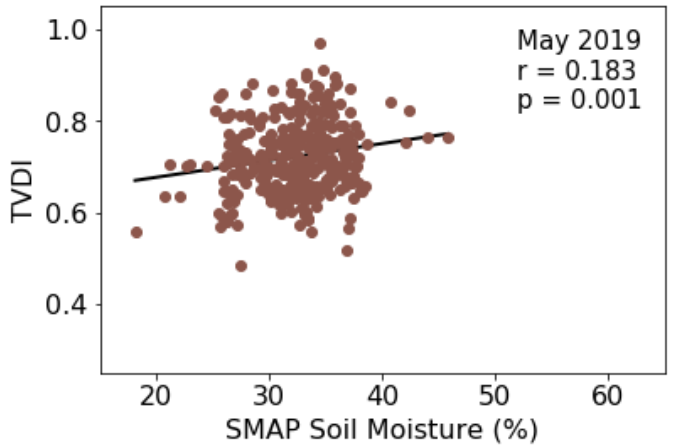
After QA (used for correlation)

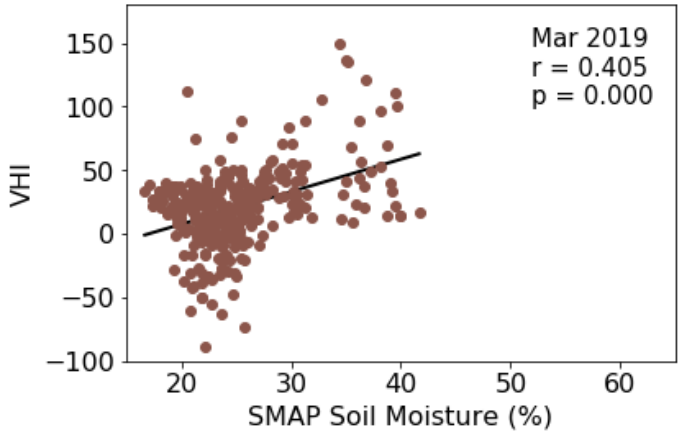
DROUGHT INDEX AND SOIL MOISTURE CORRELATION



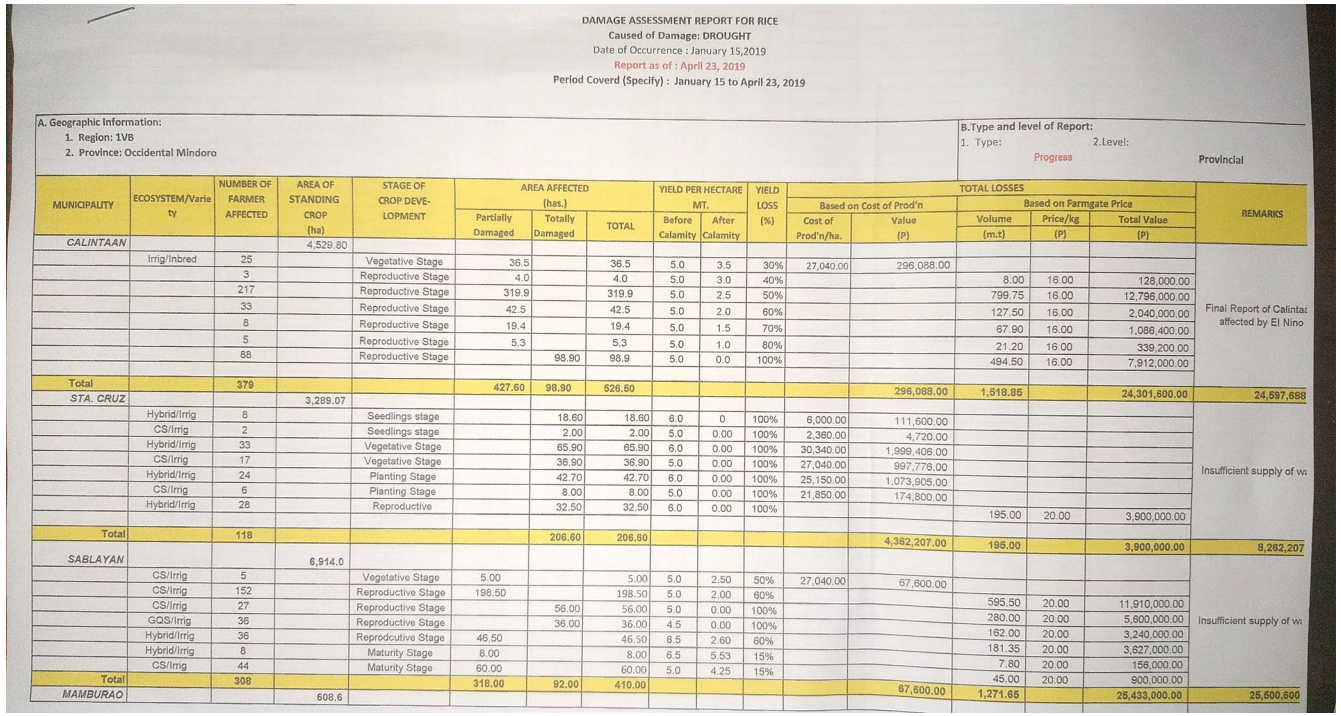








DROUGHT IMPACT ASSESSMENT



DAMAGE ASSESSMENT REPORT FOR RICE
Caused of Damage: DROUGHT
