Desertification assessment using ecosystem resistance and resilience in drylands

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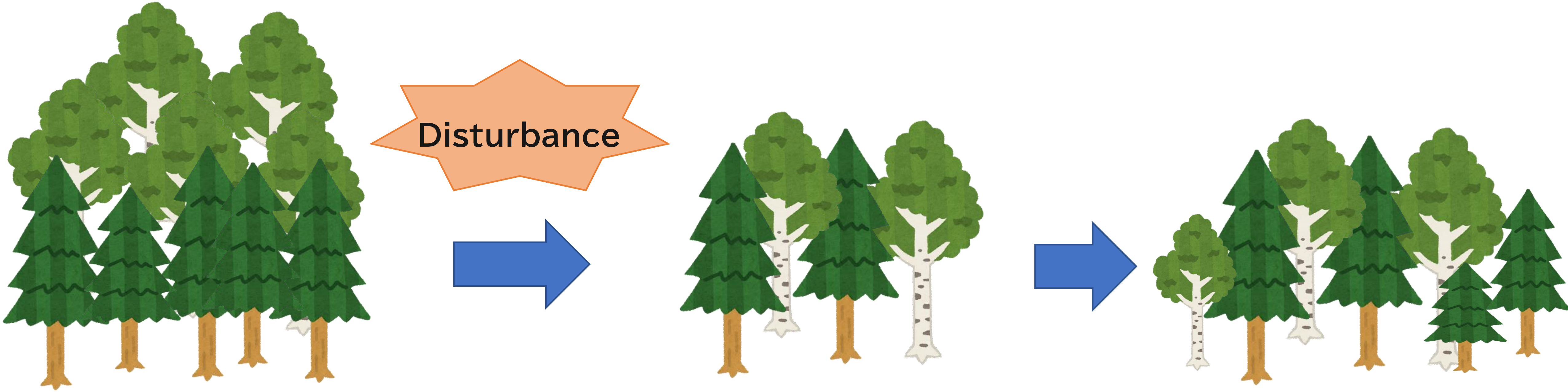
What is Resistance and Resilience ?



● **Resistance**
Index of stability

● **Resilience**
Index of recovery

Background

- ◆ Desertification has been estimated by various perspectives such as meteorology and geography

  Ex)

  - Focused on change in climate condition[1]
  - Identified degraded area using satellite-based aridity index and the normalized difference vegetation index[2]

- ◆ Desertification reduces ecosystem function

- ◆ However, the evaluation of the decertified area in terms of ecosystem function is not fully understood

Aims

- ◆ To calculate resistance and resilience for each biome
- ◆ To reveal the fluctuation of ecosystem function indices and SPEI in dryland

Methods

- Period

18 years: 2002 – 2019

- Spatial distribution

All data’ s resolution convert 5 minutes (about 9×9Km)

- Used data

MODIS Vegetation Index Product (MOD13C2,level-3product)[5]

→ Use to calculate resistance and resilience

MODIS Land Cover Type/Dynamics (MCD12C1)[6]

Global map of irrigation areas version 4.0.1[7,8]

→ Use to identify dryland biomes

Short-term SPEI (GPCC, CRU TS 4.05)[9,10]

→Use to classify the areas under drought condition

- Time step and resolution

Table.1 Time step and resolution of Used data

Data	Time step	Resolution
MOD13C2	Monthly	0.05 degree (5.6×5.6km)
MCD12C1	Yearly	0.05 degree (5.6×5.6km)
Global map of irrigation areas 4.0.1	-	0.0833 degree (9×9Km)
CRU TS 4.05	Monthly	0.5 degree (56km×56km)
GPCC Precipitation	Monthly totals	1.0 degree (111km×111km)

