Precipitation as a Potential Climate Driver of Vegetation Trends in Southwest Alaska

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Main Findings

- AVHRR-based NDVI shows declining productivity trends in the Yukon-Kuskokwim Delta region, in contrast with the circumpolar Arctic
- Gridded monthly precipitation datasets show significant variability and reveal high uncertainty in precipitation climatology across Alaska
- Precipitation decline is likely not a key reason for the declining NDVI trends in the Yukon-Kuskokwim Delta Region

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Hypothesis and Motivation

What are the possible climate drivers of observed vegetation trends in southwest Alaska, and can precipitation explain the recent browning in the YKD?

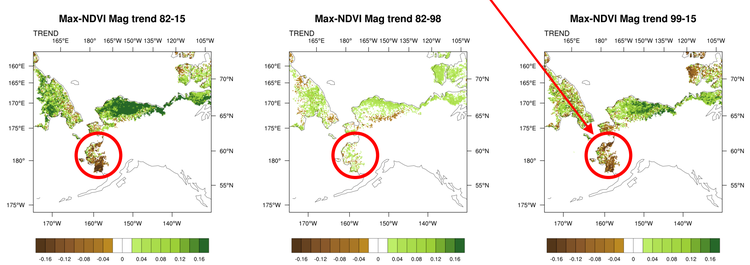


Figure 1: AVHRR-based GIMMS-3g Maximum NDVI magnitude trends for 1982-2015 (left), 1982-1999 (middle), and 1999-2015 (right). Southwest Alaska shows a clear negative NDVI trend in over the 34-year period, with a strong negative trend in the recent period (99-15). The early period (82-99) shows slight positive NDVI trends. (Figure credit: Bhatt, 2018)

NDVI = (NIR-R)/(NIR+R)

NIR: spectral reflectance in near-infrared band (0.725-1.1 µm) & R: red chlorophyll absorbing portion of spectrum (0.58-0.68 µm)

- AVHRR derived Maximum-NDVI indicates a **recent decline** in growing season vegetation productivity in **southwest** Alaska's Yukon-Kuskokwim Delta (YKD), since 1999.
- **Circumpolar** Arctic shows an overall **positive trend** in NDVI associated with **increasing temperatures**.
  - Southwest Alaska (East Bering Sea) region has experienced a comparatively large increase in the summer warmth index, >10°C month, during the growing season at >95% significance (Bhatt et al, 2010)
- **Can growing season (June, July, August) precipitation variability account for the anomalous recent browning trend in the YKD?**

Data and Methodology

- Monthly gridded precipitation data [available at: https://www.esrl.noaa.gov/psd/data/gridded/tables/precipitation.html]
  - Climate Prediction Center Merged Analysis of Precipitation (CMAP)
  - Global Precipitation Climatology Centre (GPCC)
  - Global Precipitation Climatology Project (GPCP)
  - National Centers for Environmental Prediction Reanalysis (NCEP)
  - NOAA's Precipitation Reconstruction over Land (PREC/L)
  - University of Delaware Precipitation (U.DEL)
  - European Centre for Medium-Range Weather Forecasts interim reanalysis (ERA-Interim)
- Datasets regridded to downscaled **ERA-Interim 20-km grid** (Bieniek et al, 2016)
  - ERA-Interim used as comparison dataset due to its improved spatial representation of precipitation in Alaska (Bieniek et al, 2016)
- Explored **34-year** (1982-2015) **total JJA precipitation climatology**, as well as two time periods (1982-1998, 1999-2015) to compare recent NDVI trends

Data from: Satellite estimates; gauge observations; atmospheric soundings; reanalysis

Precipitation datasets across Alaska are highly variable

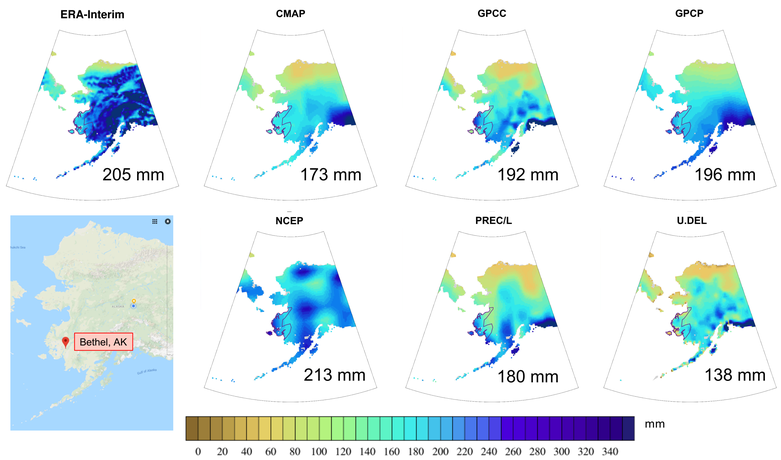


Figure 2: A 34-year (1982-2015) JJA total precipitation climatology (mm). The approximate region of the YKD is outlined and its climatological average JJA total precipitation is shown alongside each figure.

