Scale effects on grassland dynamics of the Qinghai Tibetan Plateau observed from multi-scale multispectral satellite data

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Introduction

Background vegetation trends on the QTP

Historically: long time stability

Human-nature coupled system for millenia
Sustainable nomadic livestock management

Drastic changes over the last decades

Climate Change | Population Growth | Econ. Development | Change of Livestock Mgmt.

⇒ Altered vegetation dynamics and patterns
Introduction  

Background vegetation trends on the QTP

Related vegetation changes:

Locally severe degradation

- Loss of livelihood
- Erosion problems
- Effects on water retention

Greening trends in other locations

- Consequence of increased temperature
Dealing with scale effects – Tibetan Plateau

Background

- Climate Change
- Pastoral system
- Site conditions
- Livestock numbers
- Fencing

Note: The images and links provided are placeholders and are not part of the actual document.
Introduction

Objectives

1. Understand which environmental variables relate to an increased occurrence of declining vegetation areas (as observed from satellite data)

2. Understand how these relationships vary with scale (grain and extent)
Full QTP analysis (1 model for the complete QTP)

Approach

Reference dataset

Step 1: Google Earth Engine:

NDVI difference dataset for 2000-2018

\[ \text{MeanNDVI}_{2016-2018} - \text{MeanNDVI}_{2000-2002} \]

Landsat (30 m pixel size)

MODIS (500 m pixel size)

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**Full QTP analysis (1 model for the complete QTP) Approach**

**Reference dataset**

**Step 2:**
Declining areas = NDVI diff < -0.05

**Step 3:**
Reference = %cover Declining areas in 0.085° grid cells

Grid cells including large lakes and large rivers were excluded

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Approach

Landsat

FracCov Declining NDVI

- 0
- 0.1
- 0.2
- 0.3
- 0.4
- 0.5
- 0.6
- 0.7
- 0.8
- 0.9

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Full QTP analysis (1 model for the complete QTP) - Approach

Reference dataset - overview

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Approach

Explanatory variables

Mean values for 0.085° grid cells:

**Bioclim:**
- BIO1 = Annual Mean Temperature
- BIO3 = Isothermality (BIO2/BIO7) (* 100)
- BIO11 = Mean Temperature of Coldest Quarter
- BIO12 = Annual Precipitation
- BIO16 = Precipitation of Wettest Quarter

**Topography:**
- Eastn = Eastness (Aspect)
- North = Northness (Aspect)
- Alt = Elevation above sea level
- Rugg = Ruggedness Index
- Slo = Slope (Percent)

**Climate Change:**
- precc = Precipitation change 1979-2016
- tempc = Temperature change 1979-2016

**Human Footprint:**
- Hfp_e = Human footprint 1993
- Hfp_l = Human footprint 2009
- Hfp_c = Human footprint change

**Pika:**
- Pika = Pika species distribution model (MaxEnt)

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Random Forest

500 trees
mtry = Square root of number of predictors

%Cover Declining NDVI areas ~ Bioclim + Topography + Climate Change + Human Footprint + Pika

Two models:

1. %Cover declining NDVI areas derived from Landsat
2. %Cover declining NDVI areas derived from MODIS
Full QTP analysis (1 model for the complete QTP)

Results

Landsat

MODIS

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Discussion

Bioc5 = Max. Temp. Warmest Month

Bioc15 = Precipitation Seasonality

Altitude

Temperature Change

Cloud effective emissivity

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Discussion

Large natural gradient

Biocl. 12 - Mean annual precipitation

Wetter, lower, warmer

%Cover declining areas - Landsat

More vegetation, more decline

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Moving window work-flow

Run RF model for each grid cell

Include all grid cells in a 3° x 3° window

Store results

Variable importance (RF model)

Spearman Correlation (individual predictors)
Moving window analysis

Results

- Variable importance varies with location
- Clear hotspots visible
- This information may get lost when applying a single model for the complete plateau
Correlation varies with location

Correlations shifts from negative to positive correlations depending on the location on the plateau

Conclusions drawn from models across the complete Plateau may be misleading

\[ \text{cor} = 0.06 \]

\[ \text{cor} = 0.14 \]
Conclusions

The %cover of declining vegetation areas on the QTP can be successfully related with a set of environmental and anthropogenic variables

Strong scale effects when...

...comparing Landsat- and MODIS-based reference data
...comparing models in different parts of the QTP

Not yet addressed:

Decisive scale in terms of management is at finer grain (ongoing investigation)
That’s it! Thank you for your attention!

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Full QTP analysis (1 model for the complete QTP)

Approach
Reference dataset - overview

UAV data 2015
- Degraded meadows
- Shrubs/lands

Landsat NDVI Diff. 2000-2016
- Degraded meadows
- Shrubs/lands
- NDVI Difference
  - -0.5
  - -0.4
  - -0.3
  - -0.2
  - -0.1
  - 0
  - 0.1
  - 0.2
  - 0.3
  - 0.4
  - 0.5

MODIS NDVI Diff. 2000-2016
- Degraded meadows
- Shrubs/lands
- NDVI Difference
  - -0.5
  - -0.4
  - -0.3
  - -0.2
  - -0.1
  - 0
  - 0.1
  - 0.2
  - 0.3
  - 0.4
  - 0.5

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F. E. Fassnacht: Scale effects on grassland dynamics of the QTP observed from space
Full QTP analysis (1 model for the complete QTP)

Approach

Reference dataset - overview

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