Methods

1. Identifying dryland biomes

- Biomes

Barren, Closed Shrub, Open Shrub, Savanna, Woody Savanna

→ remove an irrigation area in each biome

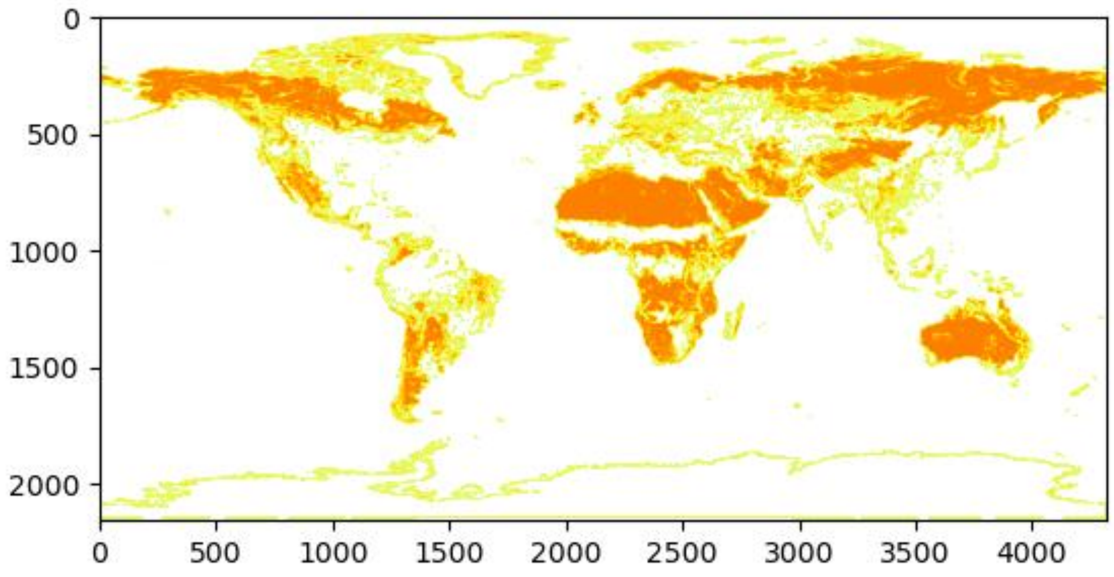


Fig.1 Map of the target biome area(orange colored)

Methods

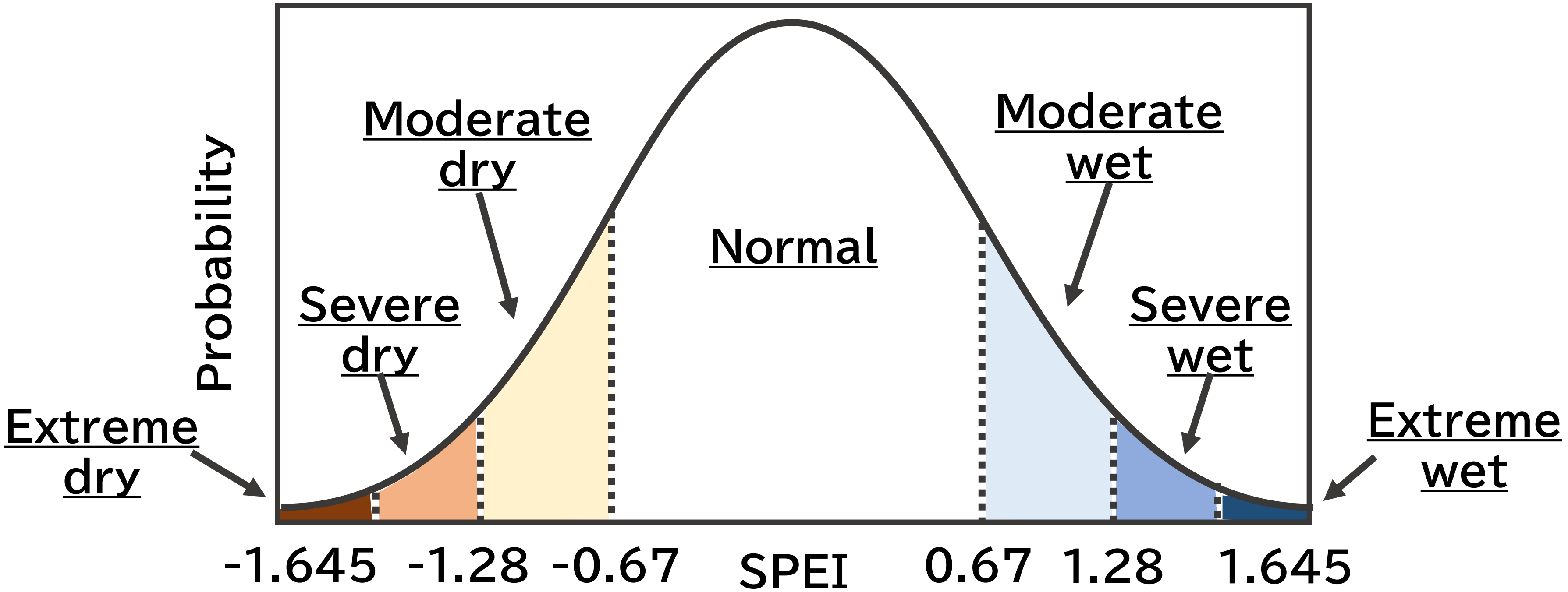
2. Classifying the areas under drought condition

