UNIVERSITY OF TWENTE.

CLIMATE CONDITIONS AND DROUGHT IMPACTS

JANNEKE ETTEMA, VASILY KOKOREV,
HARALD VAN DER WERFF

ITC FACULTY OF GEO-INFORMATION SCIENCE AND EARTH OBSERVATION

OBJECTIVE

- To showcase you what research ITC does on drought, and what is still to be done
- Be inspirational to you all, to be curious and explorative

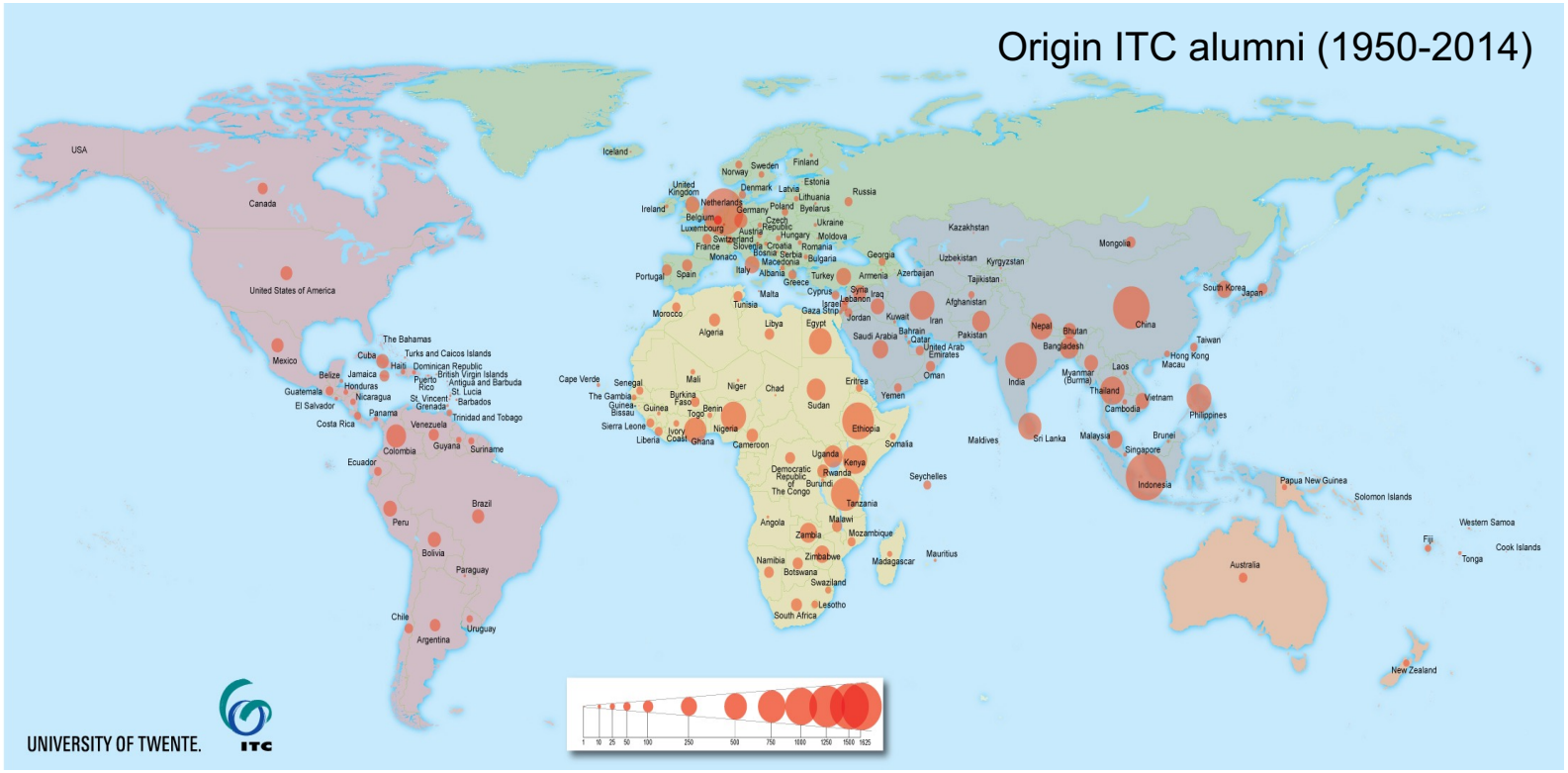
CONTENT

- Introduction on ITC
- My curiosity: joint research – weather impact / time aspect in geological remote sensing
- My inspiration: IPCC report
- My contribution: example PhD student research on precipitation regime changes in Maritime Continent
- My goals

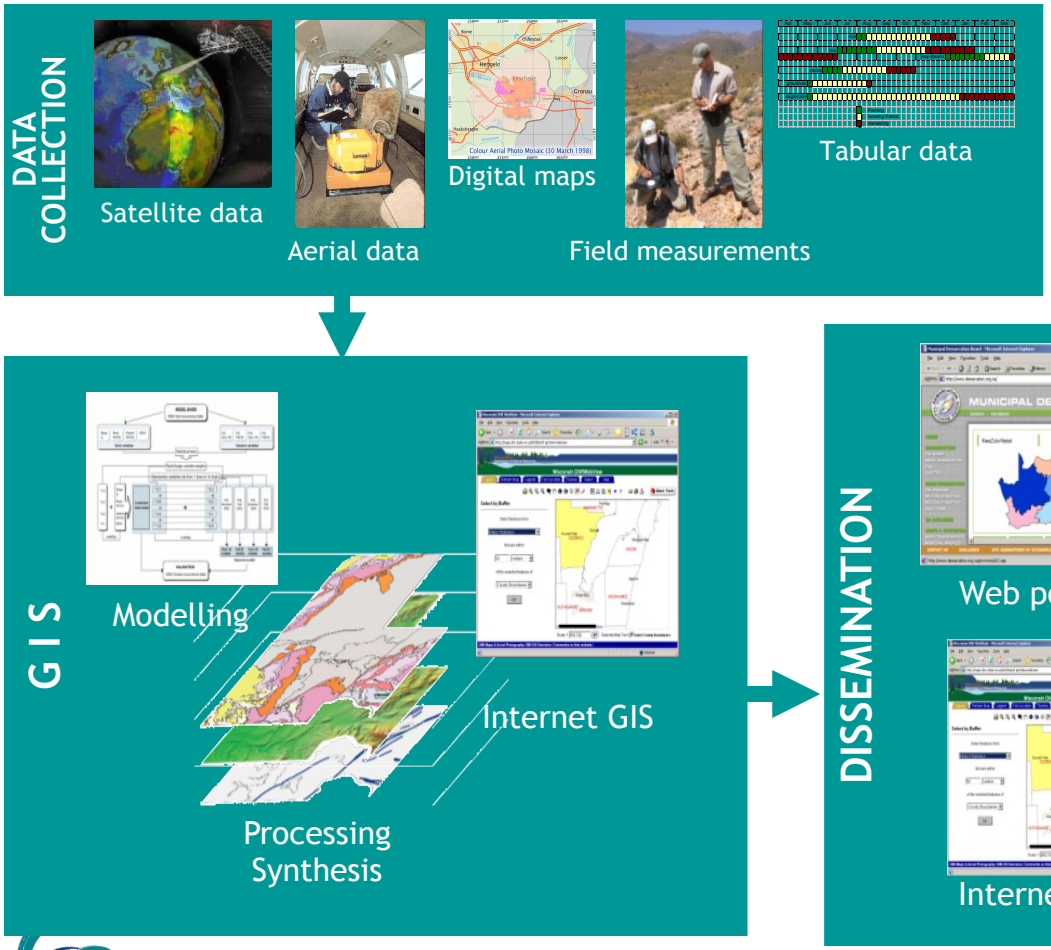
ITC – FACULTY OF GEO-INFORMATION SCIENCE AND EARTH OBSERVATION

Mission:

Development and transfer of knowledge in geo-information science and earth observation



ITC - KNOWLEDGE FIELDS



Research themes	
Geo-information Processing	Space for Global development
Earth Observation Science	
Earth Systems Analyses	
Natural Resources	
Urban and Regional Planning and Geo-information Management	
Water Resources	

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Climate data is a data layer in GIS and/or a model

DEPARTMENT ESA – EARTH SYSTEM ANALYSIS

- MSc M-GEO 2 specializations:
  - NHR: Natural Hazard and Disaster Risk Reduction
  - ARS: Applied Remote Sensing for Earth Sciences
- MSc M-SE: case study on man-made earthquake risk Groningen
- TMT trainings Hazard and Risk assessment, some with GISTDA
- *https://www.itc.nl*