Date of Occurrence : January 15,2019
Report as of : April 23, 2019
Period Coverd (Specify) : January 15 to April 23, 2019

A. Geographic Information:
1. Region: 1VB
2. Province: Occidental Mindoro

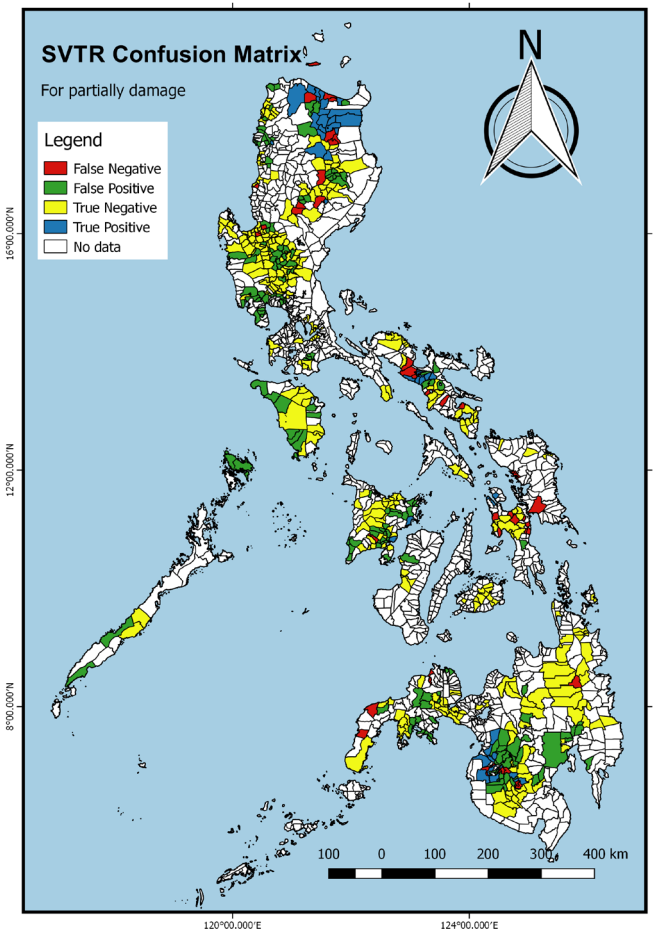
B.Type and level of Report:
1. Type: Progress 2.Level: Provincial

