Changes in Peak Streamflow and its Associated Rainfall across the Hawaiian Islands from 1970 to 2005

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Flash flood at Kihei in March, 2017 (Photo: Libby Fulton)

Image credit: Kresta Kay/The Watchers

Are extreme rainfall and flooding getting more intense in Hawai‘i?

2018 April

Daily rainfall in Kauai from 4/14 to 4/15: 1,262 mm (49.69 in)

Photo from USATODAY

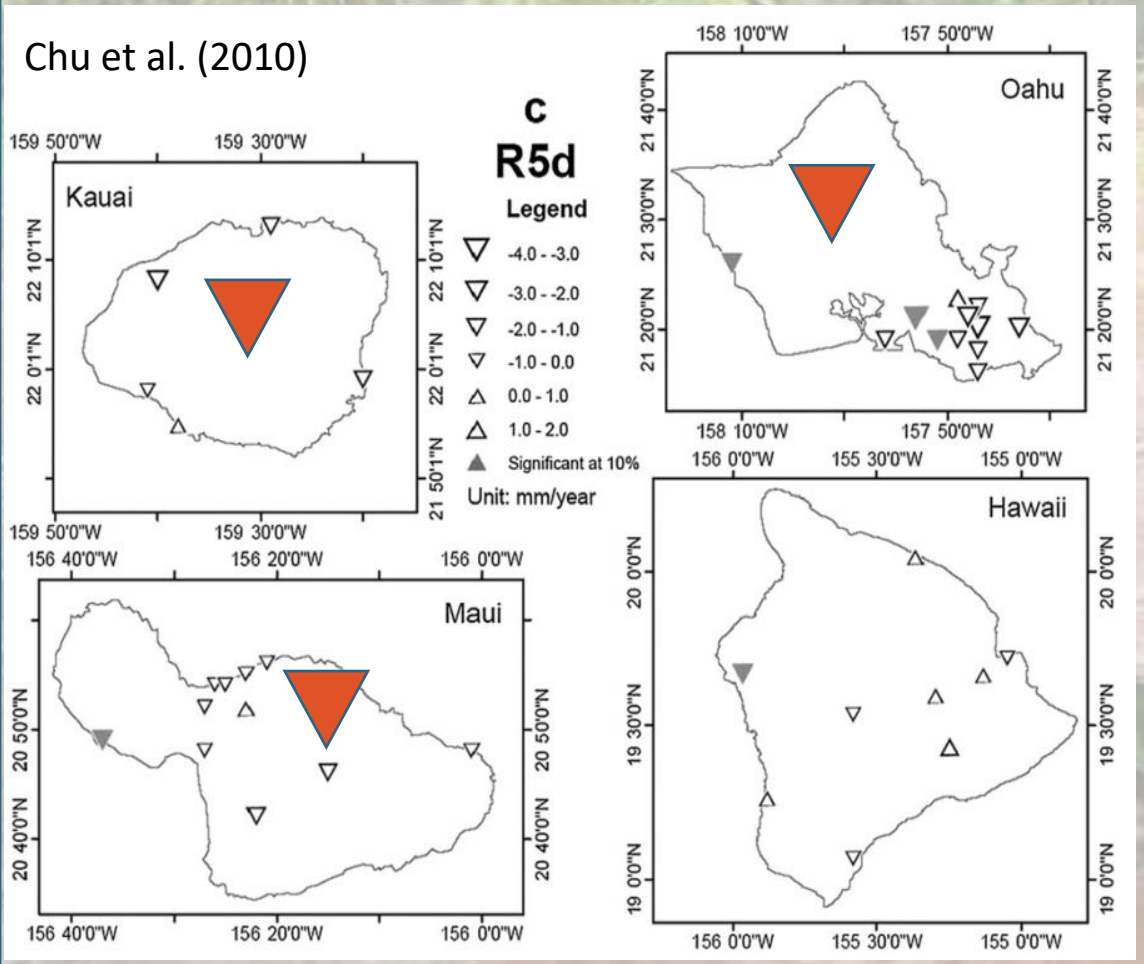
Photo from The New York Times

2018 August

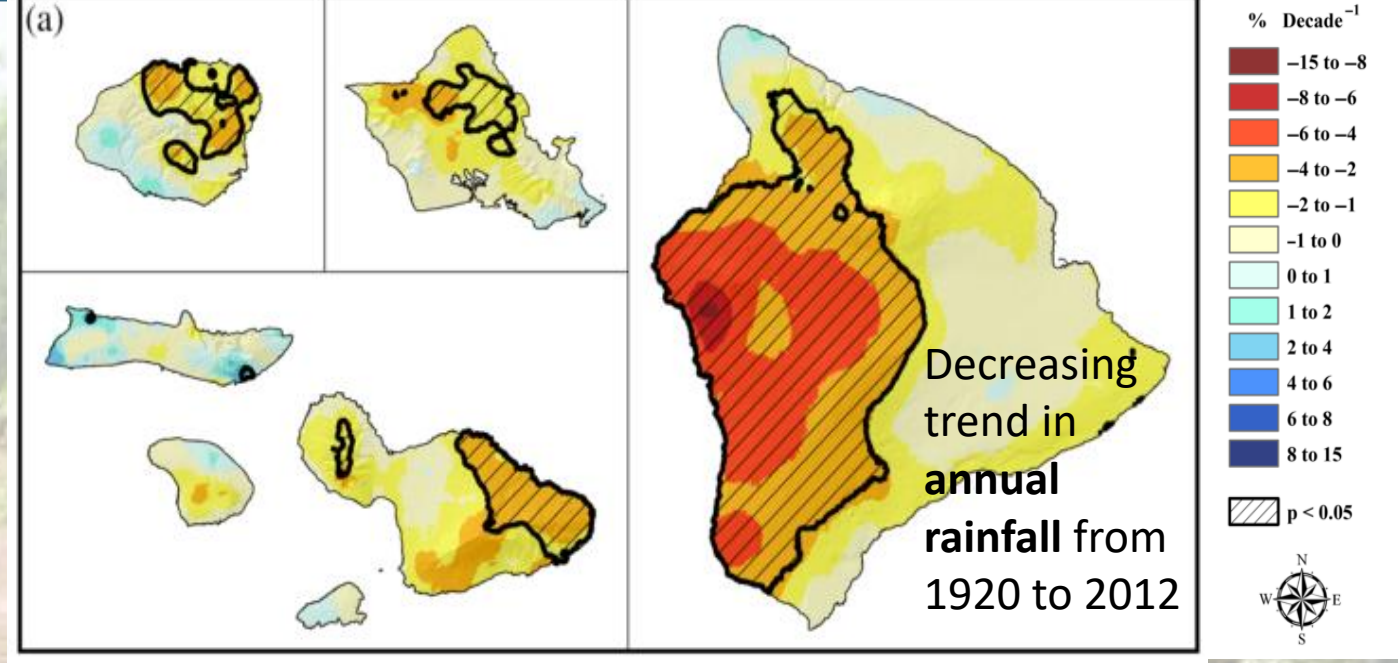
Daily rainfall on Hilo from 8/22 to 8/23: ~ 500 mm (20 in)

