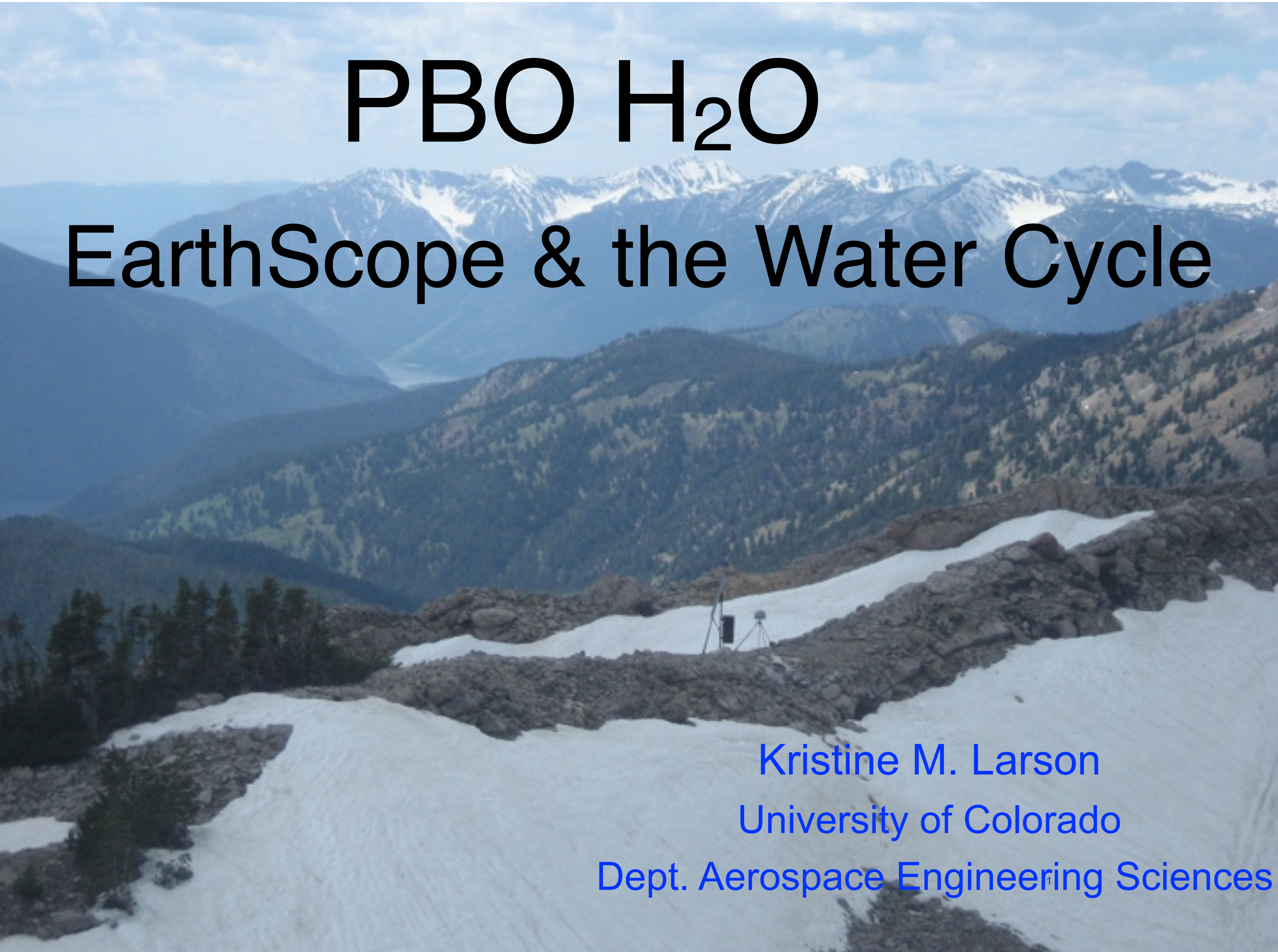
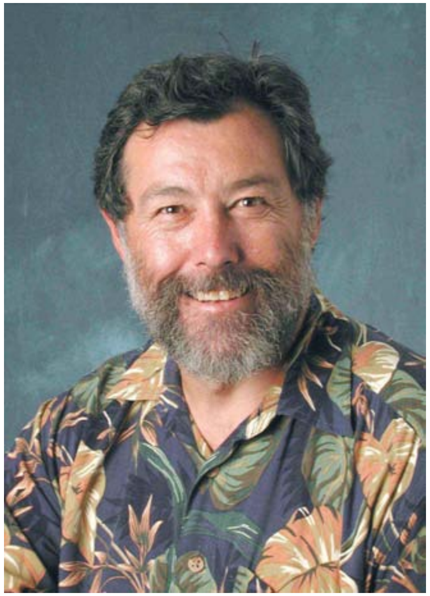
PBO H_2O