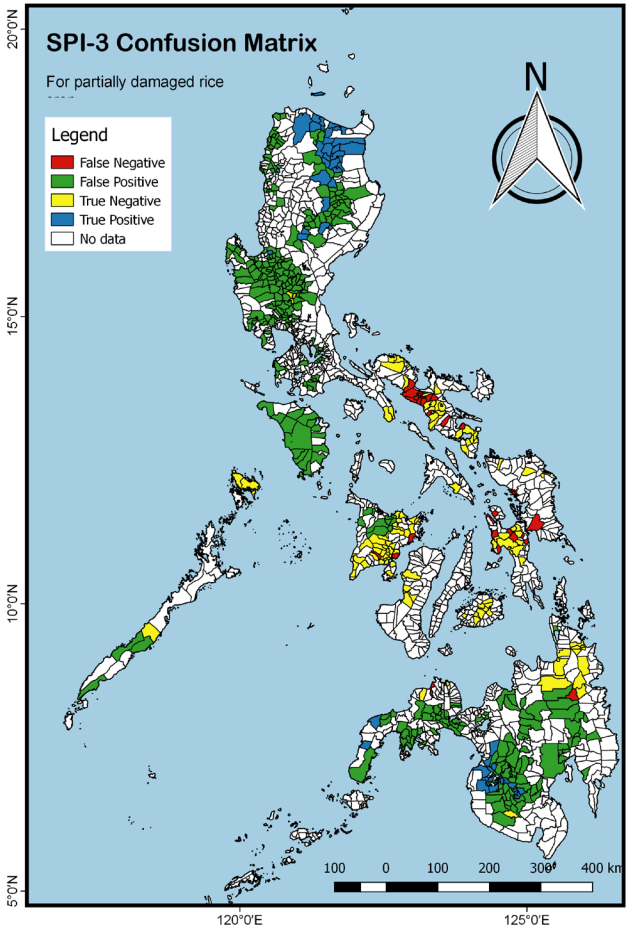
MUNICIPALITY	ECOSYSTEM/Variety	NUMBER OF FARMER AFFECTED	AREA OF STANDING CROP (ha)	STAGE OF CROP DEVE-LOPMENT	AREA AFFECTED (has.)			YIELD PER HECTARE MT.		YIELD LOSS (%)	TOTAL LOSSES				REMARKS
					Partially Damaged	Totally Damaged	TOTAL	Before Calamity	After Calamity		Based on Cost of Prod'n		Based on Farmgate Price		
											Cost of Prod'n/ha.	Value (P)	Volume (m.t)	Price/kg (P)	Total Value (P)	
CALINTAAN			4,529.80													
	Irrig/Inbred	25		Vegetative Stage	36.5		36.5	5.0	3.5	30%	27,040.00	296,088.00				Final Report of Calintaa affected by El Nino
		3		Reproductive Stage	4.0		4.0	5.0	3.0	40%			8.00	16.00	128,000.00	
		217		Reproductive Stage	319.9		319.9	5.0	2.5	50%			799.75	16.00	12,796,000.00	
		33		Reproductive Stage	42.5		42.5	5.0	2.0	60%			127.50	16.00	2,040,000.00	
		8		Reproductive Stage	19.4		19.4	5.0	1.5	70%			67.90	16.00	1,086,400.00	
		5		Reproductive Stage	5.3		5.3	5.0	1.0	80%			21.20	16.00	339,200.00	
		88		Reproductive Stage		98.90	98.9	5.0	0.0	100%			494.50	16.00	7,912,000.00	
Total		379			427.60	98.90	526.50					296,088.00	1,518.85		24,301,600.00	24,597,688
STA. CRUZ			3,289.07													
	Hybrid/Irrig	8		Seedlings stage		18.60	18.60	6.0	0	100%	6,000.00	111,600.00				Insufficient supply of w
	CS/Irrig	2		Seedlings stage		2.00	2.00	5.0	0.00	100%	2,360.00	4,720.00				
	Hybrid/Irrig	33		Vegetative Stage		65.90	65.90	6.0	0.00	100%	30,340.00	1,999,406.00				
	CS/Irrig	17		Vegetative Stage		36.90	36.90	5.0	0.00	100%	27,040.00	997,776.00				
	Hybrid/Irrig	24		Planting Stage		42.70	42.70	6.0	0.00	100%	25,150.00	1,073,905.00				
	CS/Irrig	6		Planting Stage		8.00	8.00	5.0	0.00	100%	21,850.00	174,800.00				
	Hybrid/Irrig	28		Reproductive		32.50	32.50	6.0	0.00	100%			195.00	20.00	3,900,000.00	
Total		118				206.60	206.60					4,362,207.00	195.00		3,900,000.00	8,262,207
SABLAYAN			6,914.0													
	CS/Irrig	5		Vegetative Stage	5.00		5.00	5.0	2.50	50%	27,040.00	67,600.00				Insufficient supply of w
	CS/Irrig	152		Reproductive Stage	198.50		198.50	5.0	2.00	60%			595.50	20.00	11,910,000.00	
	CS/Irrig	27		Reproductive Stage		56.00	56.00	5.0	0.00	100%			280.00	20.00	5,600,000.00	
	GQS/Irrig	36		Reproductive Stage		36.00	36.00	4.5	0.00	100%			162.00	20.00	3,240,000.00	
	Hybrid/Irrig	36		Reprodcutive Stage	46.50		46.50	6.5	2.60	60%			181.35	20.00	3,627,000.00	
	Hybrid/Irrig	8		Maturity Stage	8.00		8.00	6.5	5.53	15%			7.80	20.00	156,000.00	
	CS/Irrig	44		Maturity Stage	60.00		60.00	5.0	4.25	15%			45.00	20.00	900,000.00	
Total		308			318.00	92.00	410.00					67,600.00	1,271.65		25,433,000.00	25,500,600
MAMBURAO			608.6													