Photo from NPR

Historical Rainfall Trends in Hawai‘i

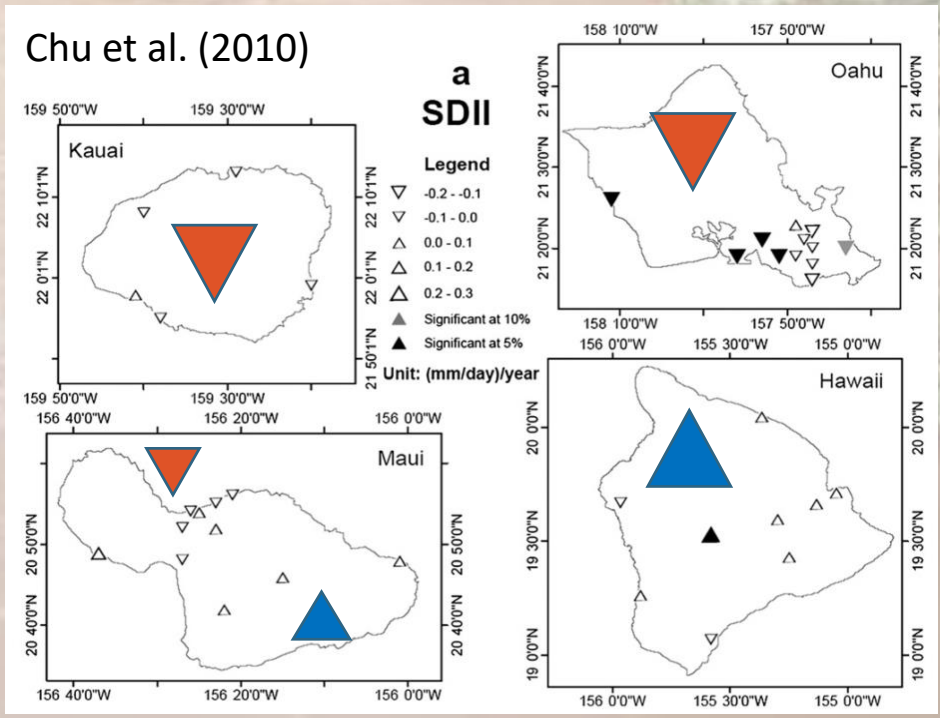


Decreasing trend in **annual max. 5-day accumulated rainfall (mm)** from 1950 to 2007



Decreasing trend in **annual rainfall** from 1920 to 2012

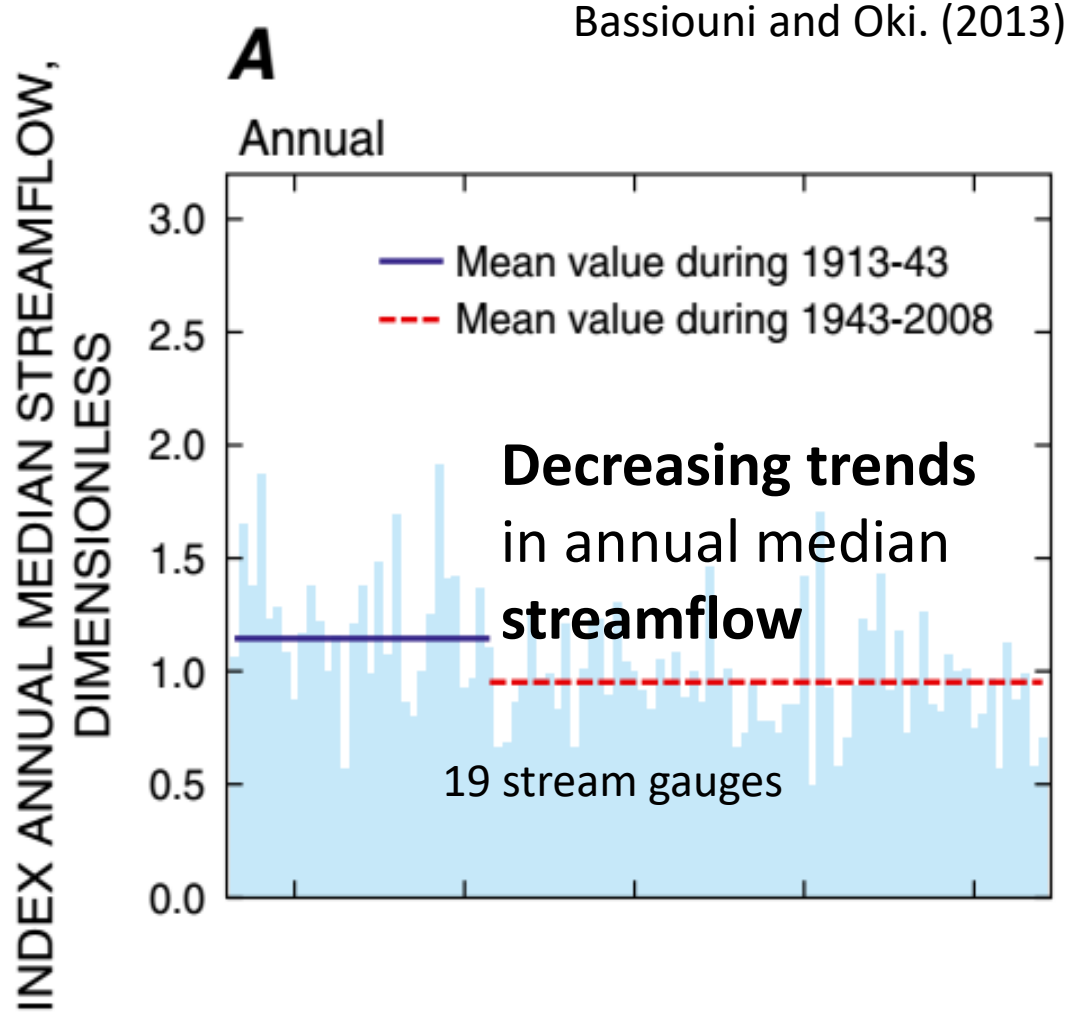
Frazier and Giambelluca (2016)