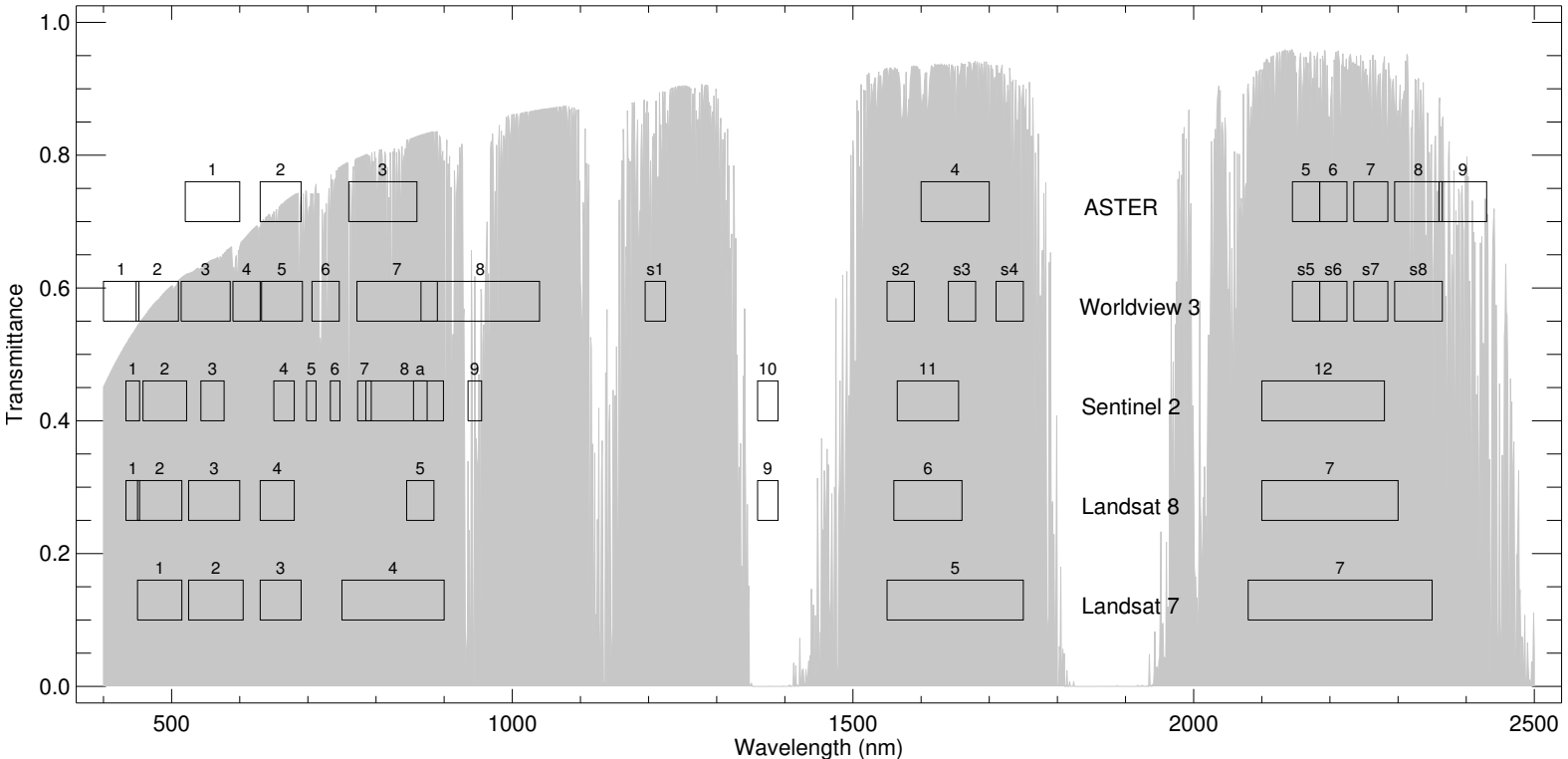
ME – DR. IR. JANNEKE ETTEMA – METEOROLOGIST

- MSc Soil, Water and Atmosphere, Wageningen University,
- Phd Greenland Regional Climate Modelling, Utrecht University
- 2001-2003: Consultant KNMI (Royal Netherlands Meteorological Institute)
- 2003-2005: Consultant ECMWF (European Centre for Medium Range Forecasts), Reading, UK
- 2010-present: Assistant Professor, ITC, University of Twente
  - Education: Weather Impact Analysis
  - Research: weather as trigger for natural disasters
  - UT Teaching and Learning Fellow (2021-2023)

What drives me: curiosity and wanting to understand things

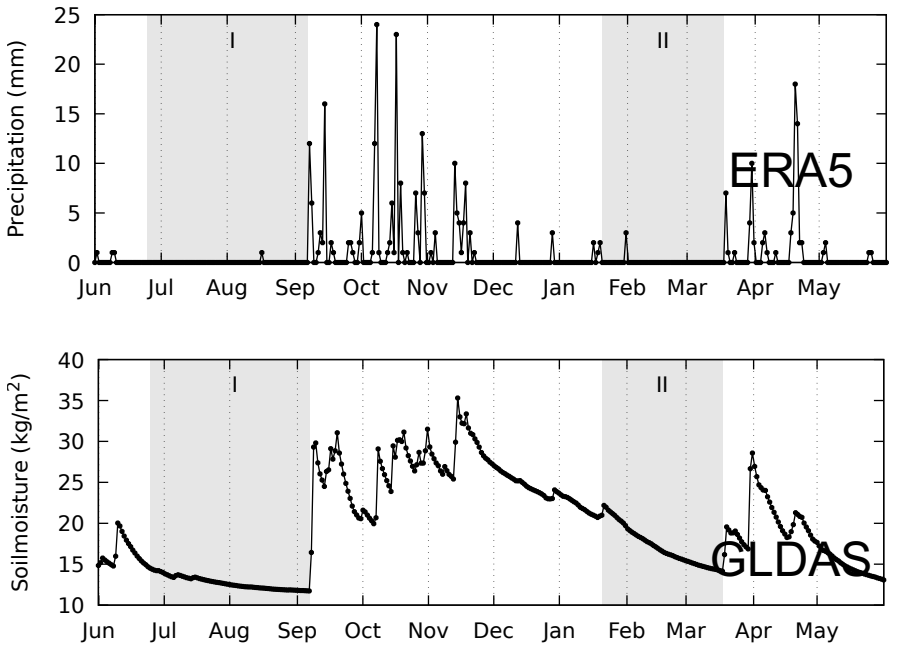
MAPPING MINERAL INDICES IN A SEMI-ARID AREA, USING SATELLITE IMAGE

- Problem statement:
  - Geological mapping at national or continental scales needs multi-temporal imagery
  - Mapping over time, the measuring environment will change



CHANGING ENVIRONMENT – SEMI ARID REGION

[Rodalquilar, Cabo de Gata, Almeria, Spain]



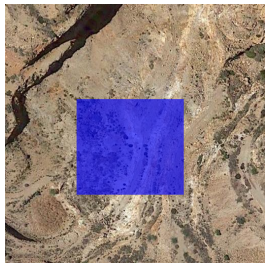
Geologists assume that any no rain/cloud image is gives high quality mapping of mineral indices

Our hypothesis: changing weather conditions do imply noise in the mapping

CHANGES IN VEGETATION AND FERRIC IRON OXIDE

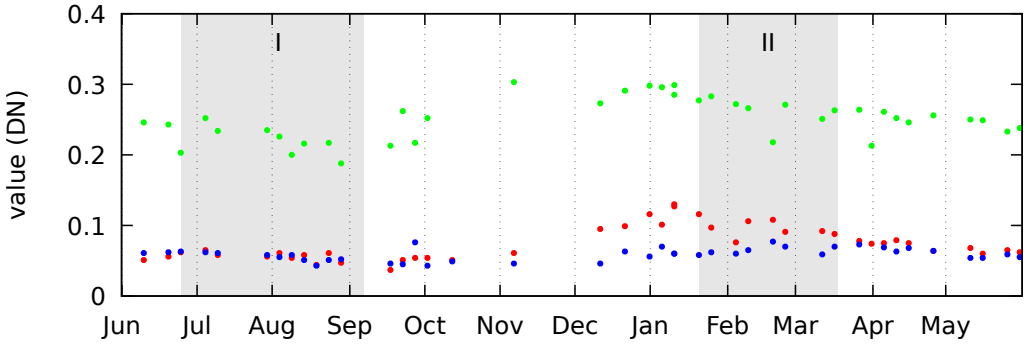
(a) Bare soil

(b) Natural vegetation



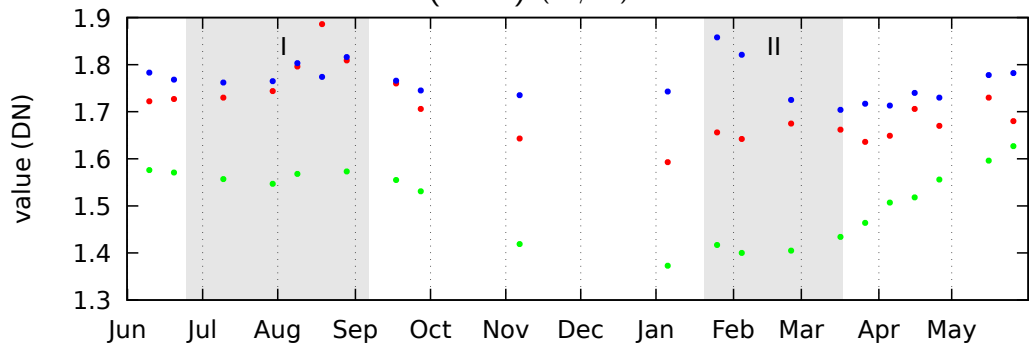
(c) Former quarry

Soil Adjusted Vegetation Index ($L * (b8 - b4)/(b8 + b4)$; with $L = 1.5$)