Data from Municipal Agriculture Officer - Mamburao, Occidental Mindoro

Data from DA-FAO

CROP DAMAGE ASSESSMENT

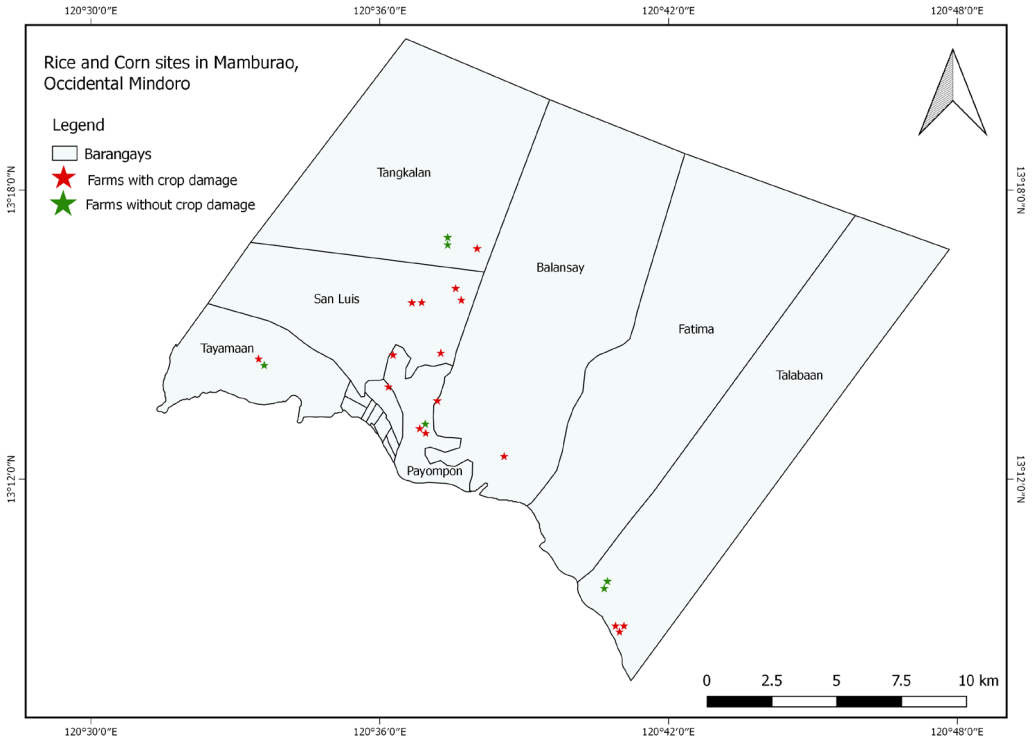


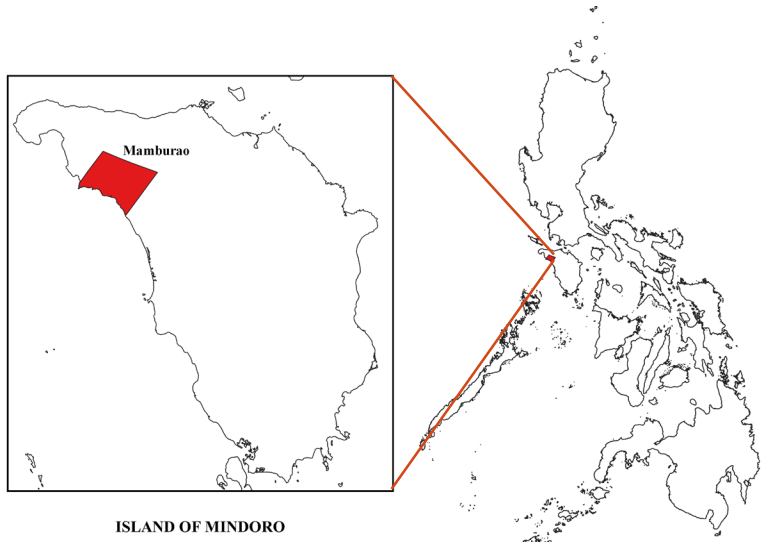