- **34-year climatology shows large spatial variability between datasets**
- **YKD receives ~140 to 220 mm during growing season months (JJA).**
  - **Bethel weather station averages 187 mm over 34-year period**
- **Downscaled ERA-Interim known to be wet biased (Bieniek et al, 2016)**

Positive precipitation trends for majority of datasets

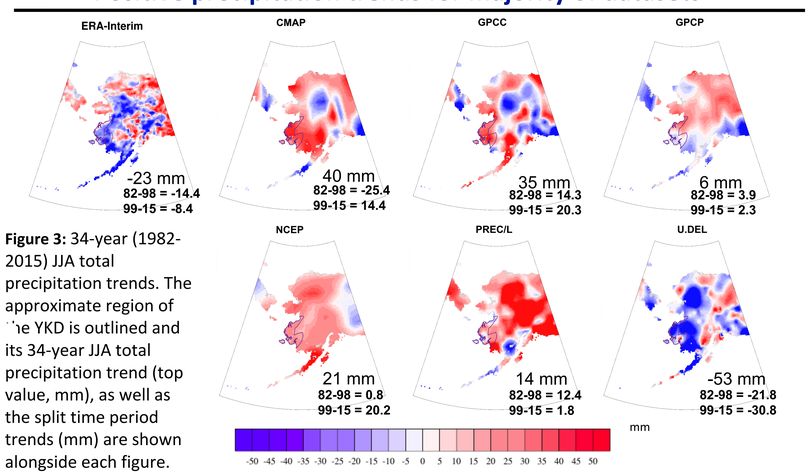


Figure 3: 34-year (1982-2015) JJA total precipitation trends. The approximate region of the YKD is outlined and its 34-year JJA total precipitation trend (top value, mm), as well as the split time period trends (mm) are shown alongside each figure.

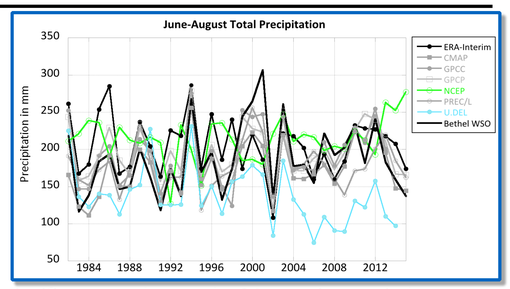
- **Trends also show little agreement between datasets**
  - **Two strong negatives = ERA-I, U.Del; Two strong positives = CMAP, GPCC**
- **Bethel trend is positive at 36 mm over the 34-year period**

Some datasets are closer than others (to Bethel at least)

Figure 4: Times series of yearly averages (mm) of JJA total precipitation for 1982-2015.

Table 1: Time series correlation to Bethel WSO

ERA-Interim	0.44
CMAP	0.83
GPCC	0.89
GPCP	0.79
NCEP	-0.33
PREC/L	0.71
U.Del	0.51



- Time series does not reveal significant trends over the 34-year time period
- Station based datasets ( ) show strong correlation to Bethel WSO data
  → Bethel is the only data point for this region
- Reanalysis does not do well (NCEP) unless downscaled for terrain and in situ observations (ERA-Interim)

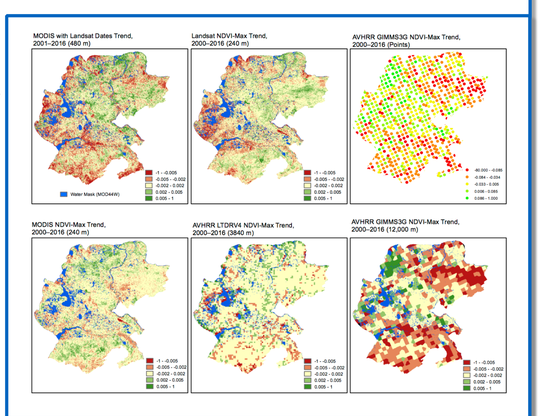
Conclusions (or just more questions?)

- Precipitation datasets are highly variable and difficult to interpret
- Data are showing both increasing and decreasing trends, but which is right?
- Precipitation alone does not account for NDVI decline in YKD
  → More to the story than precipitation
  → Other climate variables to consider: clouds, wind, extreme events

Intercomparison of NDVI datasets

NDVI trend maps derived from Landsat TM/ETM+ and MODIS permit inter-comparison of GIMMS-3g trends for 2000–2016. The high spatial resolution of Landsat (30m) and MODIS (250m) are also useful for evaluating potential climate drivers and resolving "hotspots" of NDVI change that pertain to local disturbance (e.g., coastal erosion, fire) and vegetation changes (shrub expansion) rather than broad scale climate drivers.

Both MODIS and Landsat TM/ETM+ record generally corroborate the browning observed by GIMMS-3g in coastal areas—but not in inland areas, many of which have seen a rapid increases in tall shrub cover. Taken together, the three time-series suggest trends follow a coast-inland gradient which may be related to regional climate drivers.



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