[legend: dry periods – bare soil – natural vegetation – abandoned quarry]

Ferric iron oxide (Fe^{3+}) ($b4/b3$)



[legend: dry periods – bare soil – natural vegetation – abandoned quarry]

DISCUSSION & CONCLUSION

- Changing environment might interfere with multi-temporal mapping
- Look at weather conditions when studying the surface
- Atmospheric correction is not yet studied
- Automated processing might lead to considerable (unwanted) variation in resulting products

- *Realization & my curiosity:*
  - *More and more satellite imagery becomes available, with new research potential*
  - *Know the drawbacks of the product you are using, and check whether it fits its purpose*

MY INSPIRATION: IPCC ASSESSMENT REPORT 6 (2021)

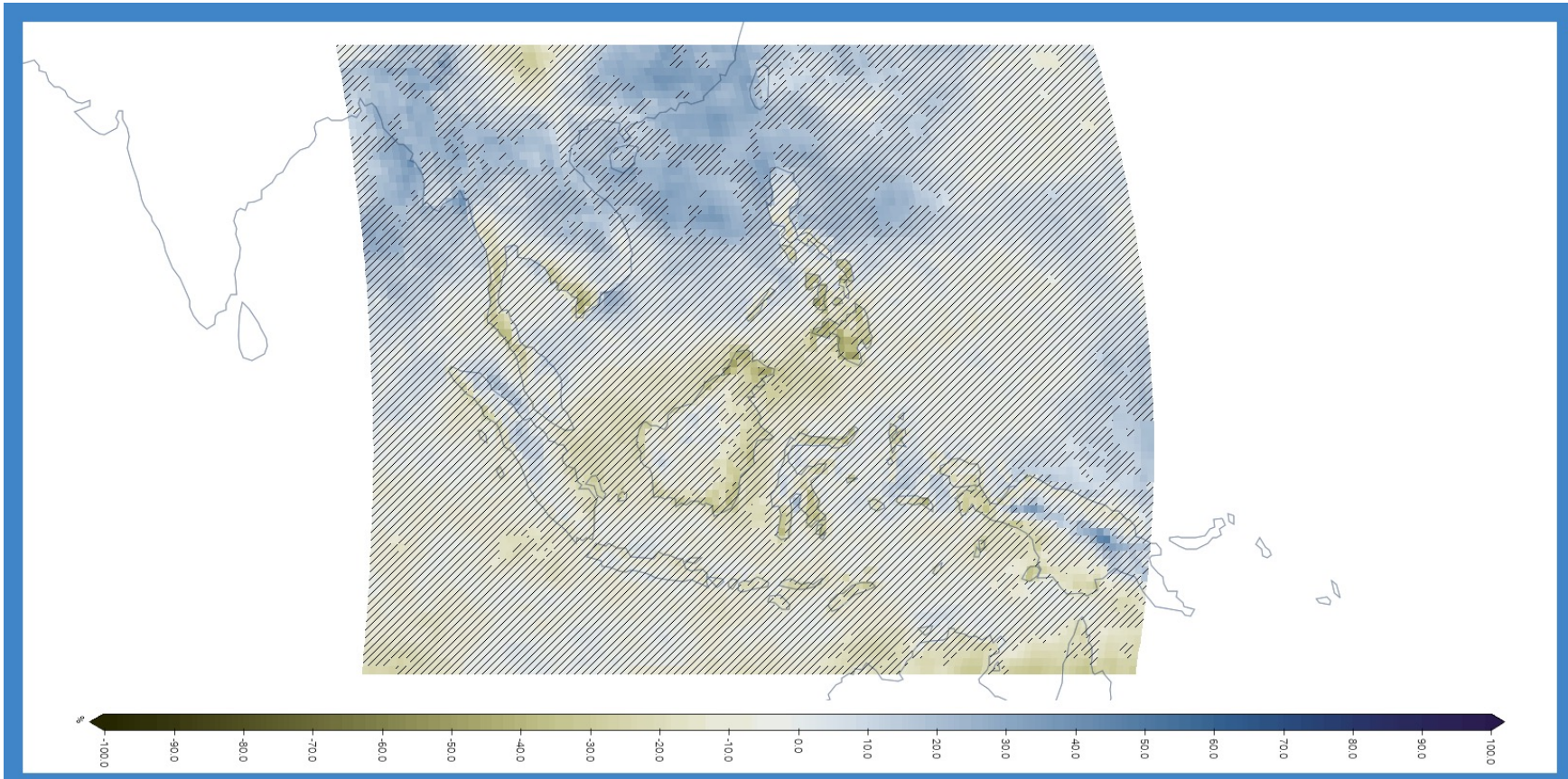
- “One of the key developments since the IPCC’s last assessment report in 2013-14 is the strengthening of the links between human-caused warming and increasingly severe extreme weather, the authors say. This is now “an established fact”, they write.”

- “Continued global warming is projected to further intensify the global water cycle, including its variability, global monsoon precipitation and the severity of wet and dry events."

- *In total, the report runs to around 3,000 pages and references more than 14,000 scientific papers*

IPCC WG1 INTERACTIVE ATLAS

- https://interactive-atlas.ipcc.ch



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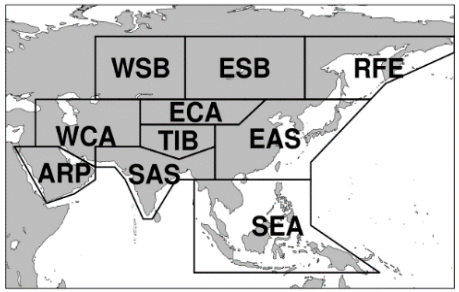
WHAT DOES IPCC SAY ON DROUGHT IMPACT?

- "The attribution of observed changes in extremes to human influence (including greenhouse gas and aerosol emissions and land-use changes) has substantially advanced since AR5, in particular for extreme precipitation, droughts, tropical cyclones, and compound extremes (*high confidence*)."
  - "A warmer climate increases moisture transport into weather systems, which on average, makes wet seasons and events wetter *(high confidence)"*
  - "Warming over land drives an increase in atmospheric evaporative demand and the severity of droughts (*high confidence)"*

CLIMATIC IMPACT-DRIVERS IN ASIA, IPCC (2021)



Region	Climatic Impact-Driver: Heat and Cold				Wet and Dry								Wind				Snow and Ice						Coastal & Oceanic					Other		
	Mean air temperature	Extreme heat	Cold spell	Frost	Mean precipitation	River flood	Heavy precipitation and pluvial flood	Landslide	Aridity	Hydrological drought	Agricultural and ecological drought	Fire weather	Mean wind speed	Severe wind storm	Tropical cyclone	Sand and dust storm	Snow, glacier and ice sheet	Permafrost	Lake, river and sea ice	Heavy snowfall and ice storm	Hail	Snow avalanche	Relative sea level	Coastal flood	Coastal erosion	Marine heatwave	Ocean acidity	Air pollution weather	Atmospheric CO_2 at surface	Radiation at surface
Arabian Peninsula (ARP)	●	●	○																				○		1		○		●	
West Central Asia (WCA)	●	●	○		5																		○		1,2		○		●	
West Siberia (WSB)	●	●	○		○		○											●											●	
East Siberia (ESB)	●	●	○		○		○											●											●	
Russian Far East (RFE)	●	●	○		○		○											●					○		1,2		○		●	
East Asia (EAS)	●	●	○				○								3								○		1,2		○		●	
East Central Asia (ECA)	●	●	○															●											●	
Tibetan Plateau (TIB)	●	●	○															●											●	
South Asia (SAS)	●	●	○															●					○		1		○		●	
South East Asia (SEA)	●	●	○		4										3								○		1,2		○		●	

1. Along sandy coasts and in the absence of additional sediment sinks/sources or any physical barriers to shoreline retreat.
2. Substantial parts of the EAS and SEA coasts are projected to prograde if present-day ambient shoreline change rates continue
3. Tropical cyclones decrease in number but increase in intensity
4. High confidence of decrease in Indonesia (Atlas.5.4.5)
5. Medium confidence of decreasing in summer and increasing in winter

- ● Already emerged in the historical period (*medium to high confidence*)
- ○ Emerging by 2050 at least in Scenarios RCP8.5/SSP5-8.5 (*medium to high confidence*)
- ○ Emerging after 2050 and by 2100 at least in Scenarios RCP8.5/SSP5-8.5 (*medium to high confidence*)

Key
High confidence of decrease
Medium confidence of decrease
Low confidence in direction of change
Medium confidence of increase
High confidence of increase
Not broadly relevant

DROUGHT IN ASIA (IPCC, 2021)

- “There is increased evidences and high confidence of more frequent heat extremes in the recent decades than in previous ones in most of Asia due to anthropogenic global warming, El Niño and urbanization”