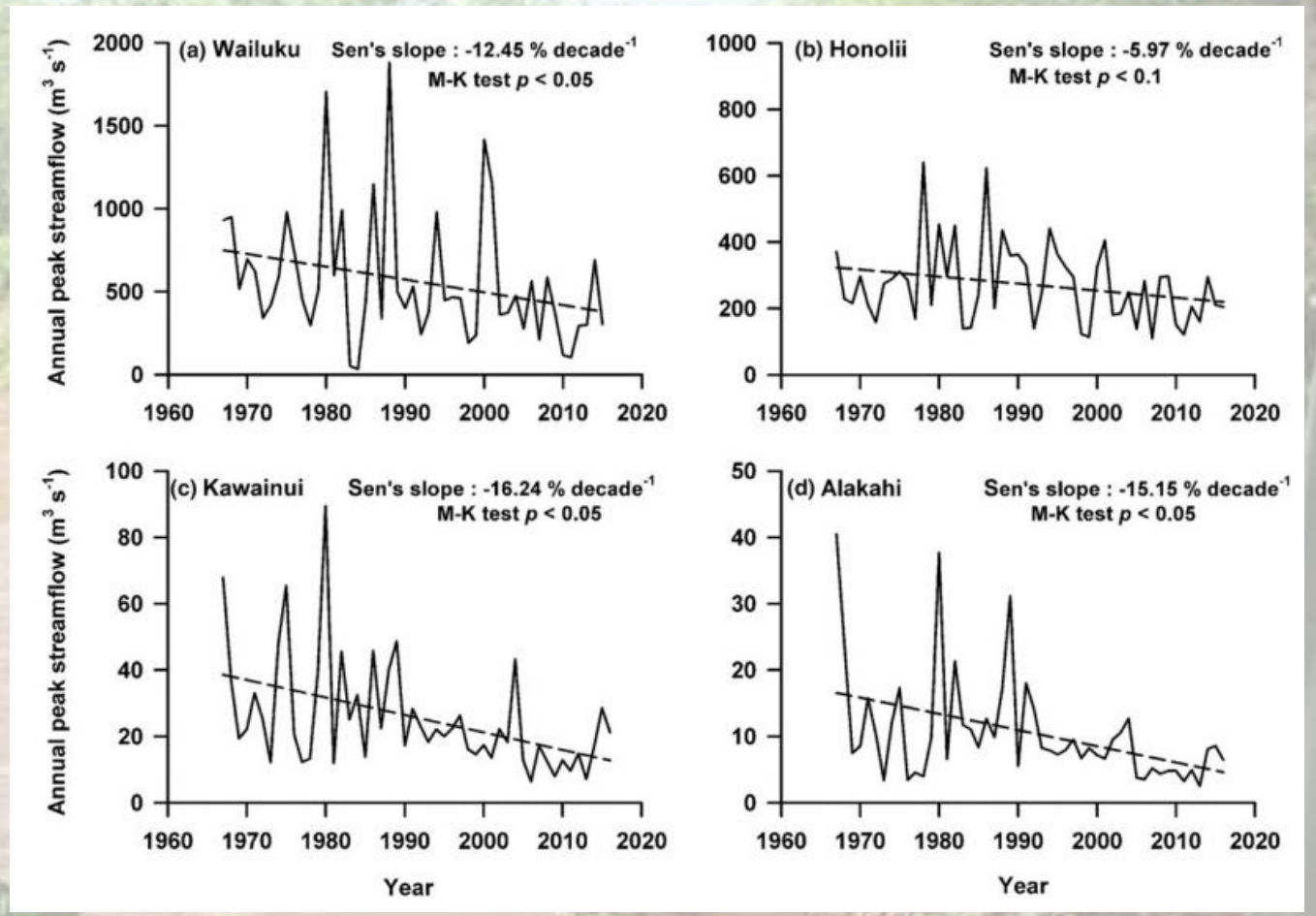
Trends in **rainfall intensity** (mm/day) from 1950 to 2007

Historical Streamflow Trends in Hawai‘i

Bassiouni and Oki. (2013)



Clilverd et al. (2019)



Decreasing trends in annual peak streamflow on the windward side across the Hawaiian Islands between 1967 and 2016

Objectives

The spatial-distribution of trends in annual maximum rainfall and annual peakflow in Hawai‘i.

>>> Trend analysis: separated

The association between trends in rainfall and peakflow by spatial pairing.

>>> Trend analysis: pairs

The temporal shifts of annual maximum rainfall and annual peakflow, respectively.

>>> Circular analysis

Methods

Data: Collect data, decide study period and standardized peakflow by watershed area

Trend analysis: RF_{max} and PF_{max}

Targets:

- annual maximum daily rainfall (RF_{max})
- annual peakflow (PF_{max})

Trend analyses:

- Non-parametric Mann-Kendall test (Hirsch and Slack, 1984; Mann, 1945) for significance, p-value < 0.05
- Sen's slope (Sen, 1968) for changes in magnitude

Trend analysis: 39 pairs

- Spatially pair gages with criteria
- Inspected the relationship between RF_{max} and PF_{max} for each pair

RF_{max} was not always coincident with PF_{max}

Trend analysis: paired daily rainfall

- Paired daily rainfall to the same date of peakflow occurred, then analyze their trends

Shifts in occurrence time

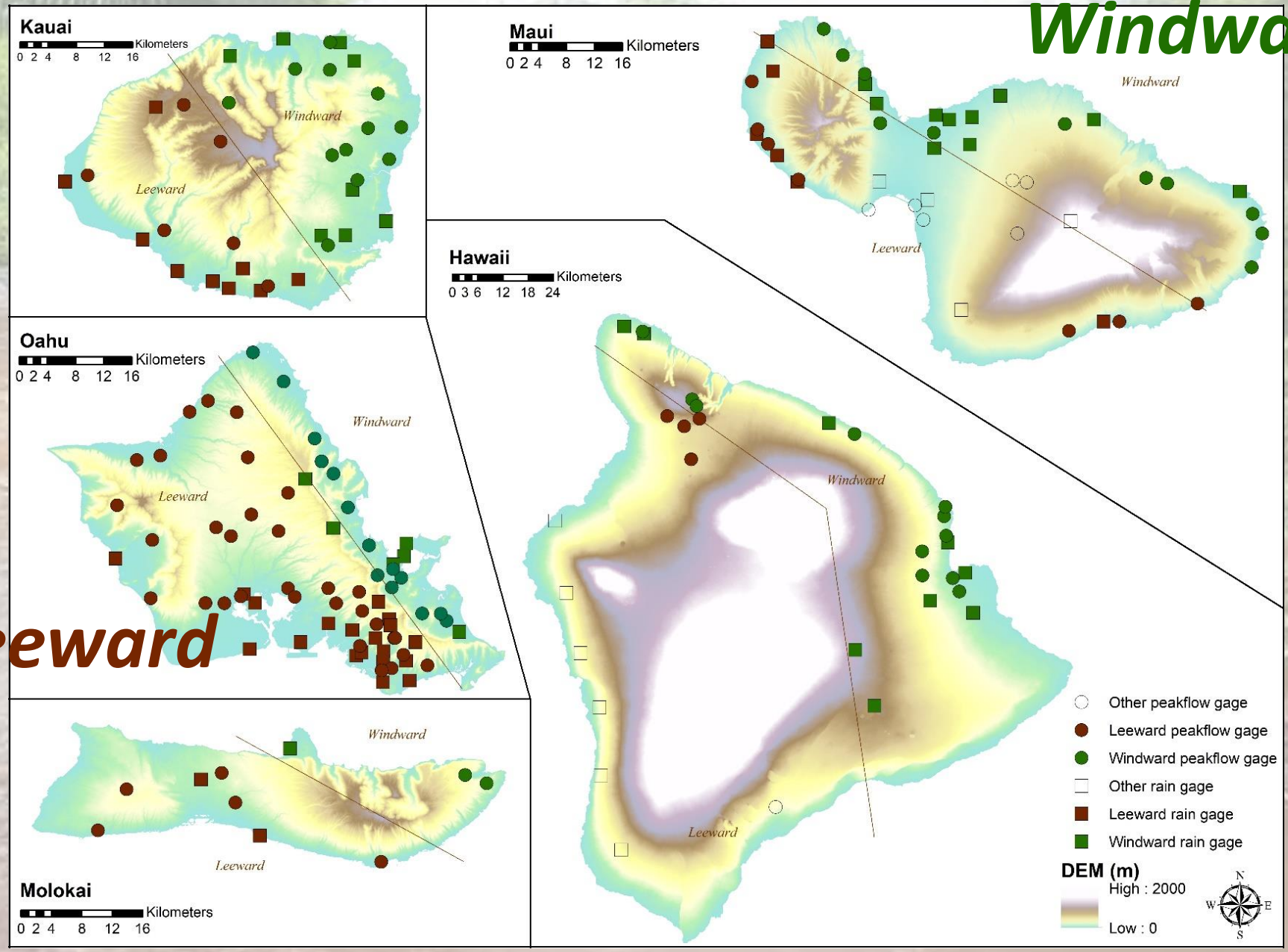
- Circular analysis (Zar, 1999; Lund et al., 2017) or both RF_{max} and PF_{max}