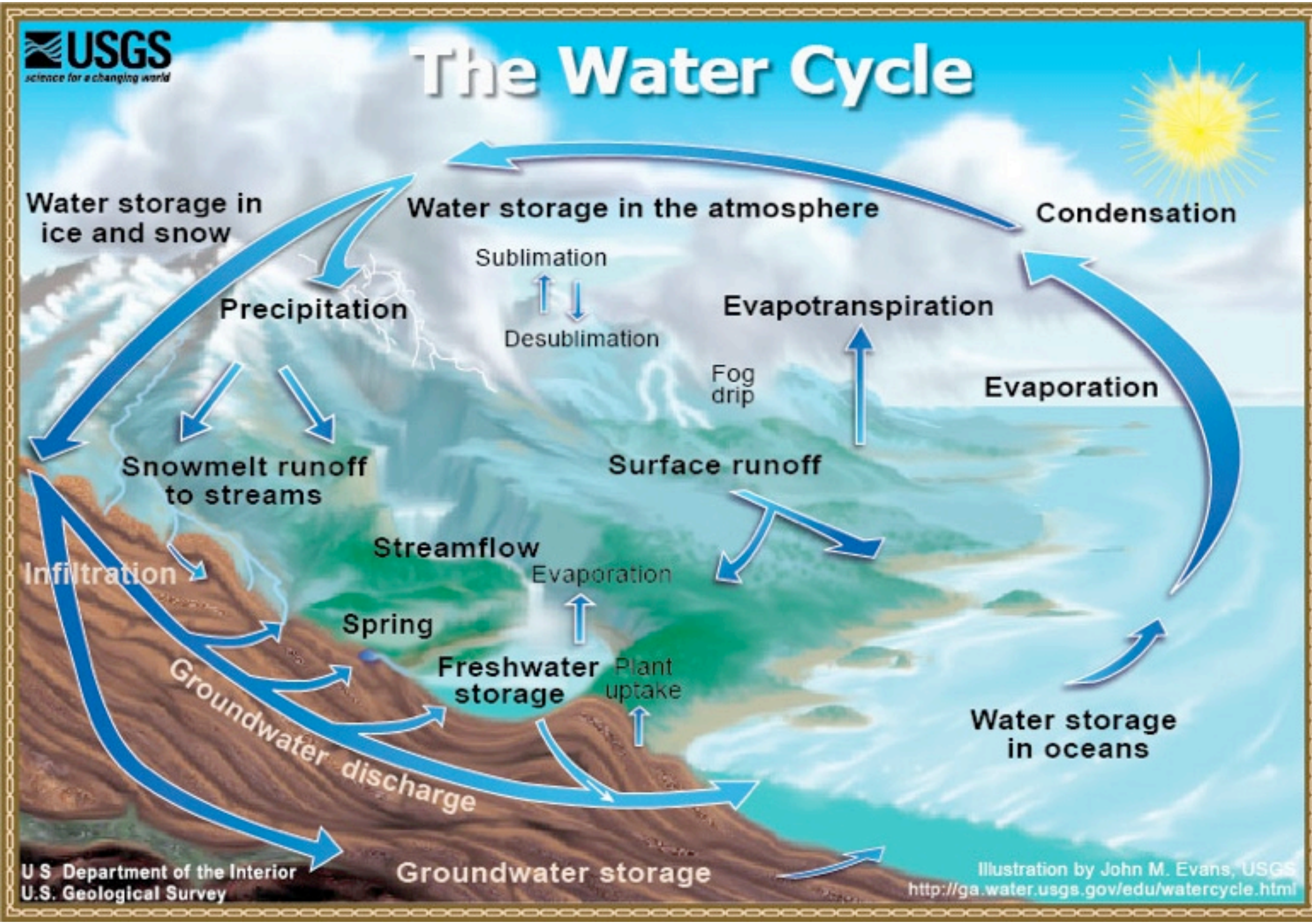
EarthScope & the Water Cycle



Kristine M. Larson
University of Colorado
Dept. Aerospace Engineering Sciences



And PBO, UNAVCO, CU interdisciplinary seedgrant, AGS 0935725 and EAR 0948957

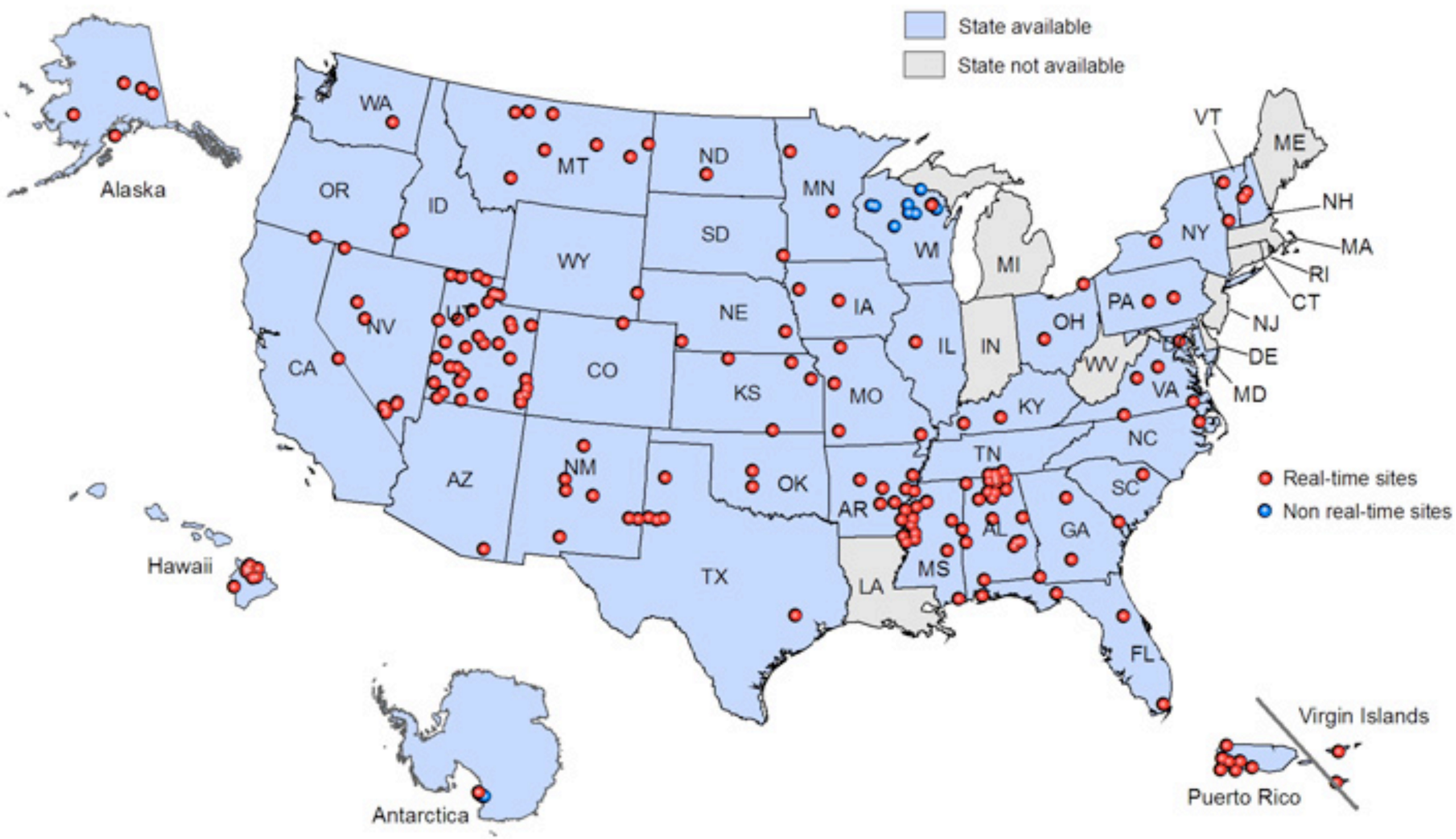

USGS
science for a changing world
The Water Cycle
Water storage in ice and snow
Water storage in the atmosphere
Condensation
Sublimation
Desublimation
Precipitation
Evapotranspiration
Fog drip
Evaporation
Snowmelt runoff to streams
Surface runoff
Streamflow
Evaporation
Infiltration
Spring
Freshwater storage
Plant uptake
Water storage in oceans
Groundwater discharge
Groundwater storage
U.S. Department of the Interior
U.S. Geological Survey
Illustration by John M. Evans, USGS
http://ga.water.usgs.gov/edu/watercycle.html