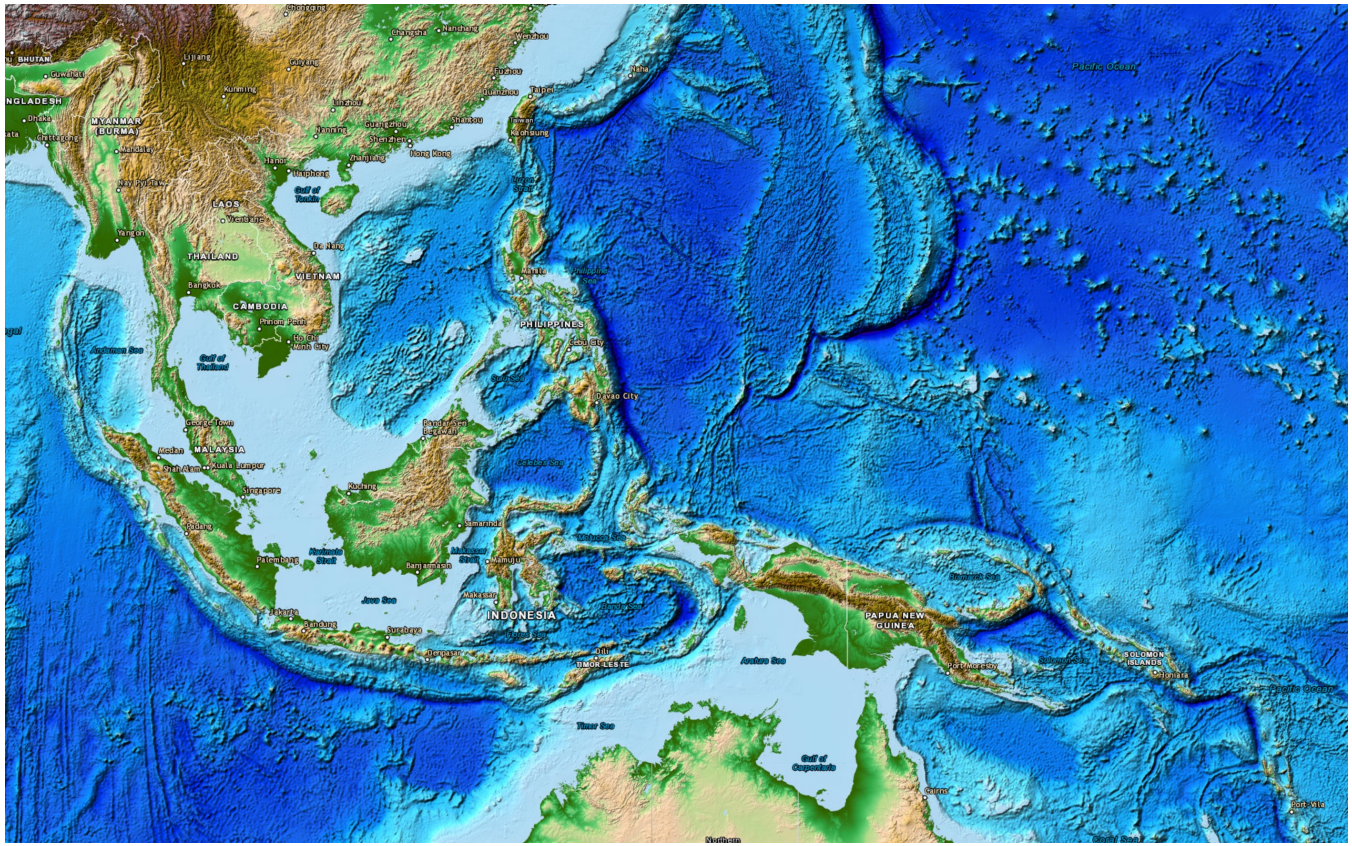
- “Human activities such as reservoir operation and water abstraction have had a profound effect on low river flow characteristics and drought impacts in many Asian regions”

- “However, broader changes in droughts could not be determined in Asia due to the mixture of total precipitation signals together with temperature increase patterns”

MY CONTRIBUTION TO CLIMATE CONDITIONS AND DROUGHT IMPACT

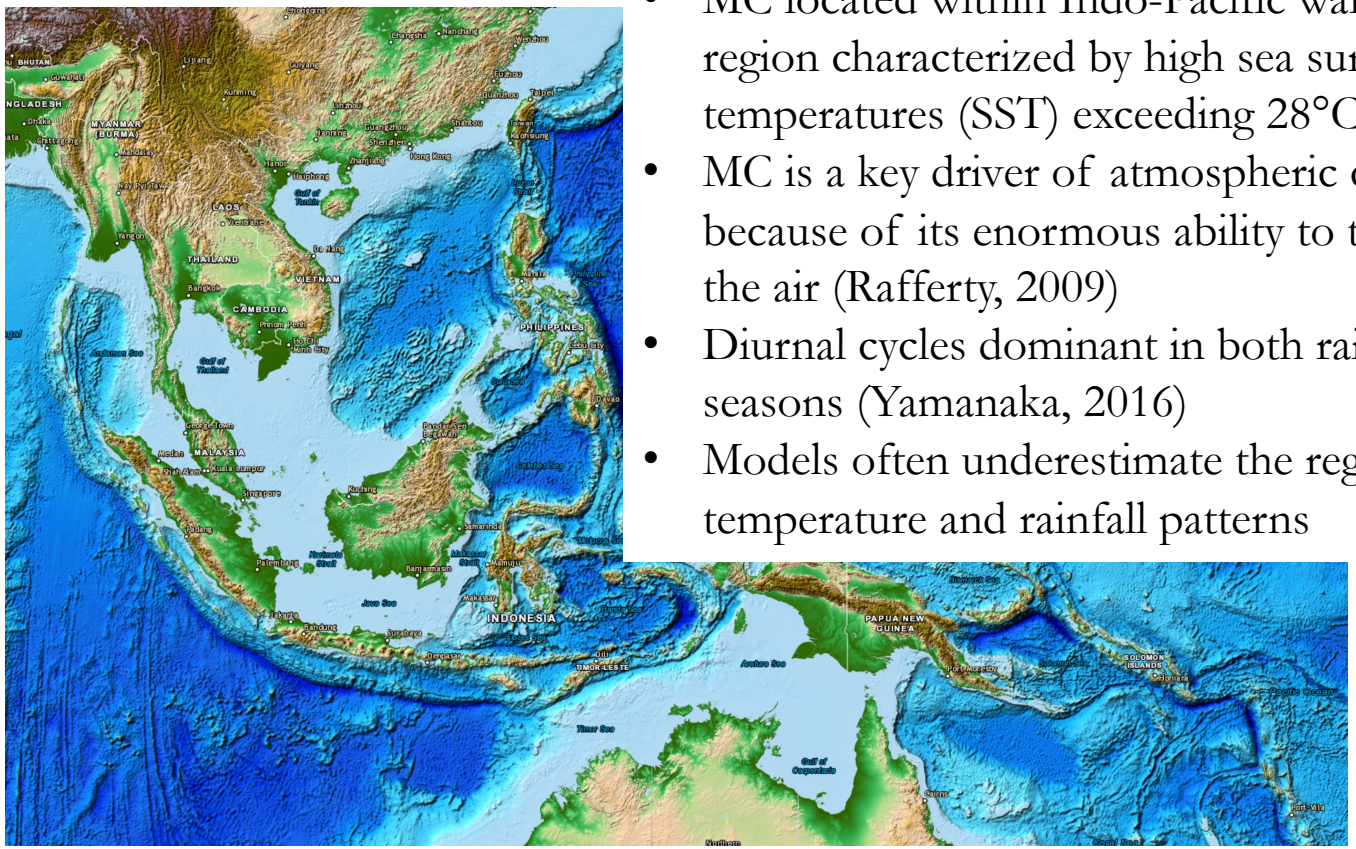
- Education: Teaching, discussing, and exploring our knowledge and defining its gaps
- Research: jointly with MSc students and PhD students, a more integrated disaster management perspective