Ongoing collaborative work with DA-FAO, PHILRICE, and DOST-ASTI

VALIDATION OF DROUGHT-AFFECTED AREA

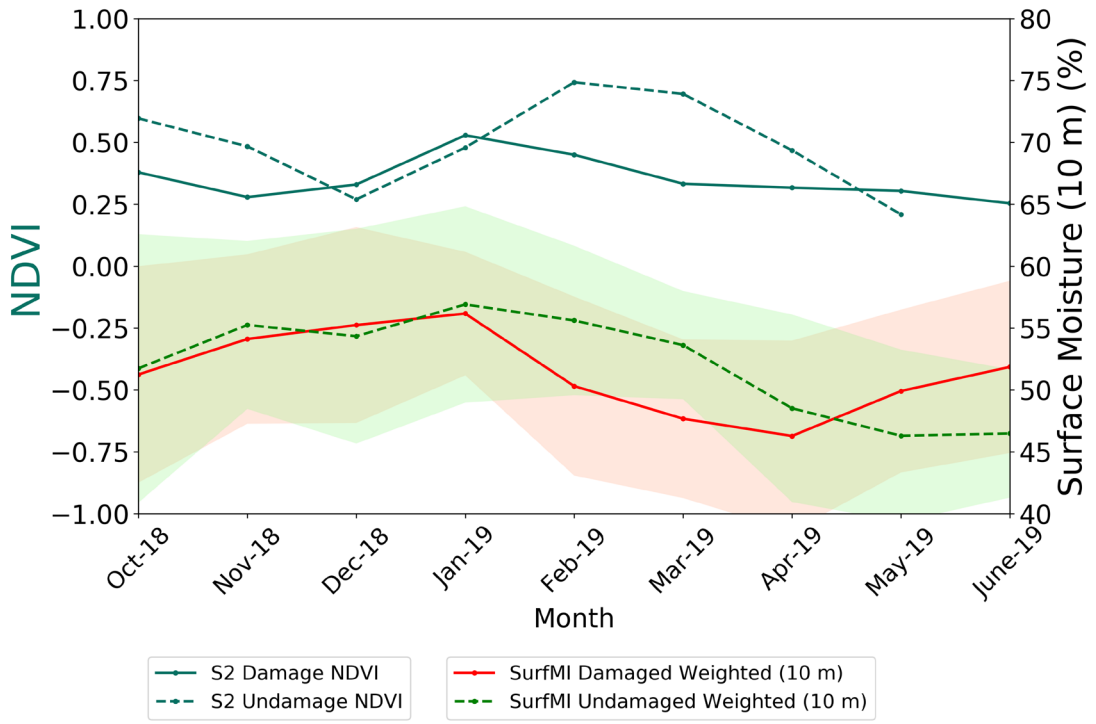
Case study in Mamburao, Occidental Mindoro, Philippines



