

Snow cover impacts on watershed discharge

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How do remotely sensed snow cover metrics impact discharge in the same water year in central Colorado?

Data checking

Data read in

First we need to get our snow metric (ndsi) data and then also download discharge data from the USGS

```
library(tidyverse)
library(lubridate)
library(dataRetrieval) #for downloading USGS data

#ndsi
ndsi <- read_csv('../data/hayman_ndsi.csv') %>%
  rename(burned=2,unburned=3) %>%
  filter(!is.na(burned),
         !is.na(unburned)) %>%
  gather(.,key='site',
         value='ndsi',
         -DateTime) # For this analysis we want the data in long format

#USGS gauge above cheeseman lake '00060'
q_hayman <- readNWISdata(sites=c('06700000'), #Site code
                        parameterCd='00060', #discharge code in cfs
                        service='dv', # service = daily values (versus annual)
                        startDate='1984-10-01', #Start date for getting the data
                        endDate = '2019-9-10') %>% # End date (today)
  rename(q_cfs = X_00060_00003,
         quality_cd = X_00060_00003_cd) %>% #rename long column name
  filter(!is.na(q_cfs)) %>% #Drop NAs which can occur when there is ice or sensor breaks
  as_tibble() #To make it act like a tibble
```

Data exploring

NDSI summary

##	DateTime	site	ndsi
##	Min. :1984-04-10	Length:3208	Min. : -0.5727
##	1st Qu.:1999-10-13	Class :character	1st Qu.: -0.4835
##	Median :2006-05-01	Mode :character	Median : -0.4307
##	Mean :2005-06-30		Mean : -0.2364
##	3rd Qu.:2013-03-17		3rd Qu.: -0.1352
##	Max. :2019-08-02		Max. : 0.9459

Q summary

```
##   agency_cd      site_no      dateTime
## Length:3133      Length:3133      Min.   :2002-08-01 00:00:00
## Class :character  Class :character  1st Qu.:2007-04-10 00:00:00
## Mode  :character  Mode  :character  Median :2011-05-31 00:00:00
##                                     Mean  :2011-04-24 03:37:24
##                                     3rd Qu.:2015-07-21 00:00:00
##                                     Max.   :2019-09-10 00:00:00
##      q_cfs      quality_cd      tz_cd
## Min.   : 53      Length:3133      Length:3133
## 1st Qu.: 124      Class :character  Class :character
## Median : 179      Mode  :character  Mode  :character
## Mean    : 243
## 3rd Qu.: 291
## Max.    :2210
```

Combining the data

Adding a water year column

When analyzing water flux data, we typically break the year up into “water years” which run from October to the end of September. For this exploratory analysis, we want to group the datasets by water year and then join them to each other so we can compare winter average, max, median, etc... of snow cover versus the next water year’s water flux. So we have to add a column called water year

Q water year

```
q_water_year <- q_hayman %>%
  mutate(month=month(dateTime),
         year_offset = ifelse(month > 9,1,0),
         wtr_yr = year(dateTime) + year_offset)

table(q_water_year$wtr_yr)
```

```
##
## 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016
##   61  183  183  164  183  183  183  183  183  183  183  183  183  183  183
## 2017 2018 2019
##  183  183  163
```

NDSI water year

```
##
## 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998
##   14   34   44   66   44   48   26   34   50   56   60   60   64   60   60
## 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
##   78  106  120  134  116  128  132  132  130  114  112  128  130   90  108
## 2014 2015 2016 2017 2018 2019
##  138  116  130  114  130  102
```

Filtering and summarizing

Now that we have our matched datasets we want to do a couple filtering operations. First, we want to make sure that we are only analyzing complete water years from the Q dataset. Second, we want to make sure we are only summarizing the snow data over months where snow cover is possible, which I would guess is between october and may. Once we have these filtering operations done, we want to summarize each dataset by water year so we can eventually join them and see if snow cover predicts Q.