Shifts in occurrence time (leeward vs. windward)

- Circular analysis for both RF_{max} and PF_{max} in different physiographic zones

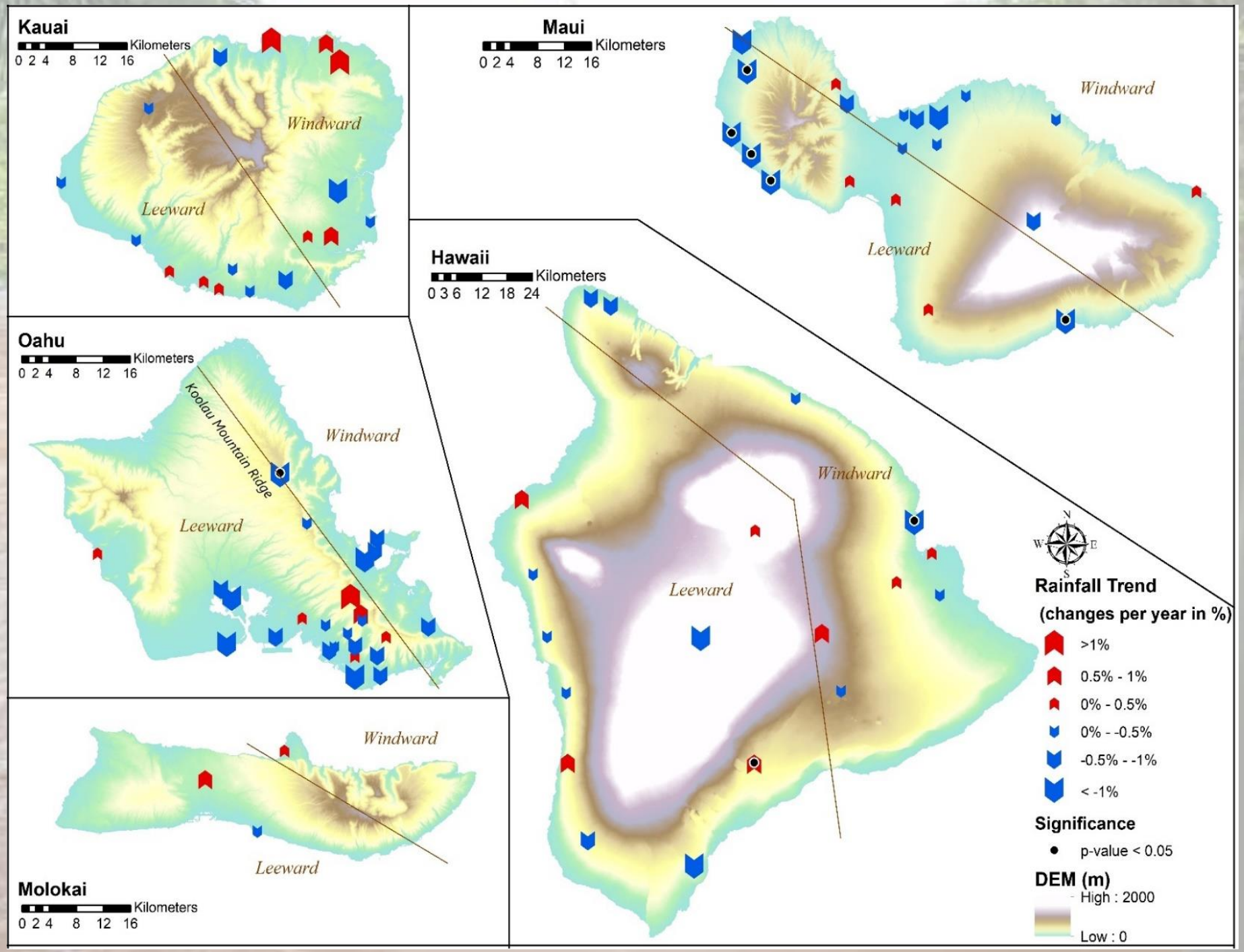
Data

- 1970 to 2005
- 84 rain gauges
- 111 peakflow gage
- The peakflow was standardized by the watershed area