Global Terrestrial Observing System Essential Climate Variables

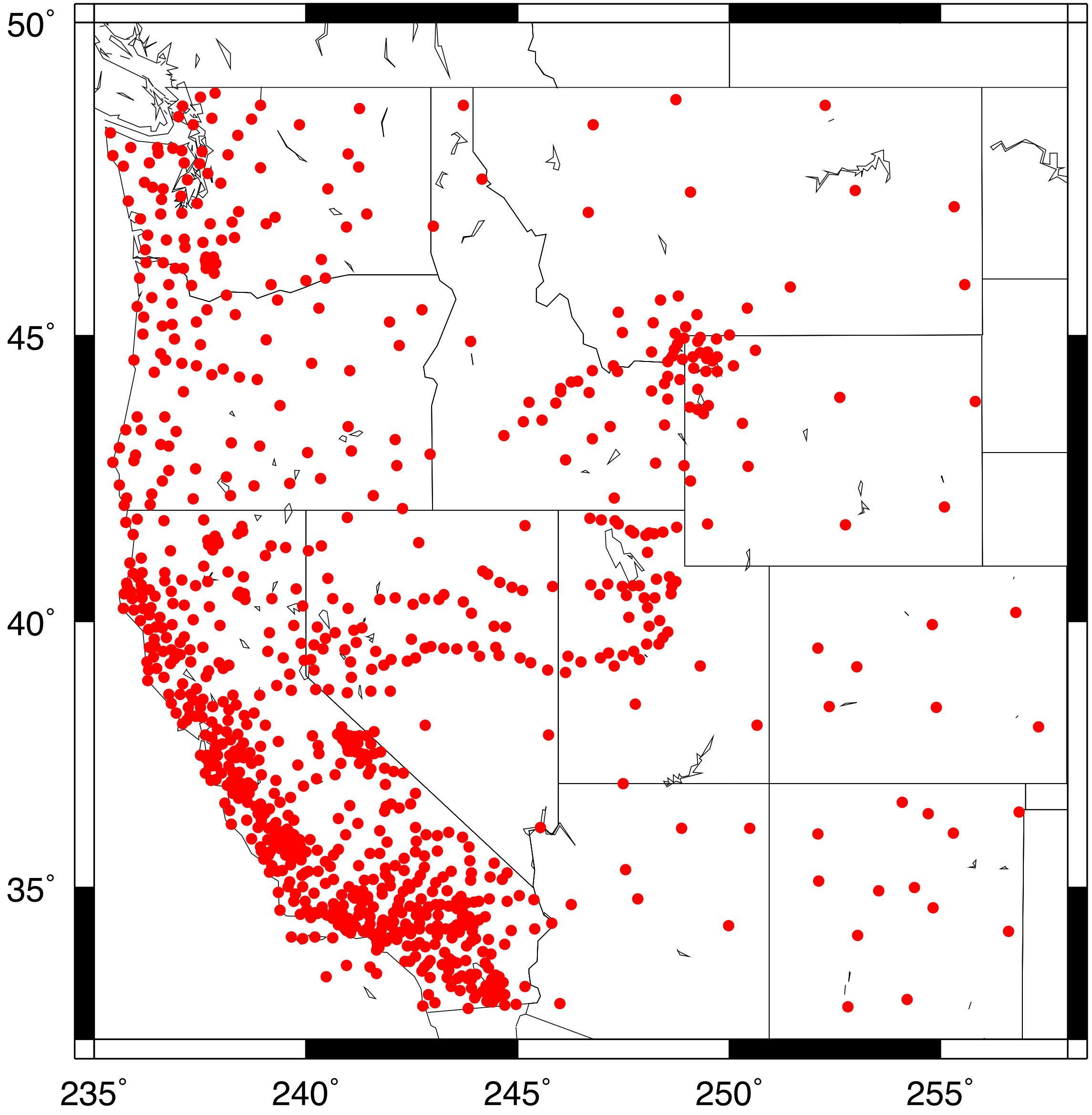
ECVs: parameters considered to be the most important for detection and assessing the impact of climate change.