- SPEI classification

Moderate drought: -1.28 < SPEI < -0.67 (25th percentile, once every four years)

Severe drought: -1.645 < SPEI < -1.28 (10th percentile , once every 10 years)

Extreme drought: SPEI < -1.645 (5th percentile , once every 20 years)



Methods

3. Calculation of resistance and resilience in each biome

- NDVI

All NDVI value is used $NDVI_{Max}$

$NDVI_m$ is calculate by averaging the values for 18 years in each grid

The Values are when SPEI is classified as Normal (-0.67 < SPEI < 0.67)

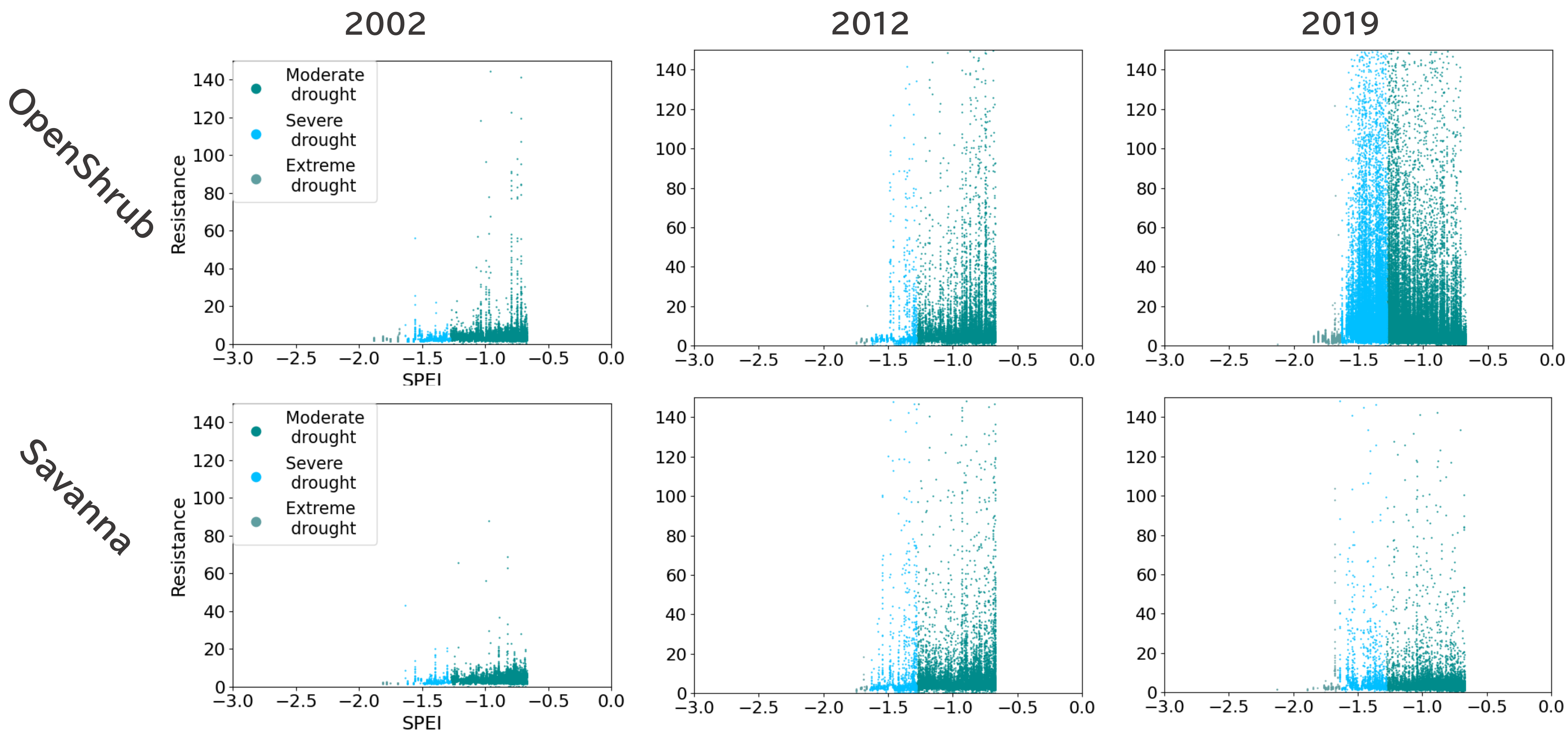
$$\textbf{Resistance} = \frac{NDVI_m}{|NDVI_e - NDVI_m|}$$