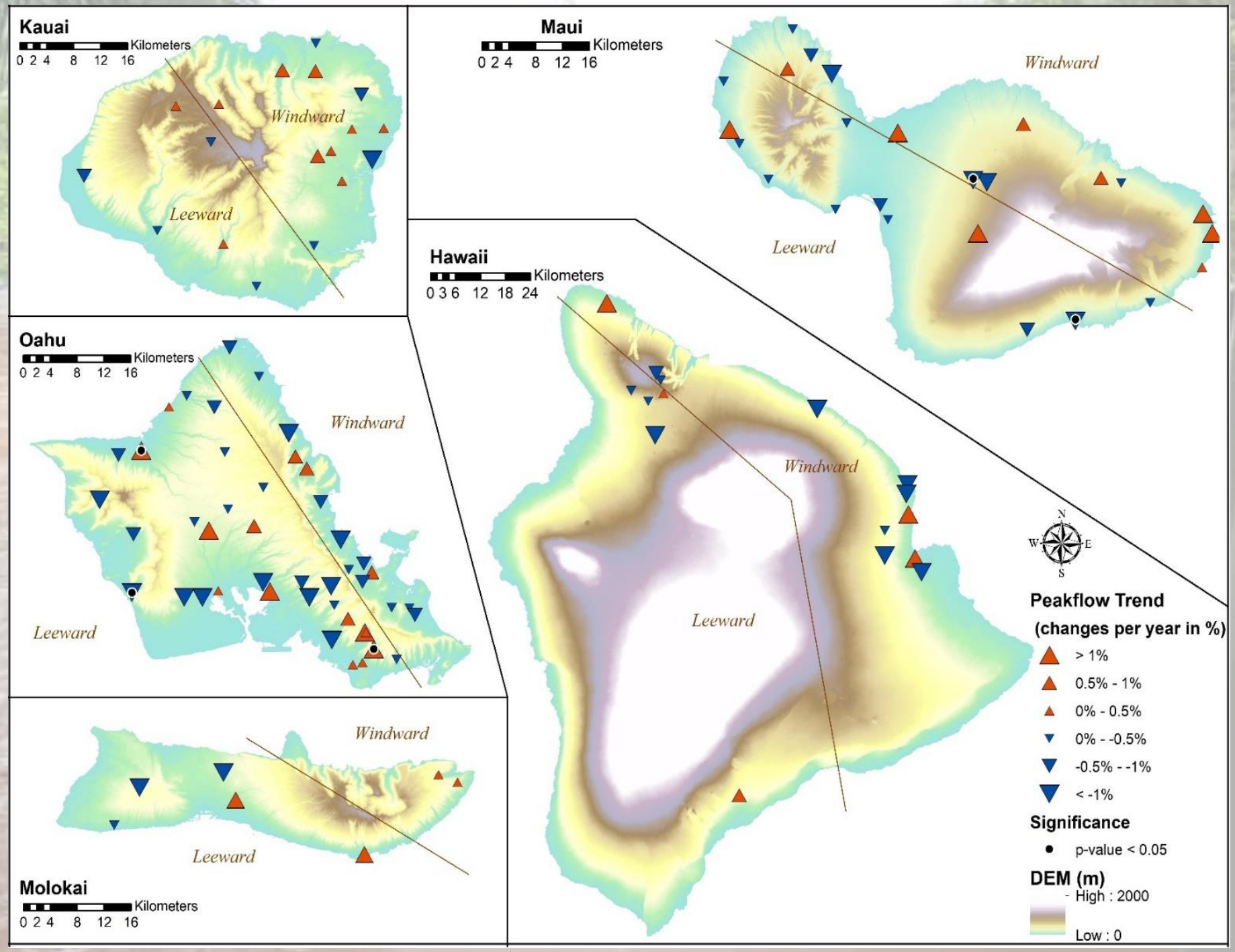
Trend analysis: RF_{max}

- More decreasing trends
- Decreasing trend dominates on Oahu and Maui
- No certain spatial distribution between physiographic zones