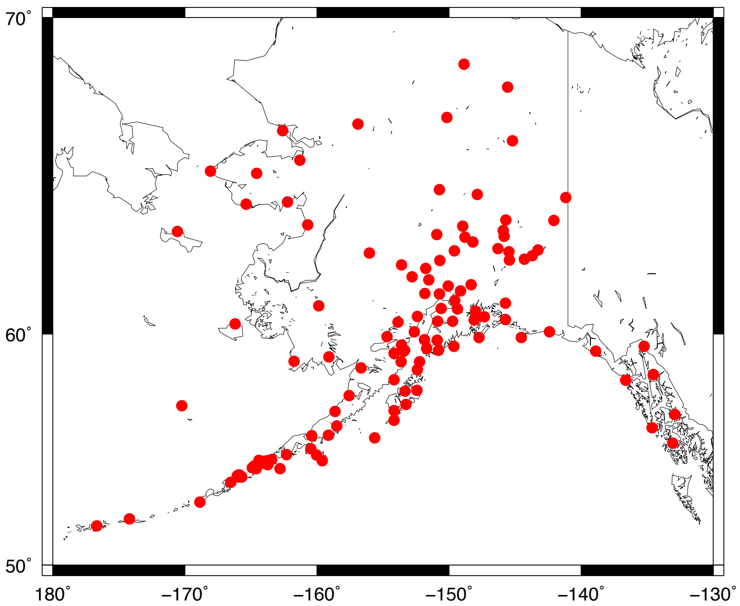
- soil moisture: land-atmosphere interactions; runoff and infiltration; plant productivity.
- snow: timing and amount of runoff; influences climate.
- above-ground biomass: global carbon budget; influences climate