PHD VASILY KOKOREV: MARITIME CONTINENT



Basemap - ETOPO1 obtained via https://maps.ngdc.noaa.gov/viewers/bathymetry/

PHD VASILY KOKOREV: MARITIME CONTINENT

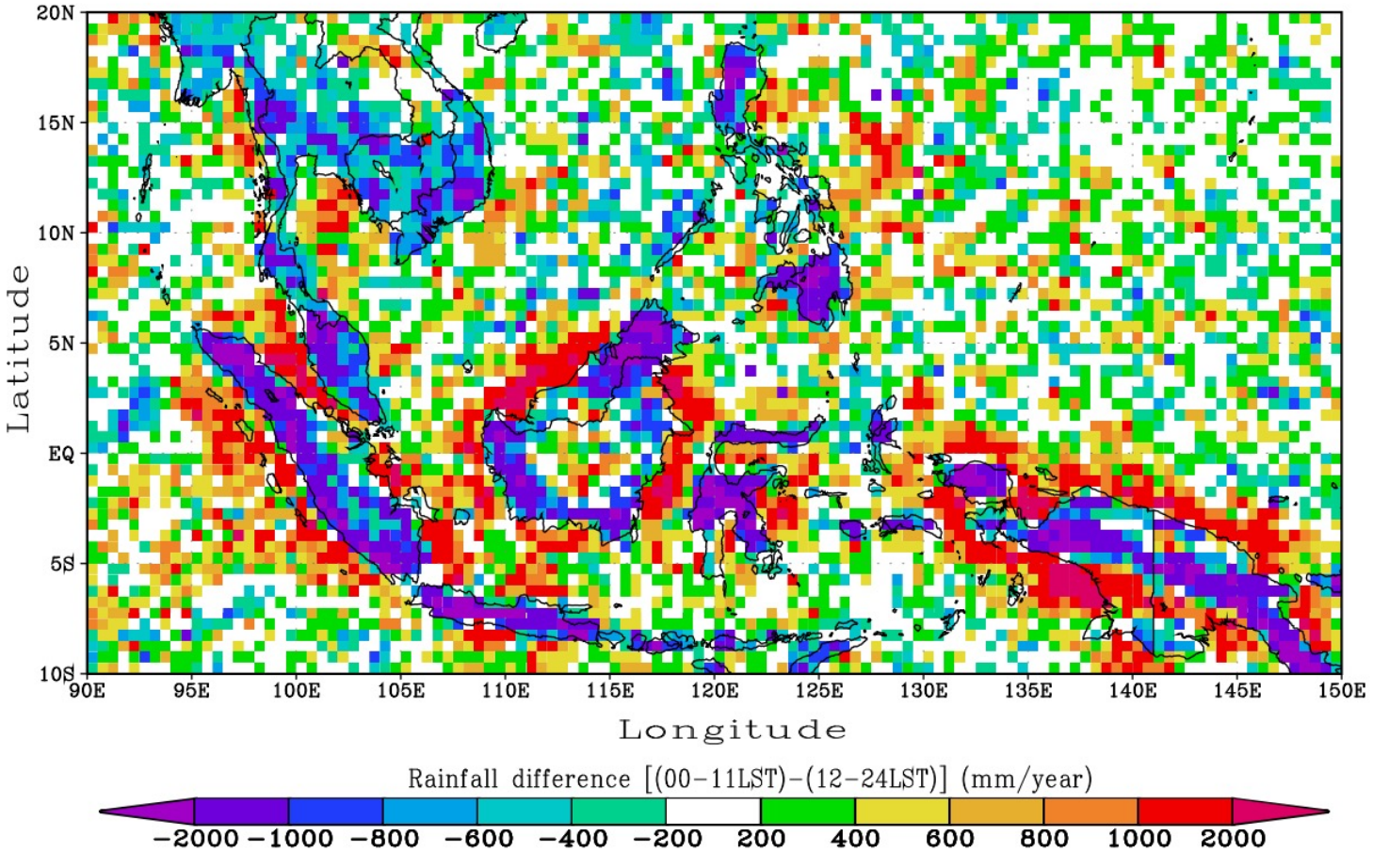


- Thousands of islands of various sizes
- MC located within Indo-Pacific warm pool, a region characterized by high sea surface temperatures (SST) exceeding 28°C
- MC is a key driver of atmospheric circulation because of its enormous ability to transfer heat to the air (Rafferty, 2009)
- Diurnal cycles dominant in both rainy and dry seasons (Yamanaka, 2016)
- Models often underestimate the region's true temperature and rainfall patterns

Basemap - ETOPO1 obtained via https://maps.ngdc.noaa.gov/viewers/bathymetry/

DOMINATION OF DIURNAL CYCLE

AM-PM differences of 3-year TRMM-PR *(Mori et al., 2004)*



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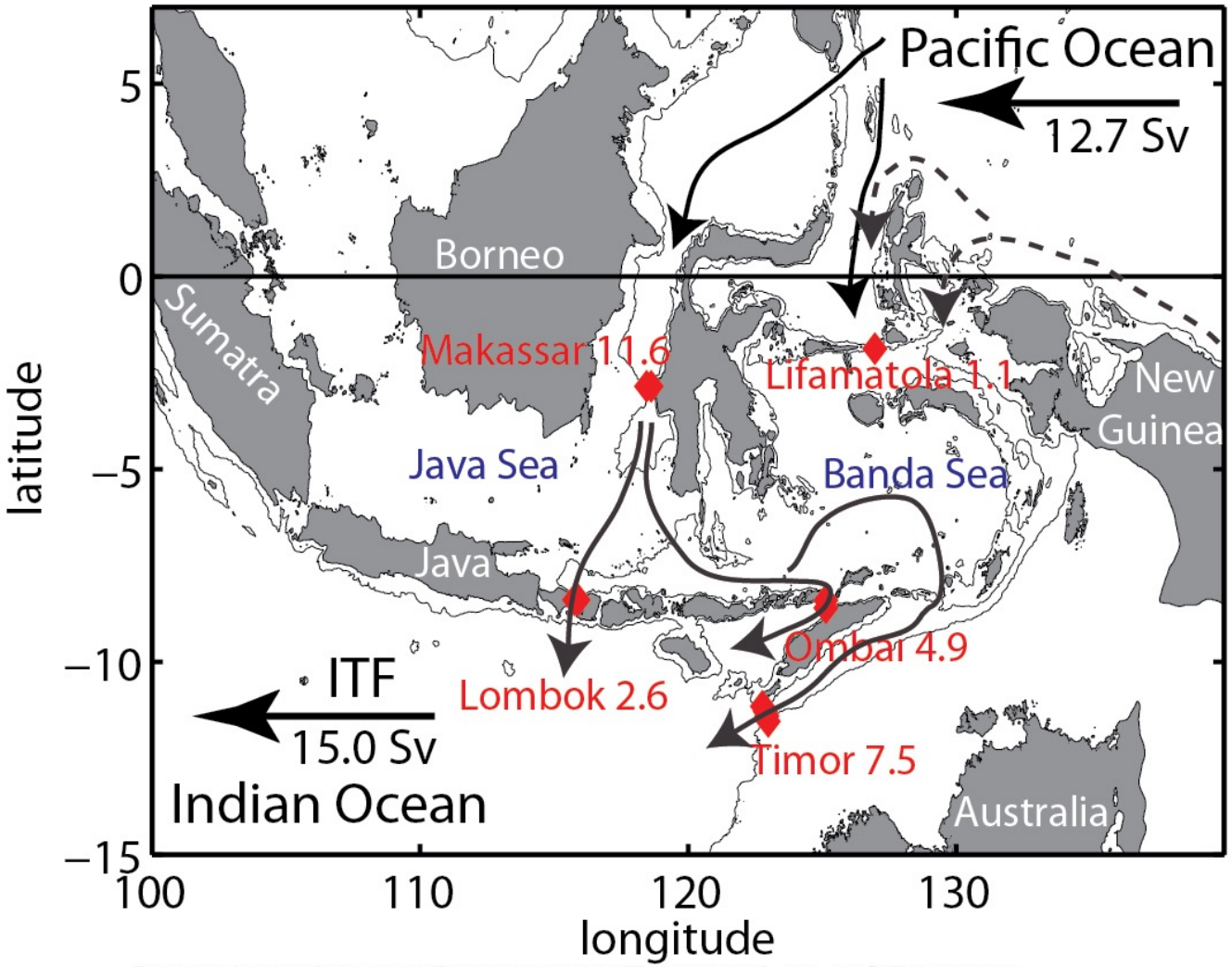
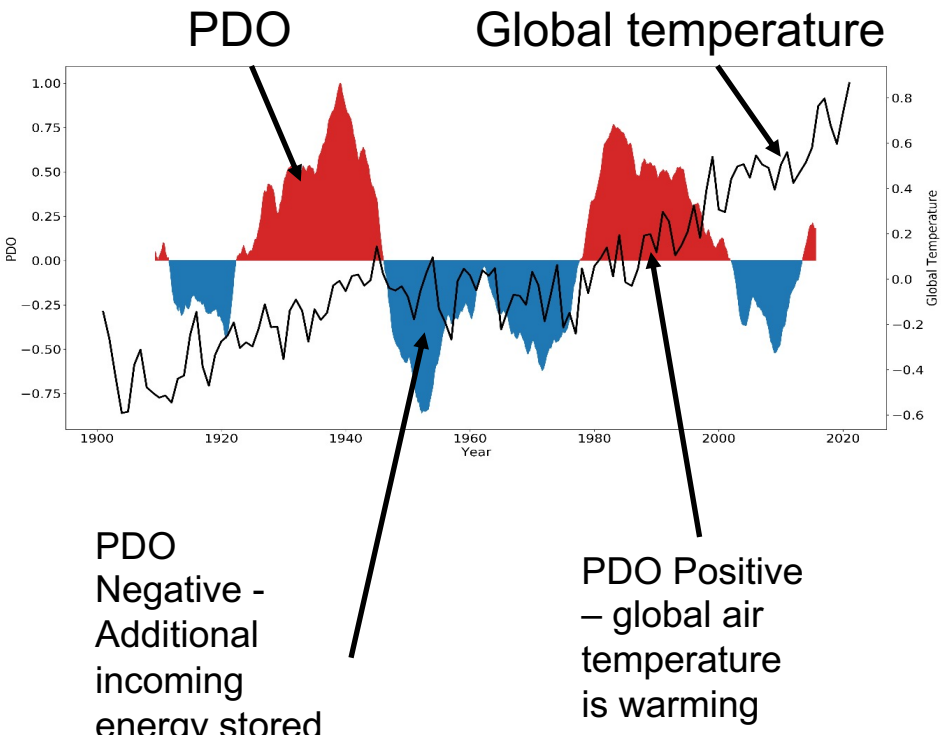
MARITIME CONTINENT: CURRENTS