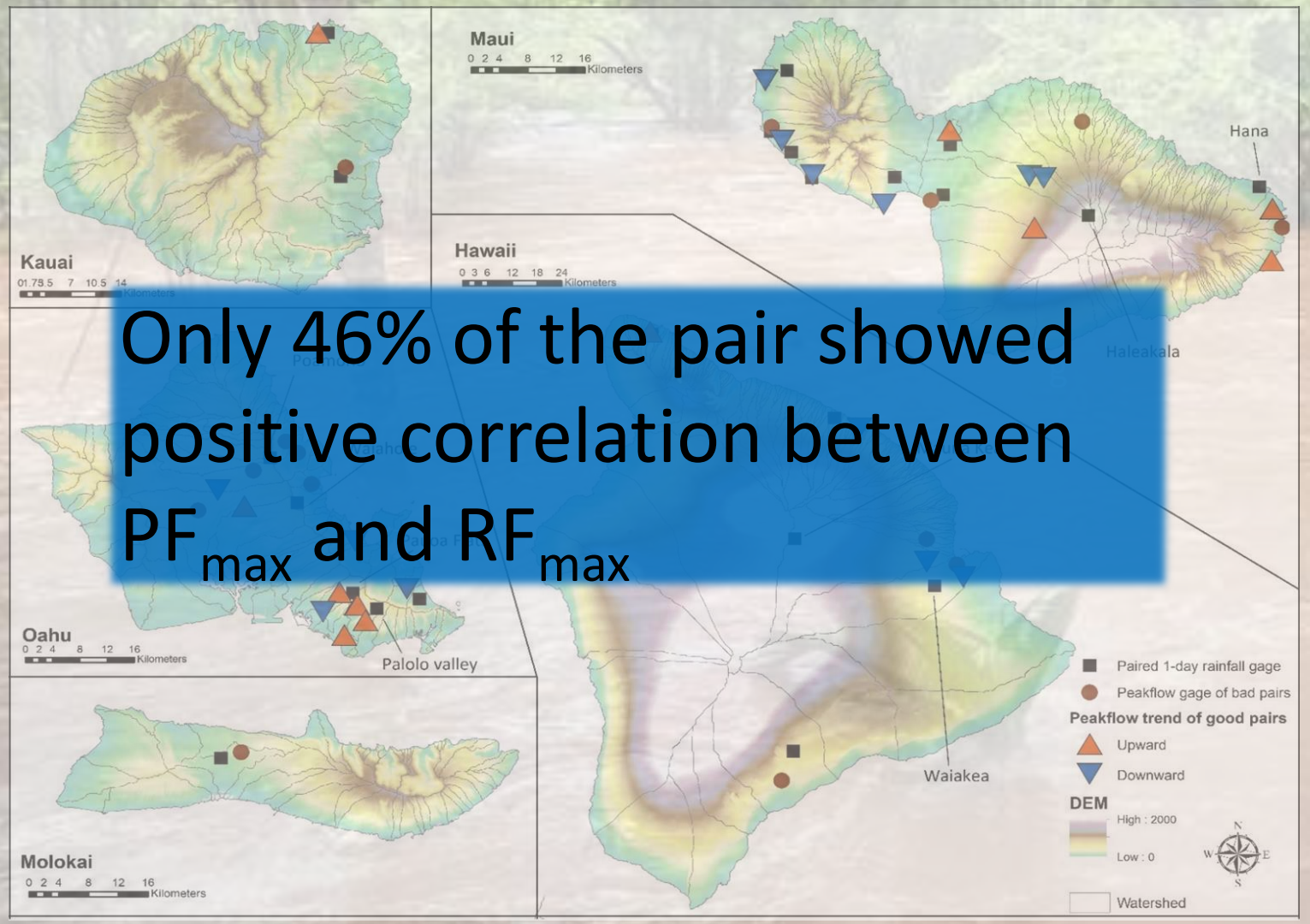


Trend analysis: PF_{max}

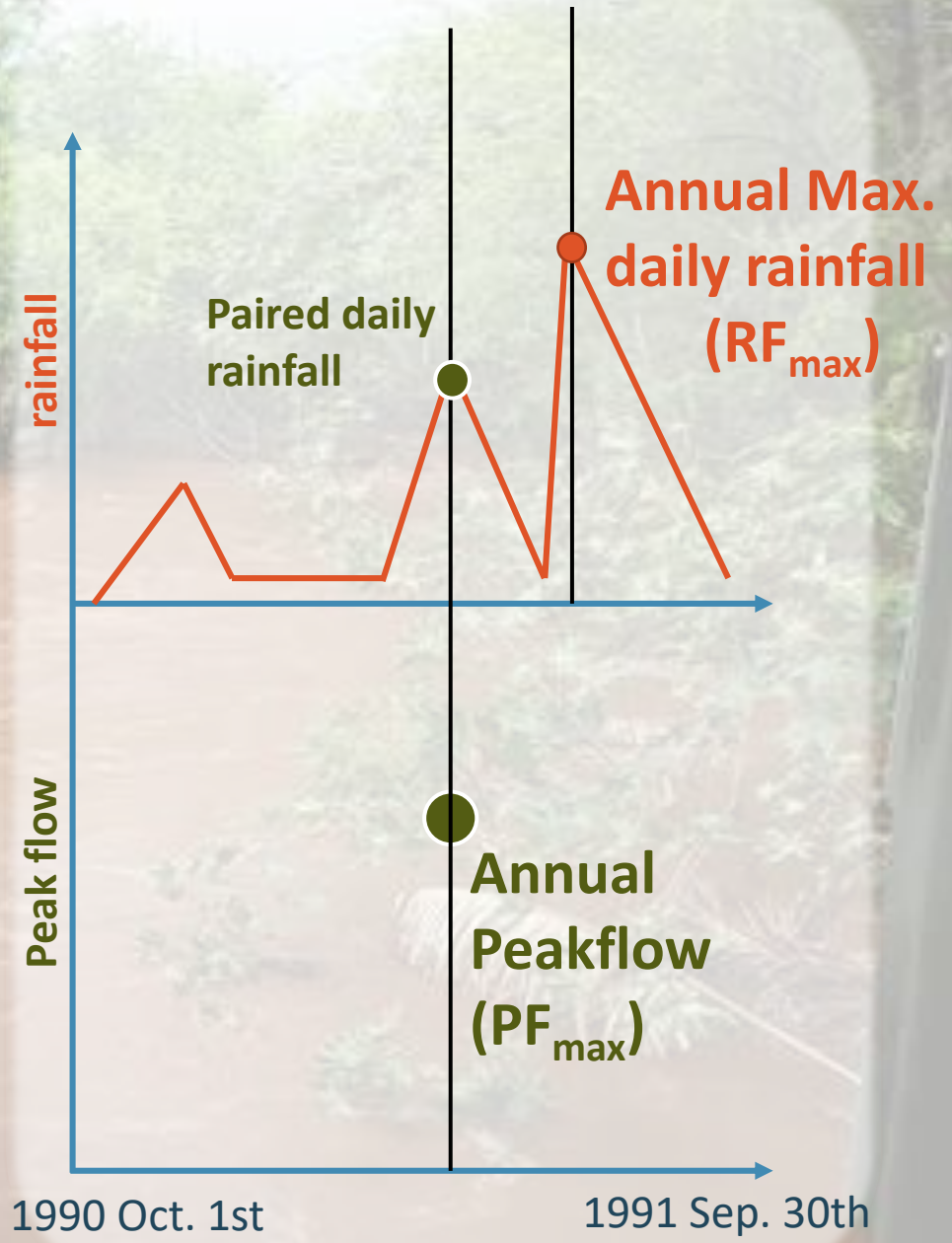
- Increasing trend dominates on Kauai
- Decreasing trend dominates on Oahu, Maui and the Island of Hawaii
- Only Kauai showed differences between windward and leeward side