$$\textbf{Resilience} = \frac{|\mathrm{NDVI}_e - NDVI_m|}{|NDVI_{e+1} - NDVI_m|}$$

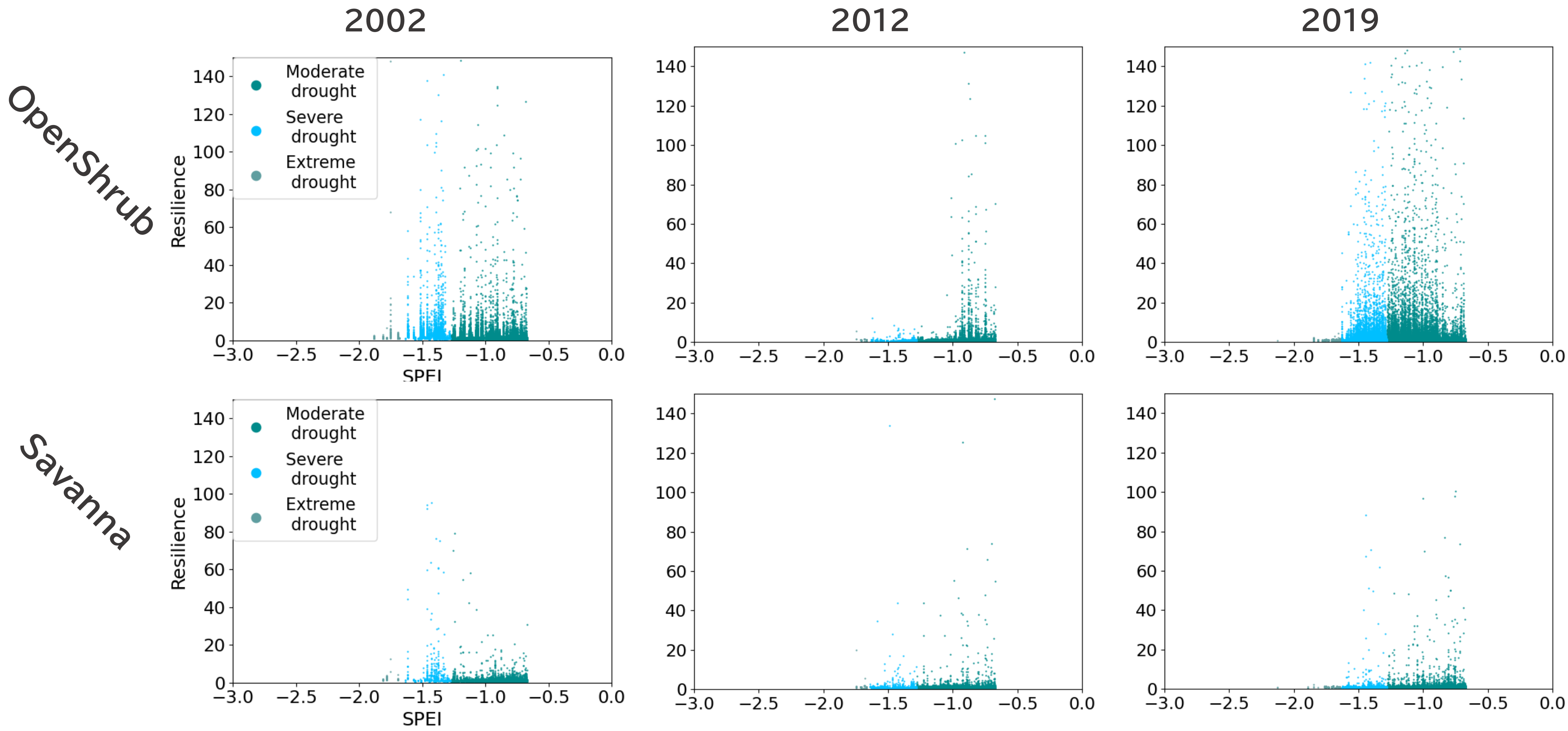
$NDVI_m$	During normal years
$NDVI_e$	During a climate event
$NDVI_{e+1}$	During the year after a climate event