Transport values from Sprintall et. al., "Direct estimates of the ITF entering the IO: 2004-2006", JGR Oceans. 2009

PACIFIC DECADAL OSCILLATION (PDO) MODULATE PRECIPITATION REGIME



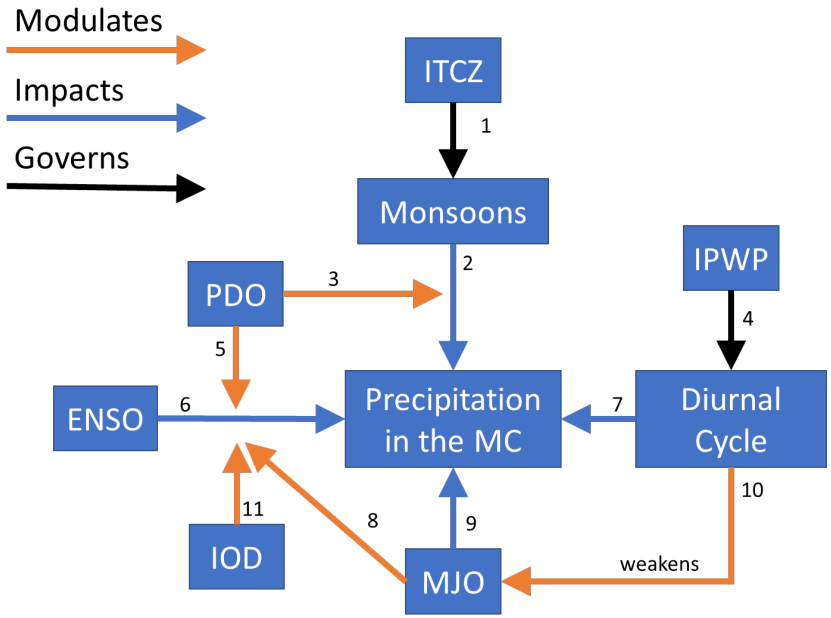


Diagram showing the main processes affecting precipitation in the MC. 1,2- (Yamanaka, 2016), 3 - (Wang et al., 2008, Kim et al., 2013), 4- (Ruppert and Johnson, 2016), 5-(Kokorev et al., 2020, Wang et al., 2014, Hu and Huang, 2009), 6- (Hendon, 2003, Supari et al., 2018), 7 - (Yamanaka, 2016), 8-(Tang and Yu, 2008, Hendon et al., 2007), 9- (Jones et al., 2004)-, 10 -(Roxy et al., 2019, Tian et al., 2006), 11- (Nur'utami and Hidayat, 2016)

DATA

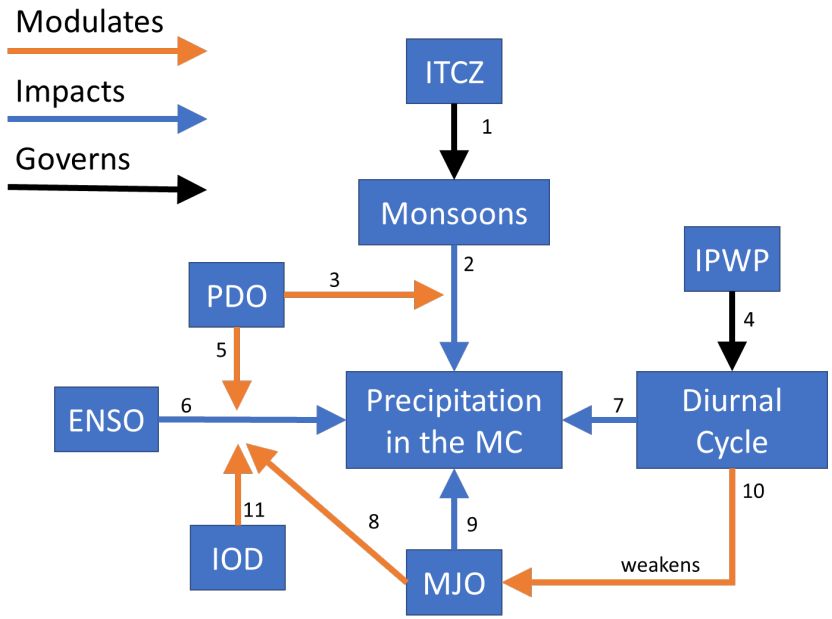
- Gridded precipitation 1901-2014 from CRU TS4
- Gridded SST 1901-2014 from NOAA ERSST v.4
- PDO and Nino 3.4 index from KNMI climate explorer
- SACA&D observational dataset
- CMIP6 models output

HYPOTHESIS1:

Pacific Decadal Oscillation phase modulates El-Niño Southern Oscillation impacts causing stronger/weaker rainfall in the Maritime Continent

"When in phase with the PDO, ENSO-induced dry–wet changes are magnified with respect to the canonical pattern. When out of phase, these dry–wet variations weaken or even disappear."

Wang, S., et al. (2014). "Combined effects of the Pacific Decadal Oscillation and El Nino-Southern Oscillation on global land dry-wet changes." Sci Rep 4: 6651.