Trend analysis: 39 pairs

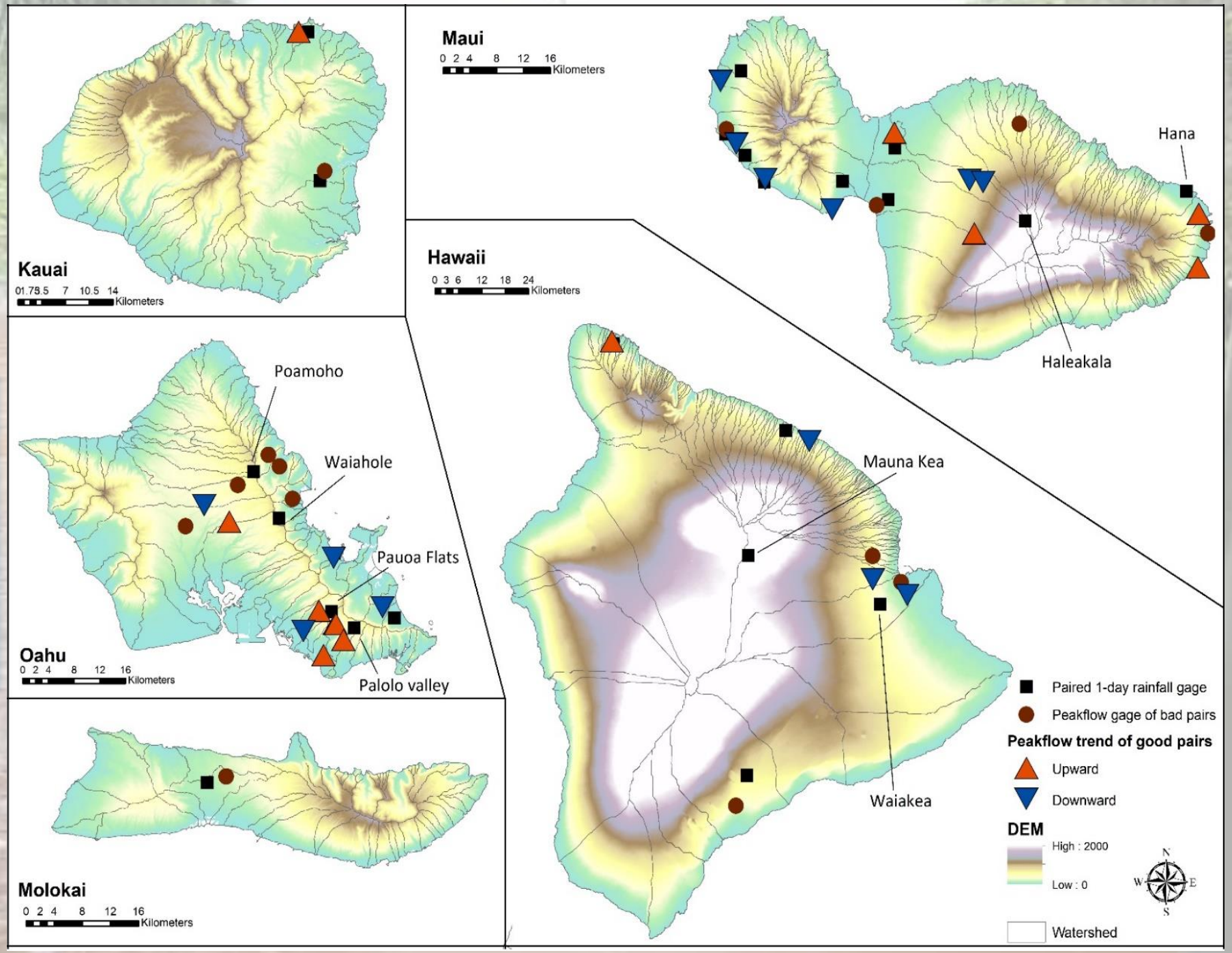


Only 46% of the pair showed positive correlation between PF_{max} and RF_{max}



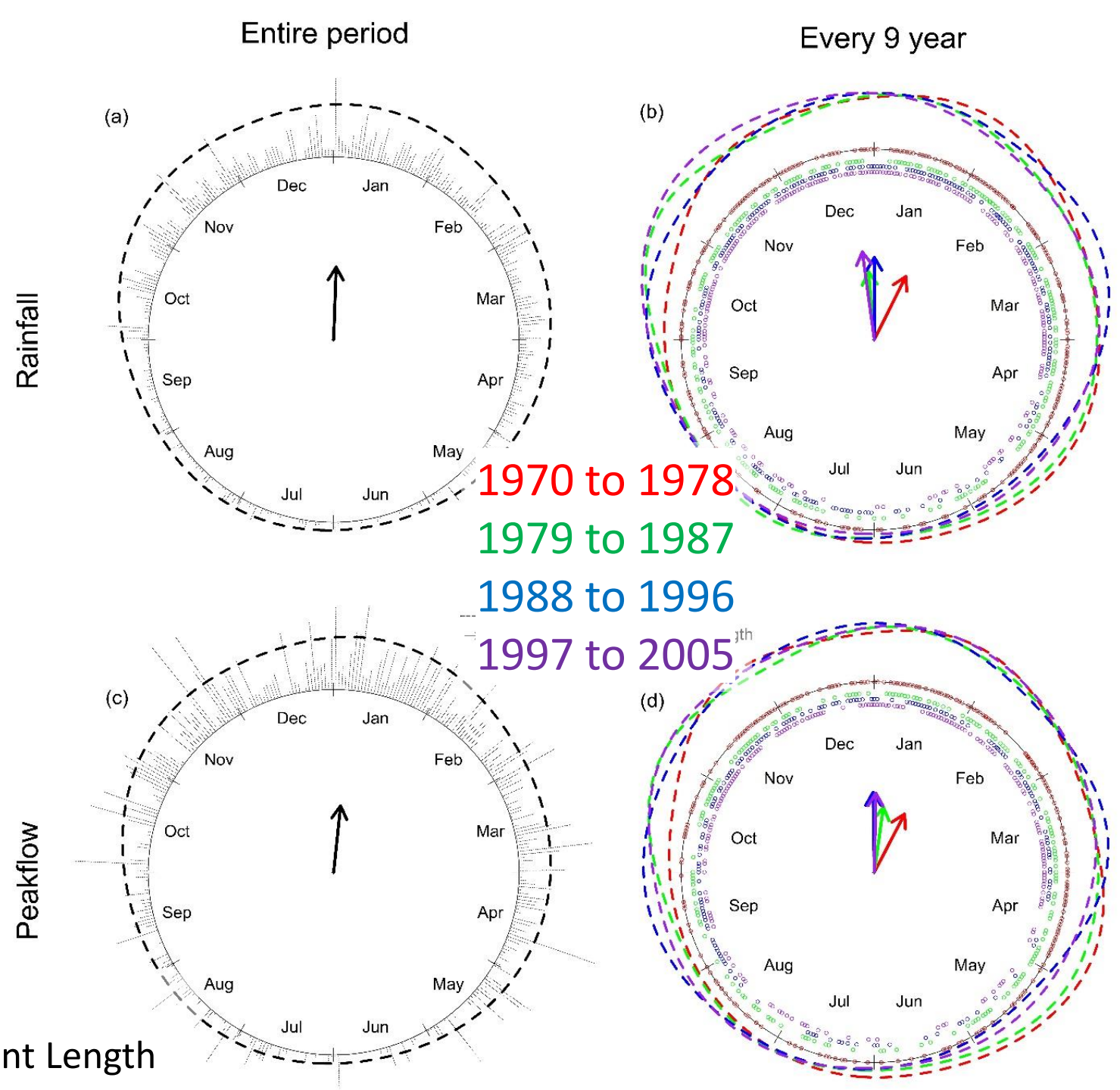
Trend analysis: Paired daily rainfall

- 67% of the pair showed positive relationship between trends of paired rainfall and annual peakflow



Shifts in occurrence time:

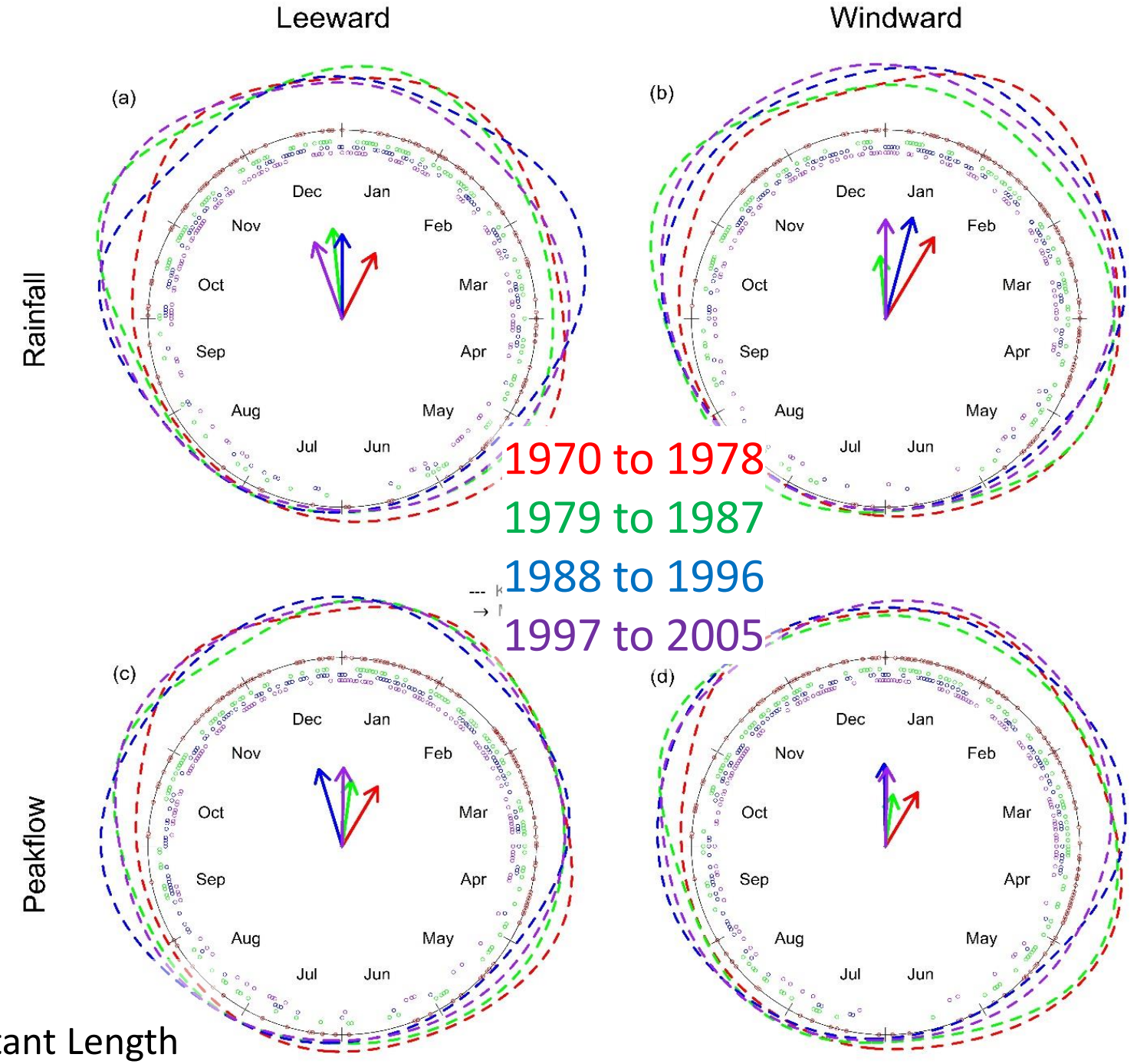
- RF_{max} occurred a little earlier than PF_{max}
- Both RF_{max} and PF_{max} shifted earlier winter



--- Kernel Density Estimates
-> Median with Mean Resultant Length

Shifts in occurrence time:
(Leeward and Windward)

Both RF_{max} and PF_{max} on the leeward side have larger variation in occurrence time, while on windward side have narrower window



--- Kernel Density Estimates
-> Median with Mean Resultant Length

Summary

- Some areas had more intense rainfall and peakflow, but most of areas showed decreasing trends.