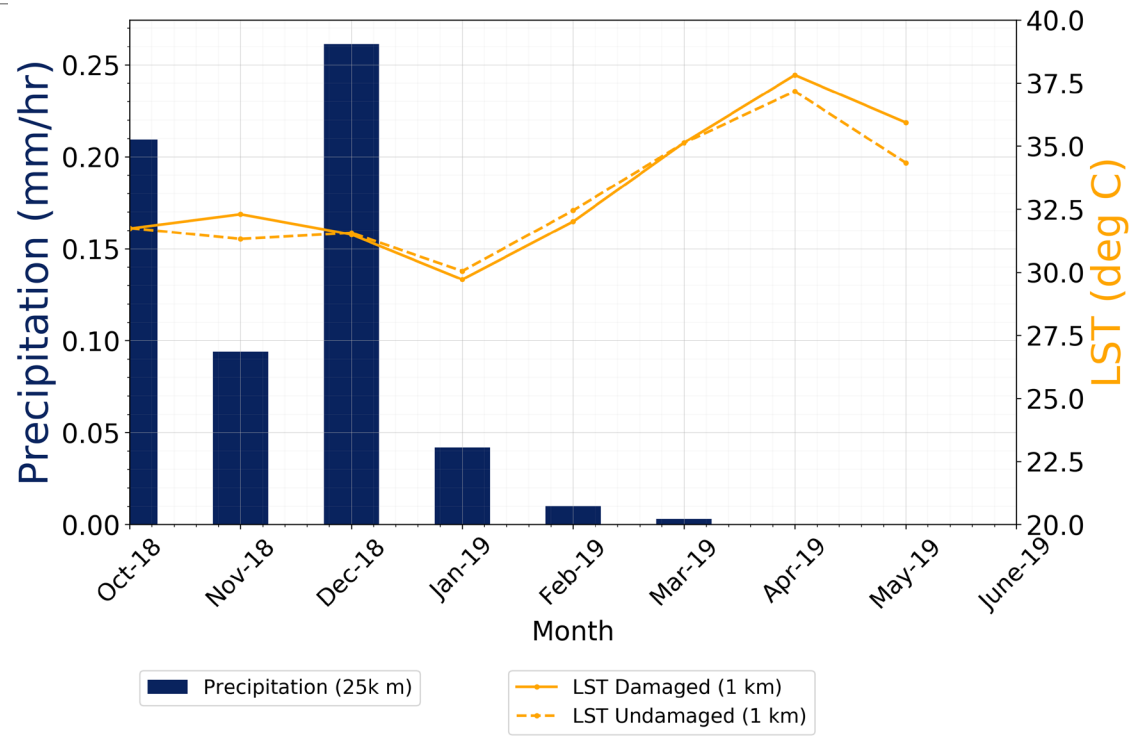


VALIDATION OF DROUGHT-AFFECTED AREA

Spatiotemporal dynamics of precipitation, soil moisture, temperature, and vegetation