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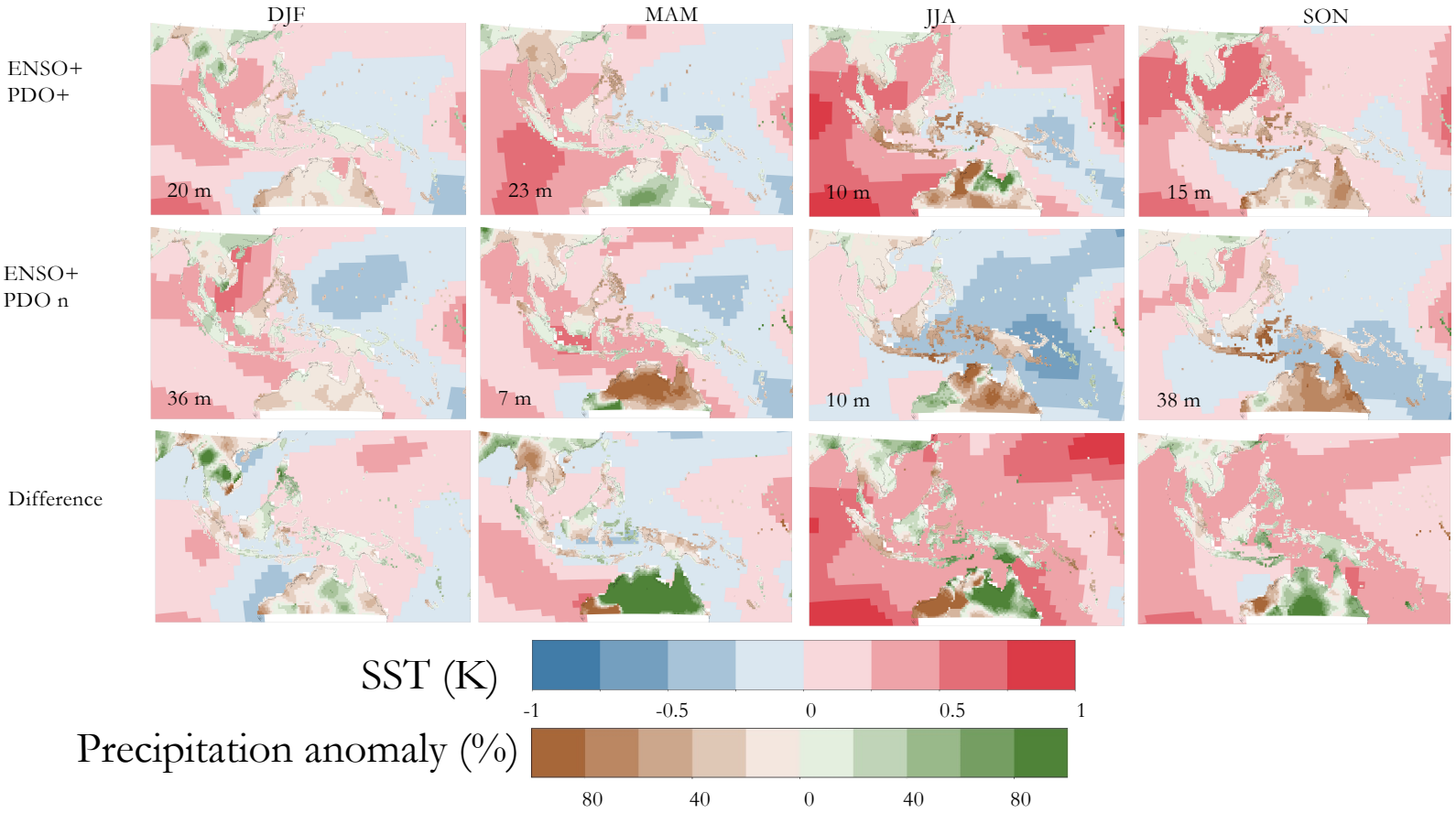
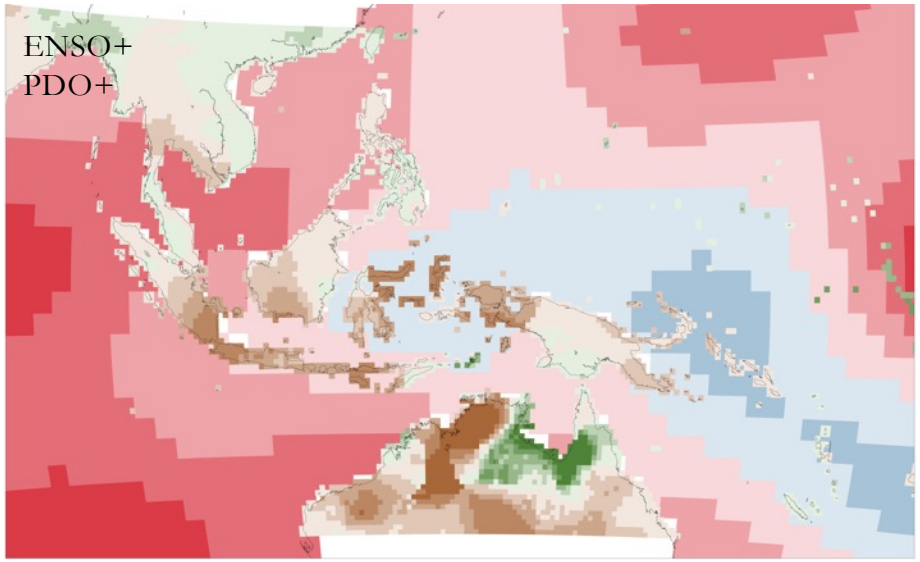
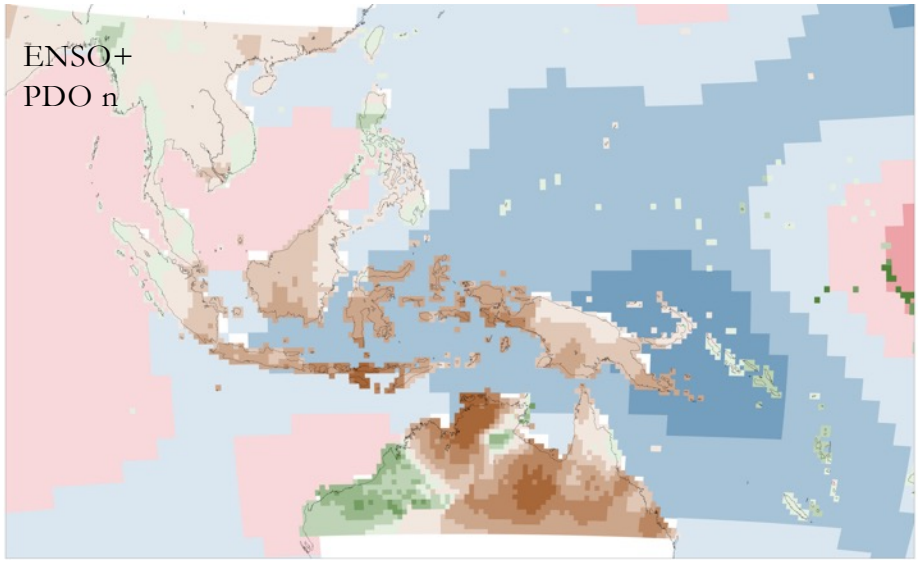
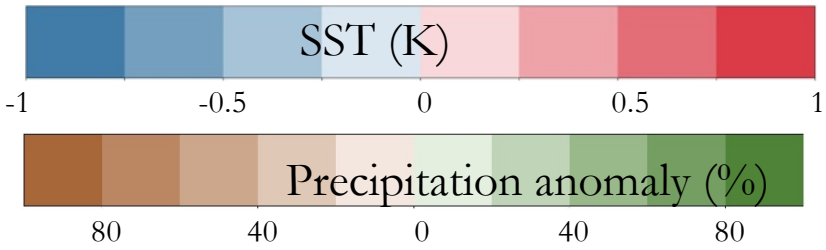
MEAN PRECIPITATION ANOMALIES, IN PHASE POSITIVE ENSO

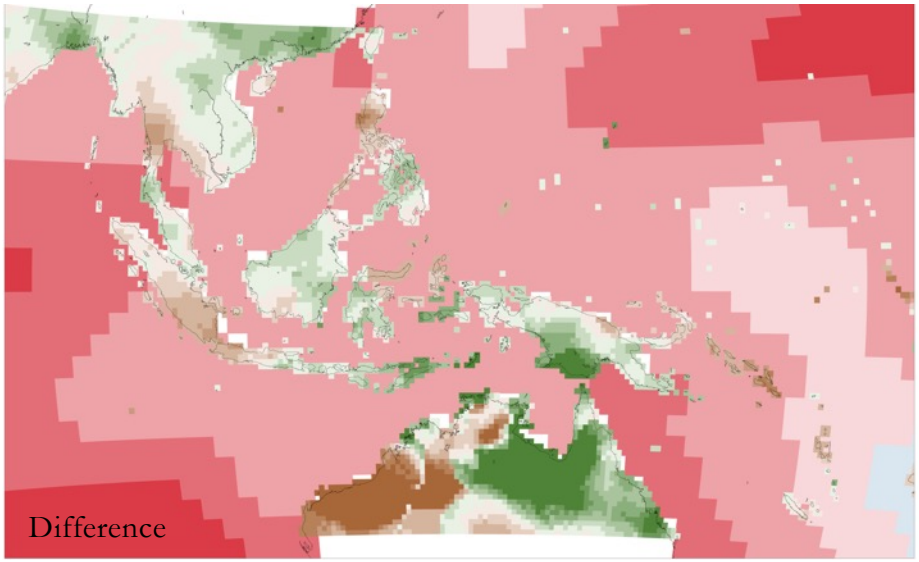


MEAN PRECIPITATION ANOMALIES, IN PHASE POSITIVE ENSO DURING JJA









Positive PDO weakens the negative precipitation impact of ENSO in season JJA

HYPOTHESIS 2:

- PDO phase change cause rapid shift in precipitation regime in the MC

- Method: Bayesian Regime shift detection
- Dataset: SACA&D daily observed precipitation