Snow water year summary statistics

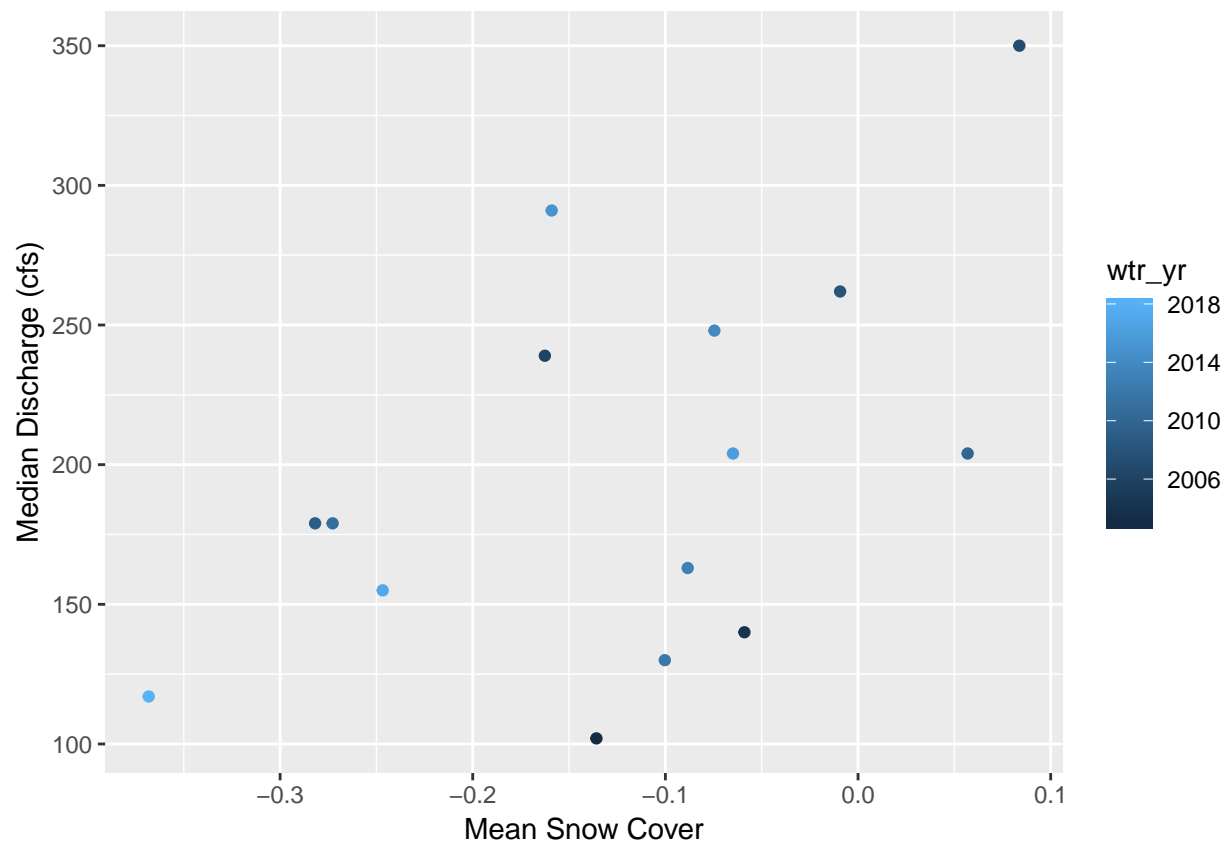
```
## # A tibble: 36 x 4
##   wtr_yr mean_ndsi max_ndsi median_ndsi
##   <dbl>   <dbl>   <dbl>   <dbl>
## 1  1984    0.483    0.605    0.483
## 2  1985   -0.104    0.539   -0.123
## 3  1986   -0.130    0.436   -0.203
## 4  1987    0.0614   0.655    0.247
## 5  1988   -0.309    0.616   -0.425
## 6  1989   -0.398   -0.208   -0.404
## 7  1990   -0.269    0.524   -0.428
## 8  1991    0.0130    0.632   -0.0550
## 9  1992   -0.0982    0.592   -0.272
## 10 1993   -0.00697   0.626   -0.0943
## # ... with 26 more rows
```

Whole Q water year summaries

```
## # A tibble: 15 x 4
##   wtr_yr mean_q max_q median_q
##   <dbl> <dbl> <dbl>   <dbl>
## 1  2003  121.  350    102
## 2  2004  145.  296    140
## 3  2006  222.  395    239
## 4  2007  325.  494    350
## 5  2008  294.  585    262
## 6  2009  253.  667    179
## 7  2010  251.  622    204
## 8  2011  272.  783    179
## 9  2012  149.  278    130
## 10 2013  184.  332    163
## 11 2014  280.  542    248
## 12 2015  562. 2210    291
## 13 2016  204.  349    204
## 14 2017  205.  582    155
## 15 2018  131.  281    117
```

Plots of Snow Cover vs Q

Mean Snow vs Median Q



Max Snow vs Median Q