National Soil Moisture Network

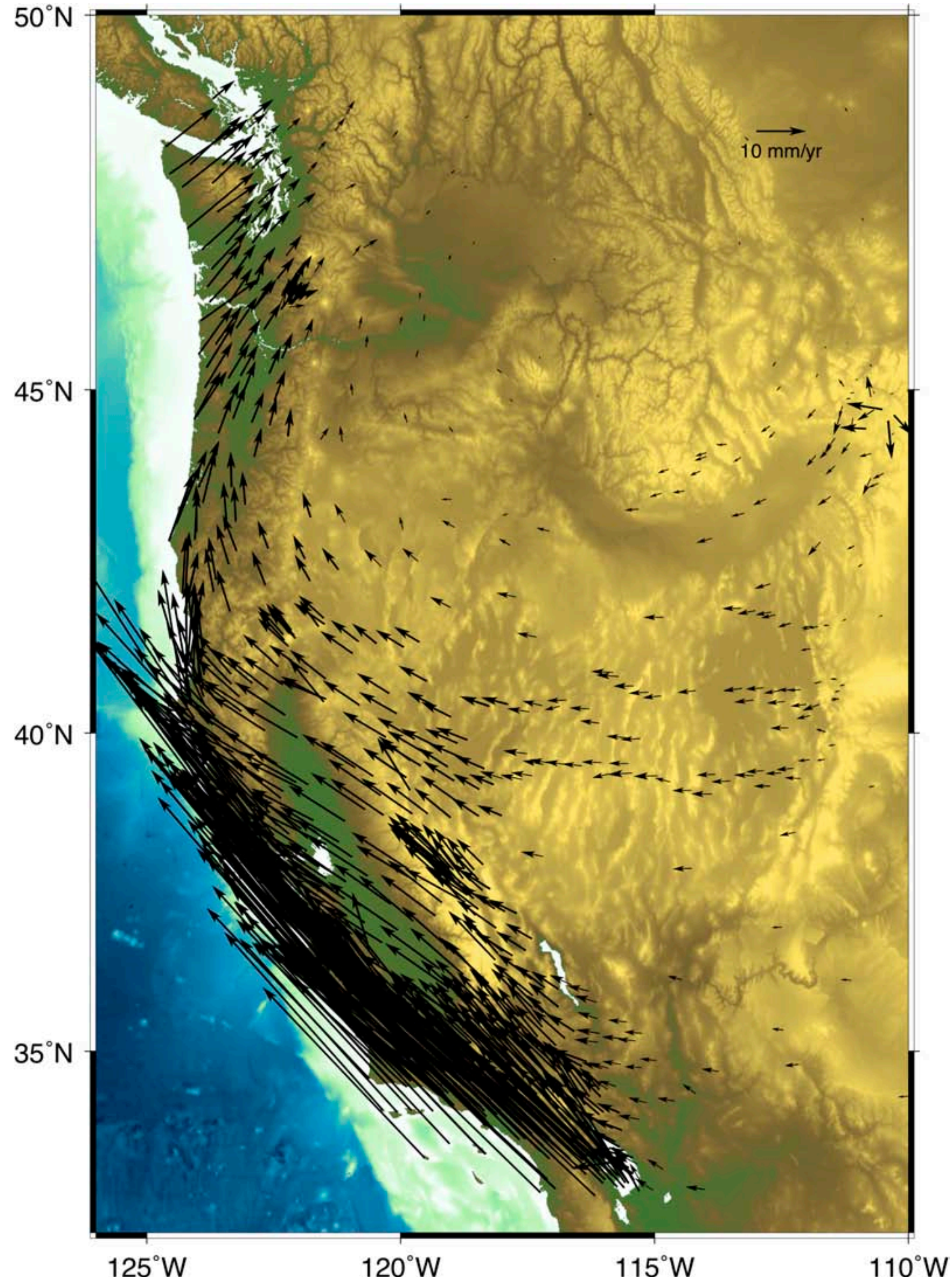


How Can PBO Contribute?