Isbell et al. (2015)[4]

Results: Relationship between resistance and SPEI



Results: Relationship between resilience and SPEI



Temporary results

- We have not yet done work to assess desertification
- As of now, our results show the following
  - The value of resistance and resilience is low overall
  - Ecosystem function indicators become higher as the number of grids in a drought state increases

Thank you for your attention

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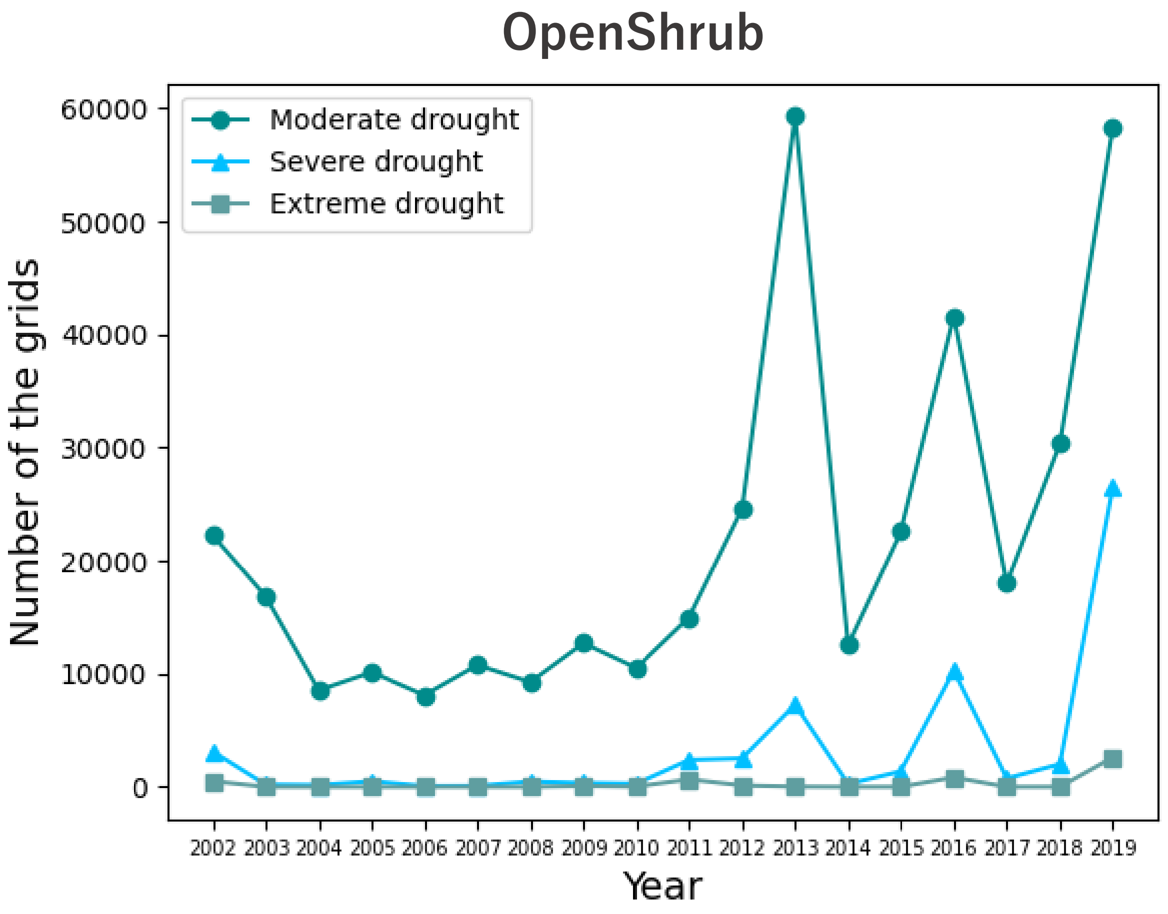
10. Harris I, Osborn TJ, Jones P and Lister D (2020) Version 4 of the CRU TS Monthly High-Resolution Gridded Multivariate Climate Dataset. Sci Data 7,109 (2020)(https://www.nature.com/articles/s41597-020-0453-3)