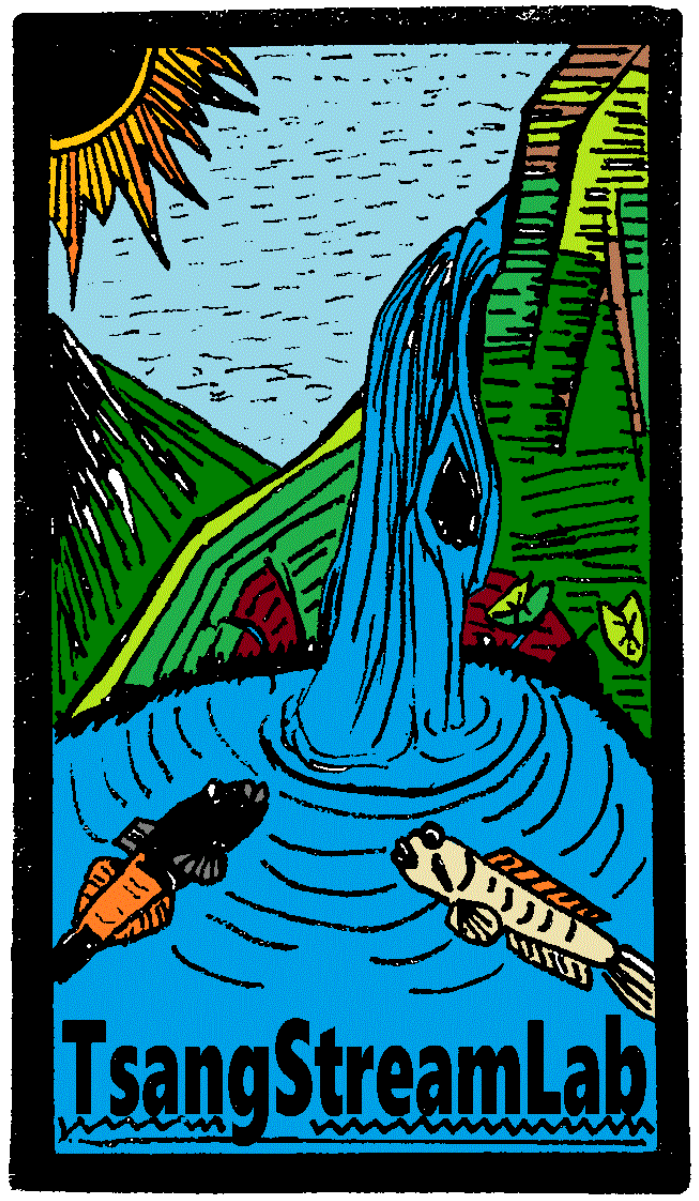
  >>> The flood might not always increase as we thought. It depends on the areas, even in an island. More regional survey and studies are needed.

- Spatial and temporal linkages are important when studying the relationship between trends in peak streamflow and maximum rainfall.

  >>> Planners and managers can't only look at maximum daily rainfall trend for flood mitigation or planning.

- The timing of RF_{max} and PF_{max}, shifted earlier, and the occurrence time fluctuated more in leeward areas than in the windward areas.

  >>> Might impact the timing when native gobies return to the stream from the ocean.



Mahalo (Thank you)!

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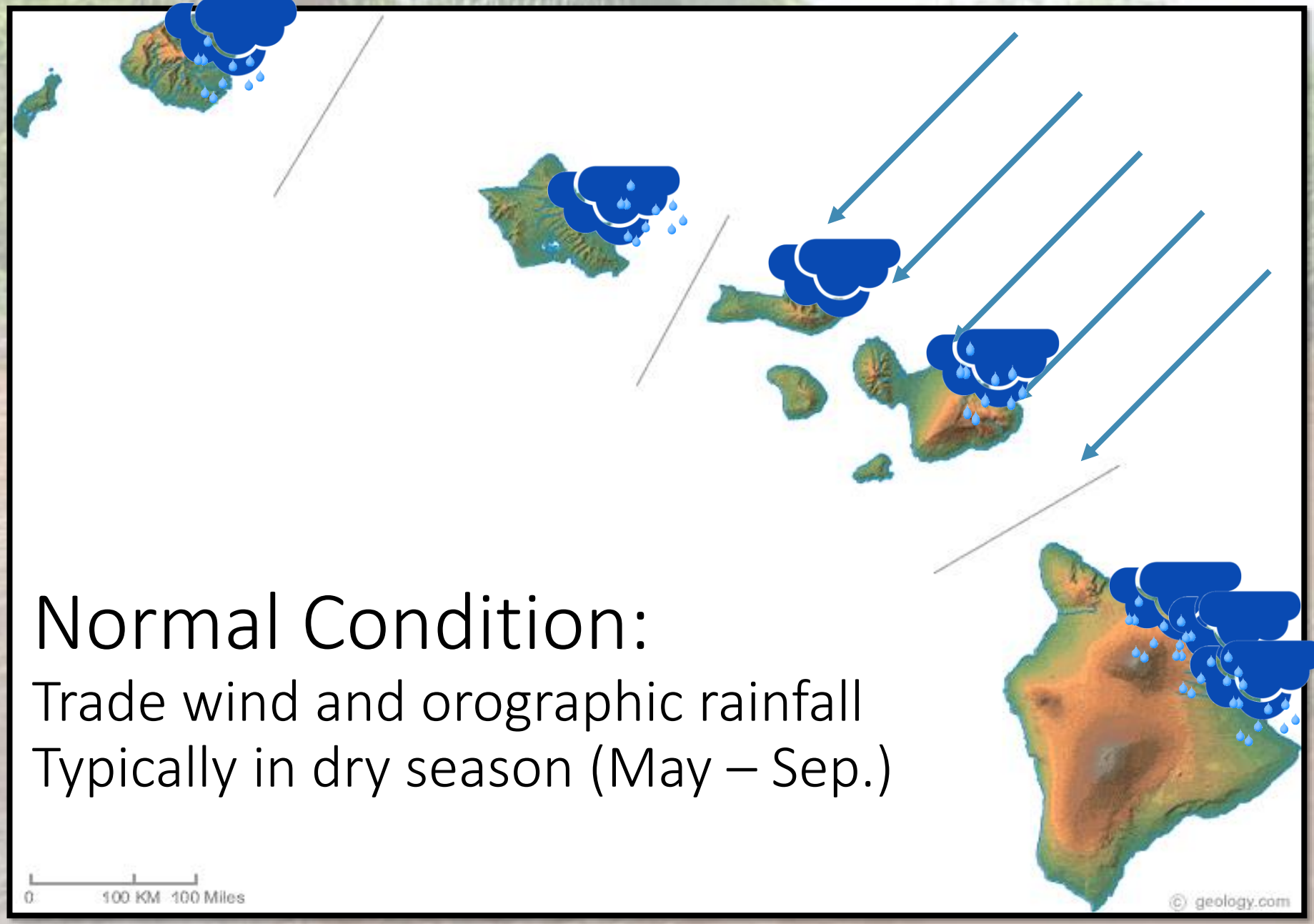

(local rain)

Normal Condition:

Trade wind and orographic rainfall

Typically in dry season (May – Sep.)