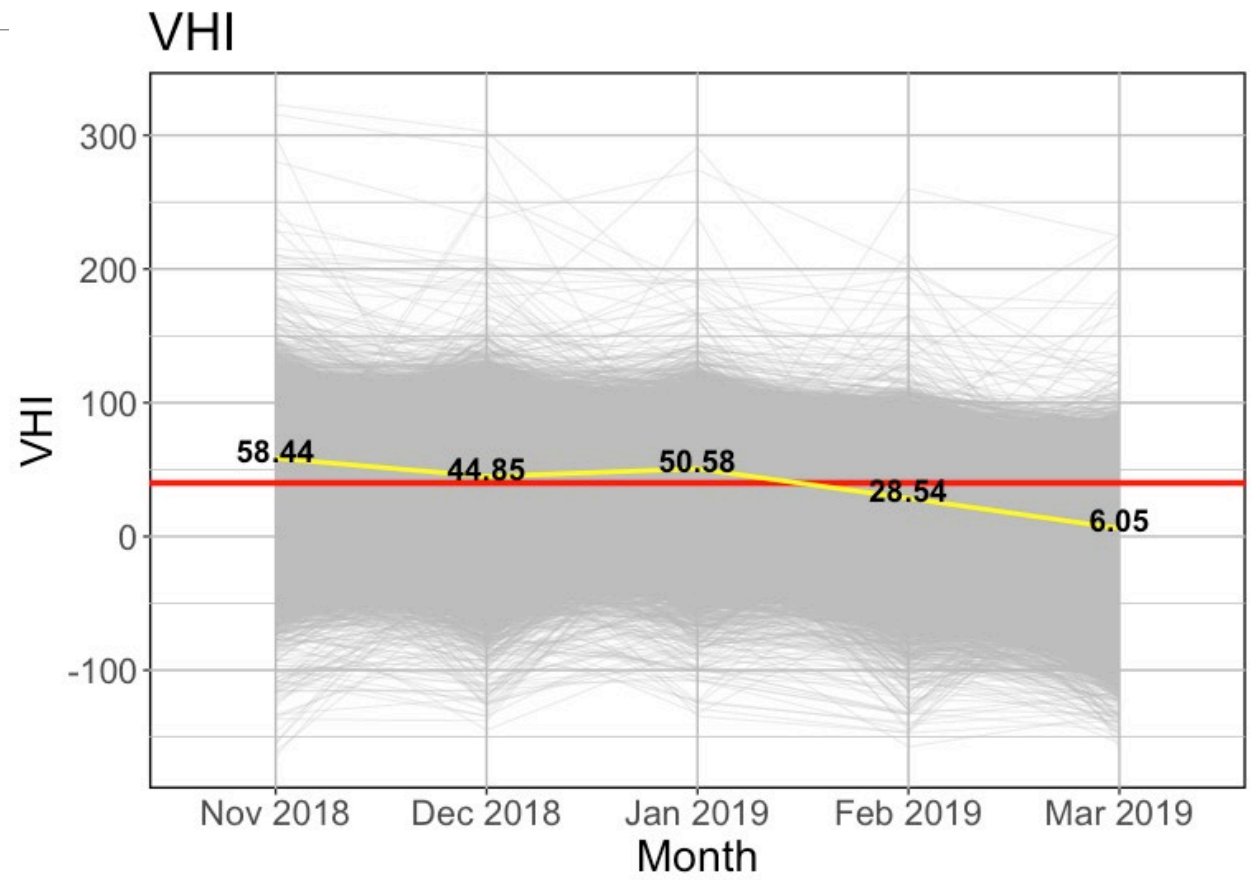


NDVI and soil moisture



Precipitation and Land Surface Temperature

VALIDATION OF DROUGHT-AFFECTED AREA



Conclusion

1. **DROUGHT PROGRESSION:**
   - ✓ Agricultural drought indices were congruent in terms of drought progression except for TVDI, while one-month lag was observed when using meteorological drought
2. **DROUGHT VERIFICATION:**
   - ✓ Drought indices are weakly correlated with satellite soil moisture
3. **DROUGHT DAMAGE ASSESSMENT:**
   - ✓ Drought drivers agree with reported damaged area
   - ✓ VHI successfully represents drought affected area

A combination of drought indices could provide a more robust metric in characterizing drought

Next Steps

- Relationship with crop damage reports – national scale
- Look at other soil moisture products
- Further investigate NDVI and LST relationship
- Effect of distinct climate types, localized studies
- More validation to adjust drought thresholds/classes