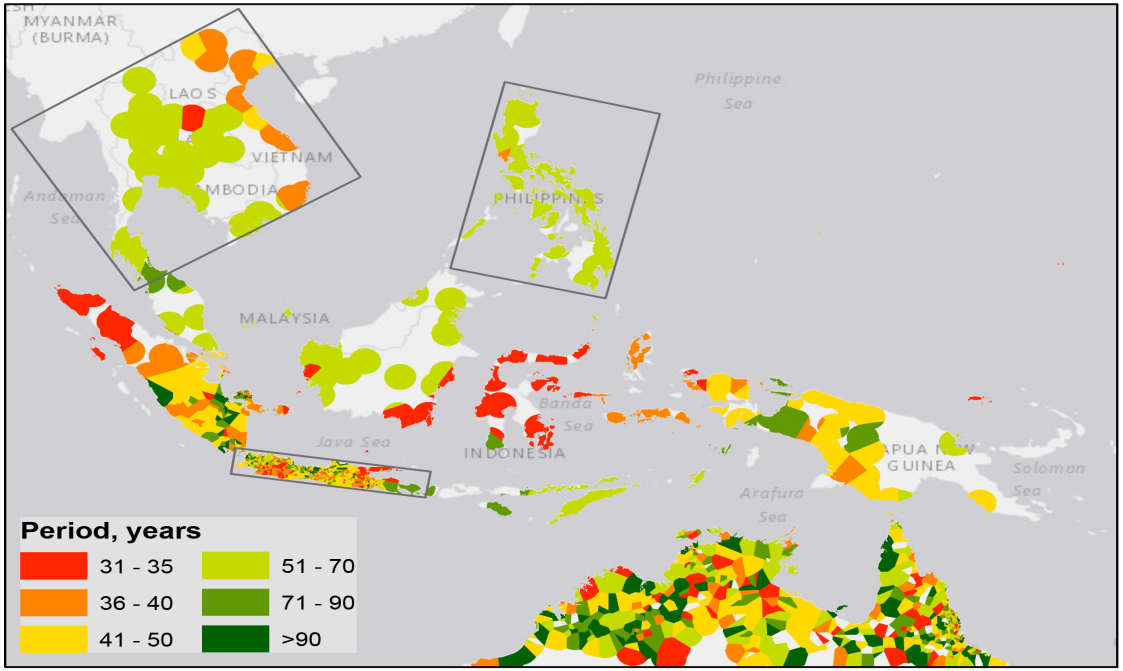
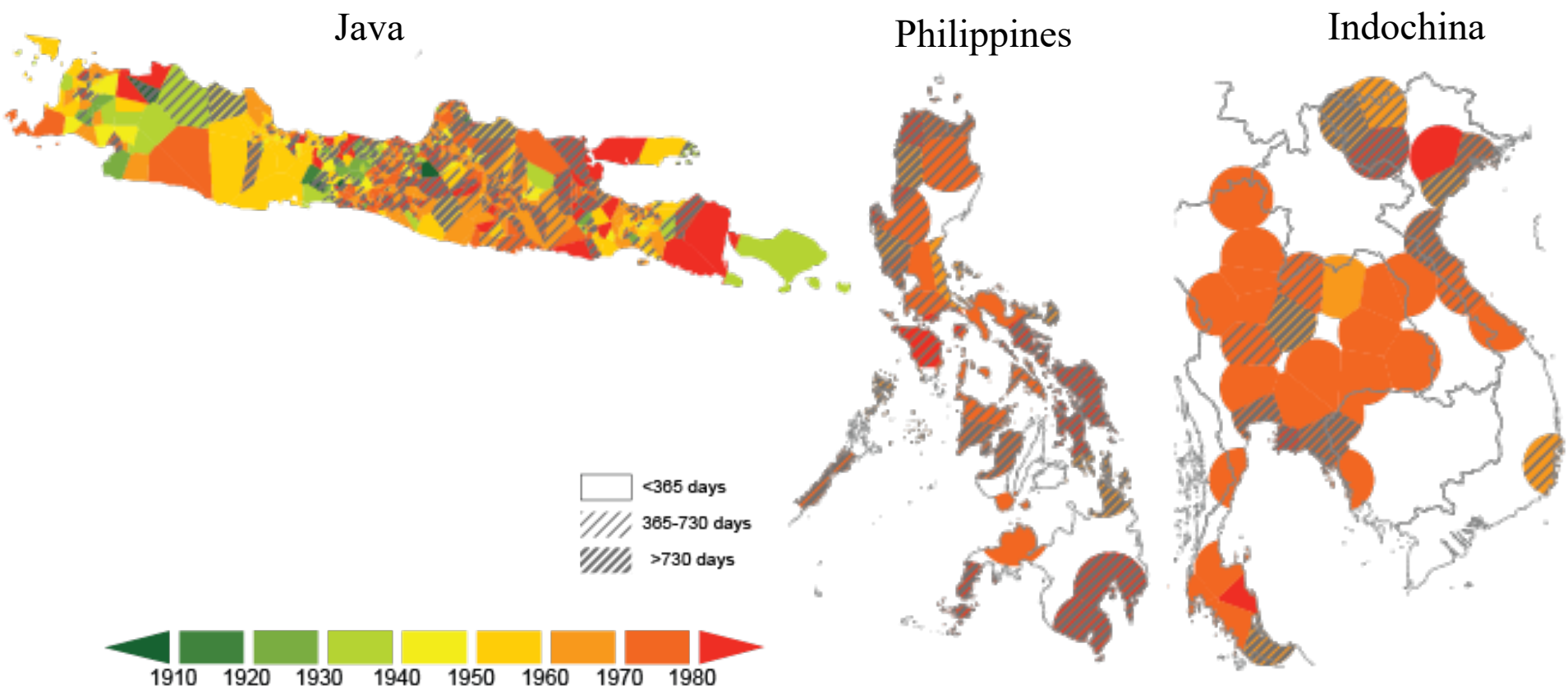


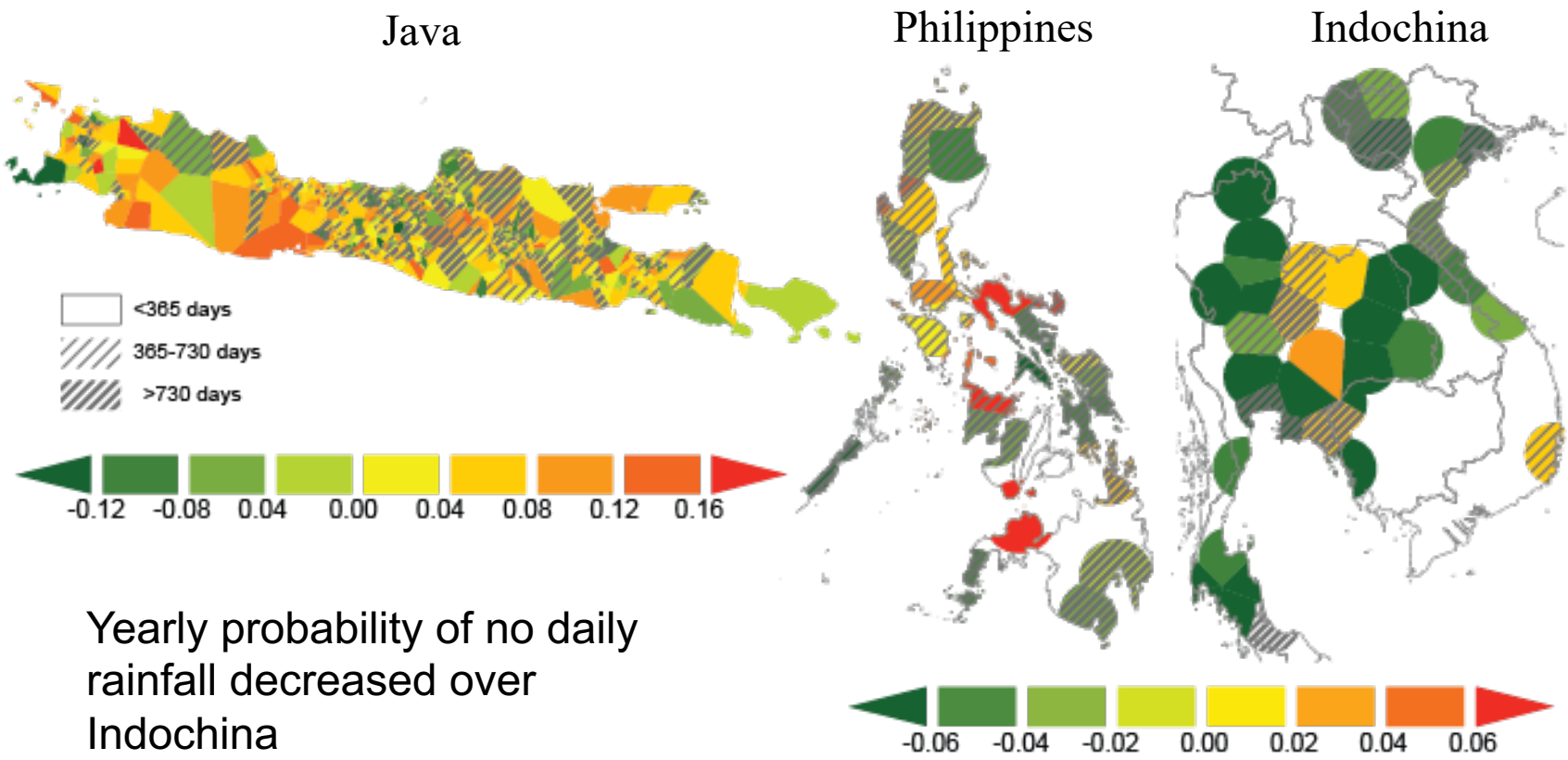
Fig.1 Length of data series available per station and 3 region examined in this study

DECADE OF REGIME SHIFT OCCURRENCE



Known PDO shift in winter 1975/1976 (from negative to positive)

YEARLY PROBABILITY OF NO RAINFALL AFTER THE REGIME SHIFT



Yearly probability of no daily rainfall decreased over Indochina

>> What happens in the future?

FUTURE CLIMATE PROJECTIONS ON PDO

- Almost all of the 20 CMIP6 models evaluated show statistically significant differences between Nino3.4+ and Nino3.4- situations, correctly showing Nino3.4+ as more dry
- For PDO most model can distinguish between PDO+ and PDO- but sign of the differences is often reversed
- Some models show statistical difference between in-phase and neutral ENSO-PDO phase combinations
- Only 1 model passed all tests to model the PDO-ENSO modulation

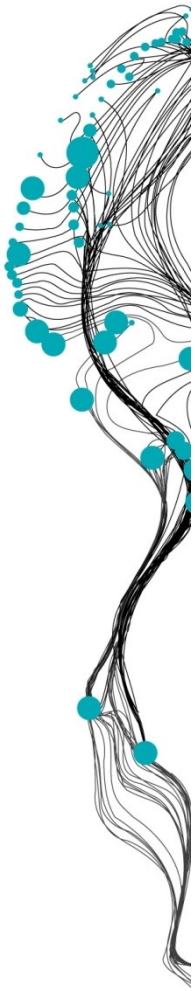
- *Future outlook: test more climate models and make a future projection*

CONCLUSION ON MARITIME CONTINENT

- A very complex region, where processes at micro and macro scale interfere, like land-atmosphere and land-ocean interactions
- Hardly any high quality, long-term observations

- Huge potential for satellite observations, especially with new constellations in the air, like sentinel

- A lot of possibilities and need for in-depth and multi-disciplinary research, especially in your region



IN CONCLUSION

- We are all working in a very intriguing and society-relevant field, where we have to find jointly solutions for future climate adaptation
- Everyone is part of the solution
- Women are needed in this scientific research field, because there is so much research work to be done, so information-based decisions can be taken

- THANK YOU!

- J.Ettema@utwente.nl