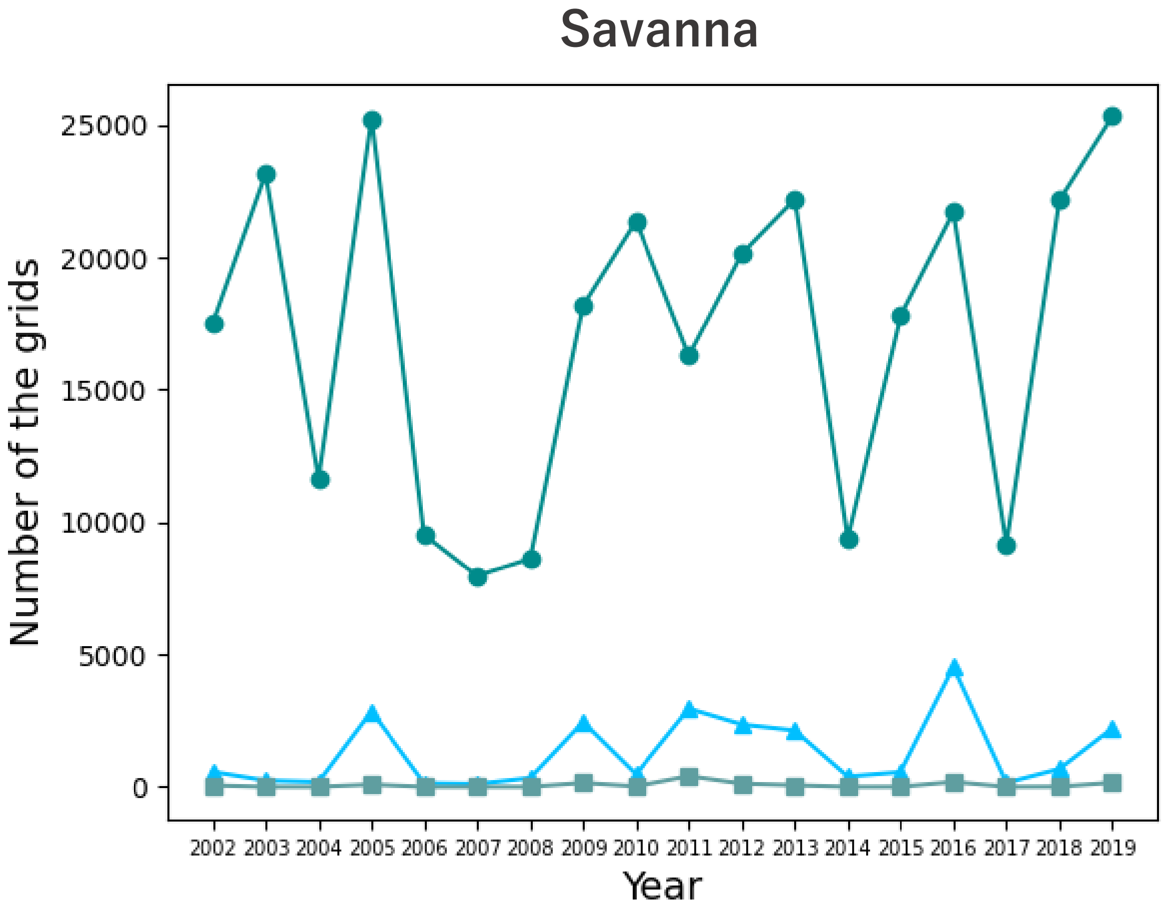
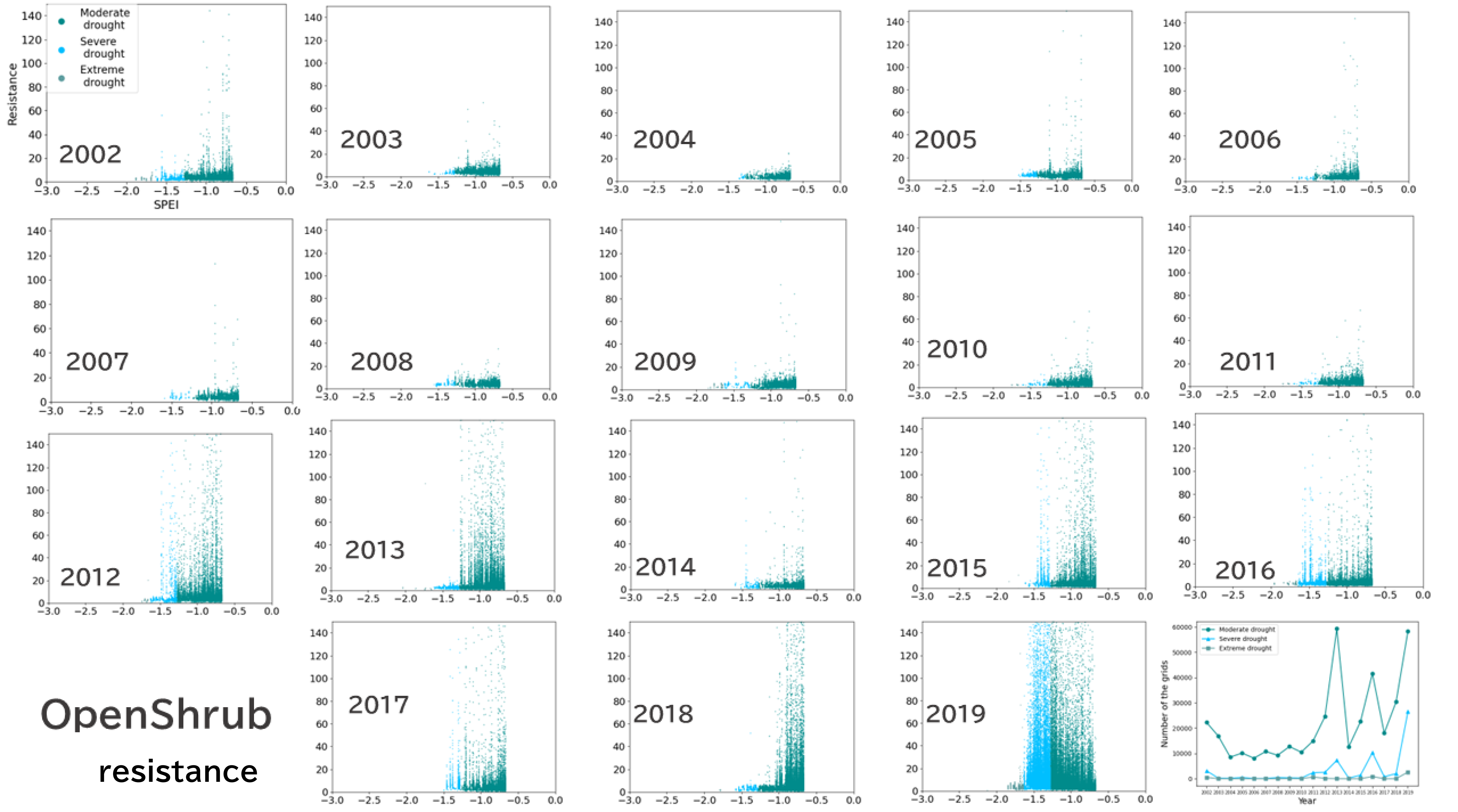
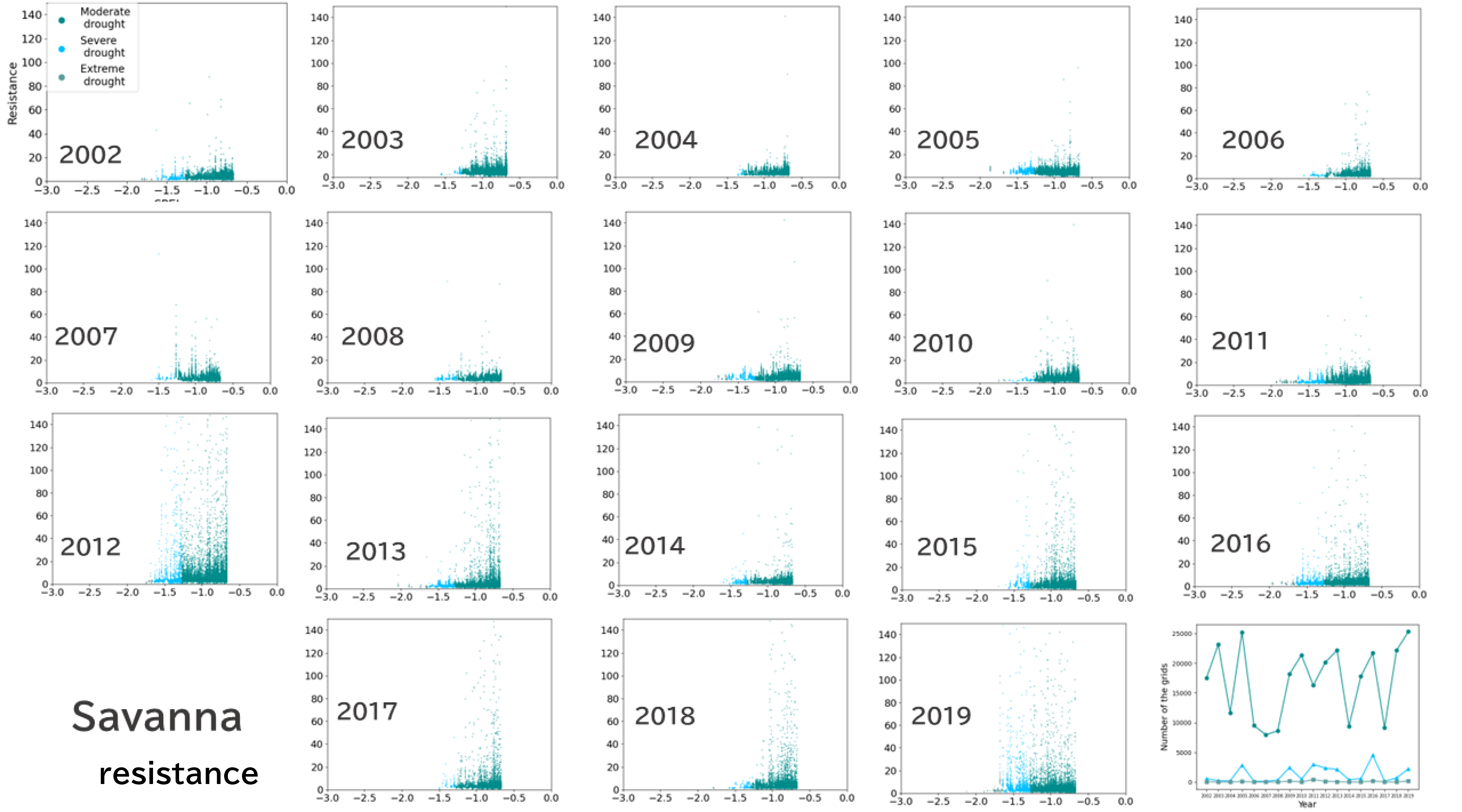


Fig.4 Example of the number of grids for each SPEI classification


Moderate drought
Severe drought
Extreme drought
Resistance
SPEI
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
OpenShrub
resistance
Number of the grids
Year



Moderate drought
Severe drought
Extreme drought
Resistance
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
Savanna
resistance
Number of the grids
Year

◆ Detailed calculation method $NDVI_{Max}$ in year

$NDVI_{monthly\ data}$ in each grid → calculate the average value for 12 months

- The NDVI value of one grid in year ($NDVI_e$, $NDVI_{e+1}$)

- $NDVI_m$ is calculate by averaging the values for 18 years in each grids

The Values are when SPEI is classified as Normal ($-0.67 < SPEI < 0.67$)

$$\textbf{Resistance} = \frac{NDVI_m}{|NDVI_e - NDVI_m|}$$

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