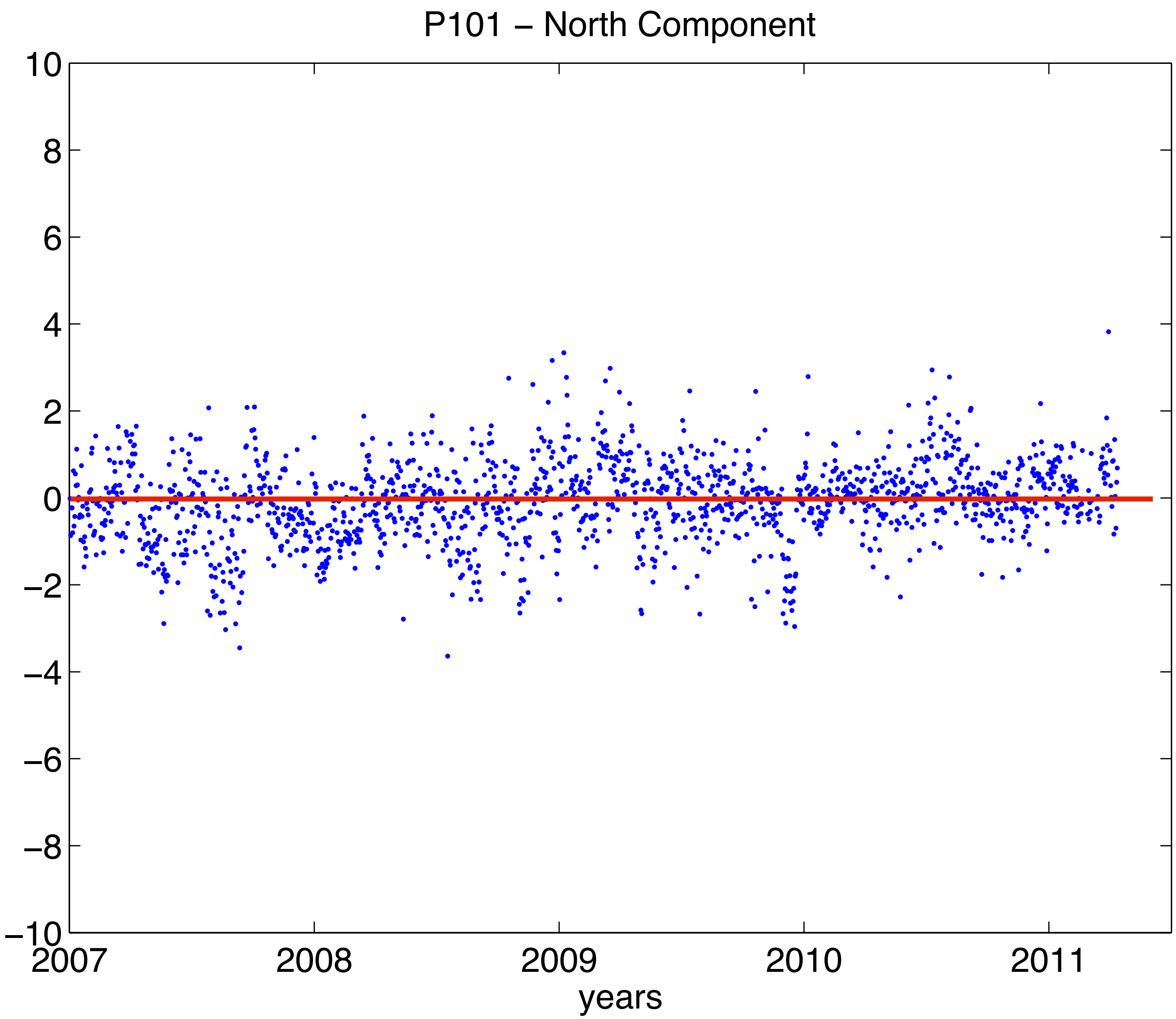


PBO has the virtue of consistent instrumentation and excellent maintenance, telemetry, and archiving support.

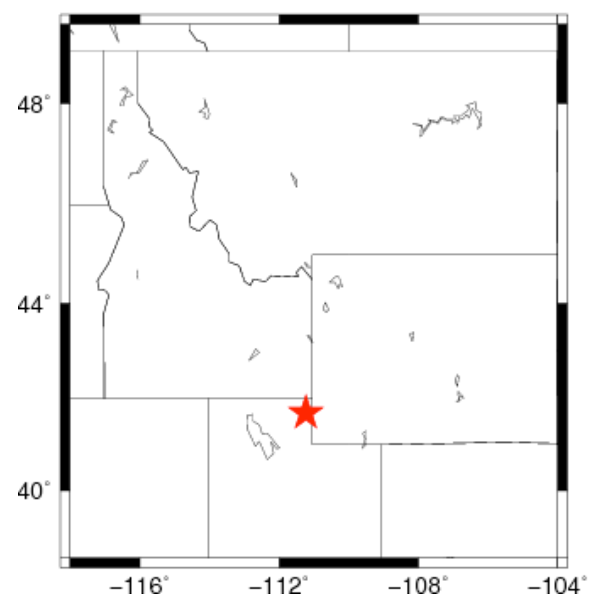


The typical view of PBO science products

Velocity vectors are based on time series



PBO Site P101: Randolph UT



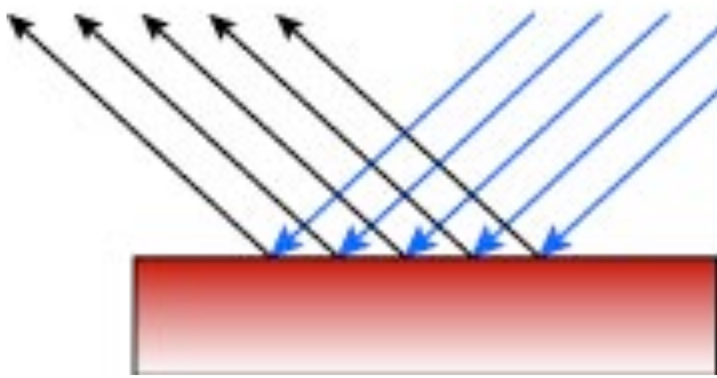
PBO H_2O view


June


January

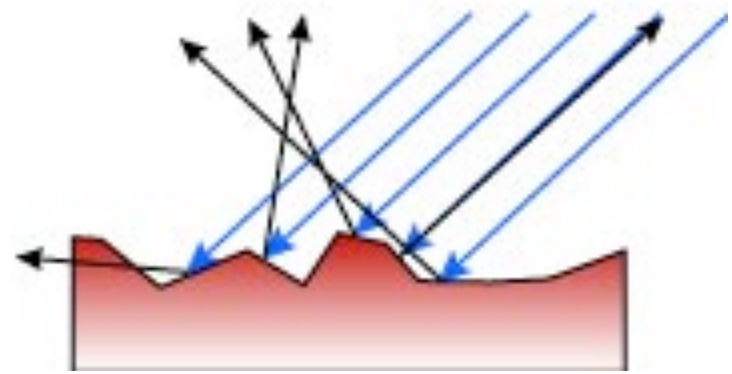
How can PBO be used to measure water cycle quantities?

specular
multipath



use for snow & soil moisture

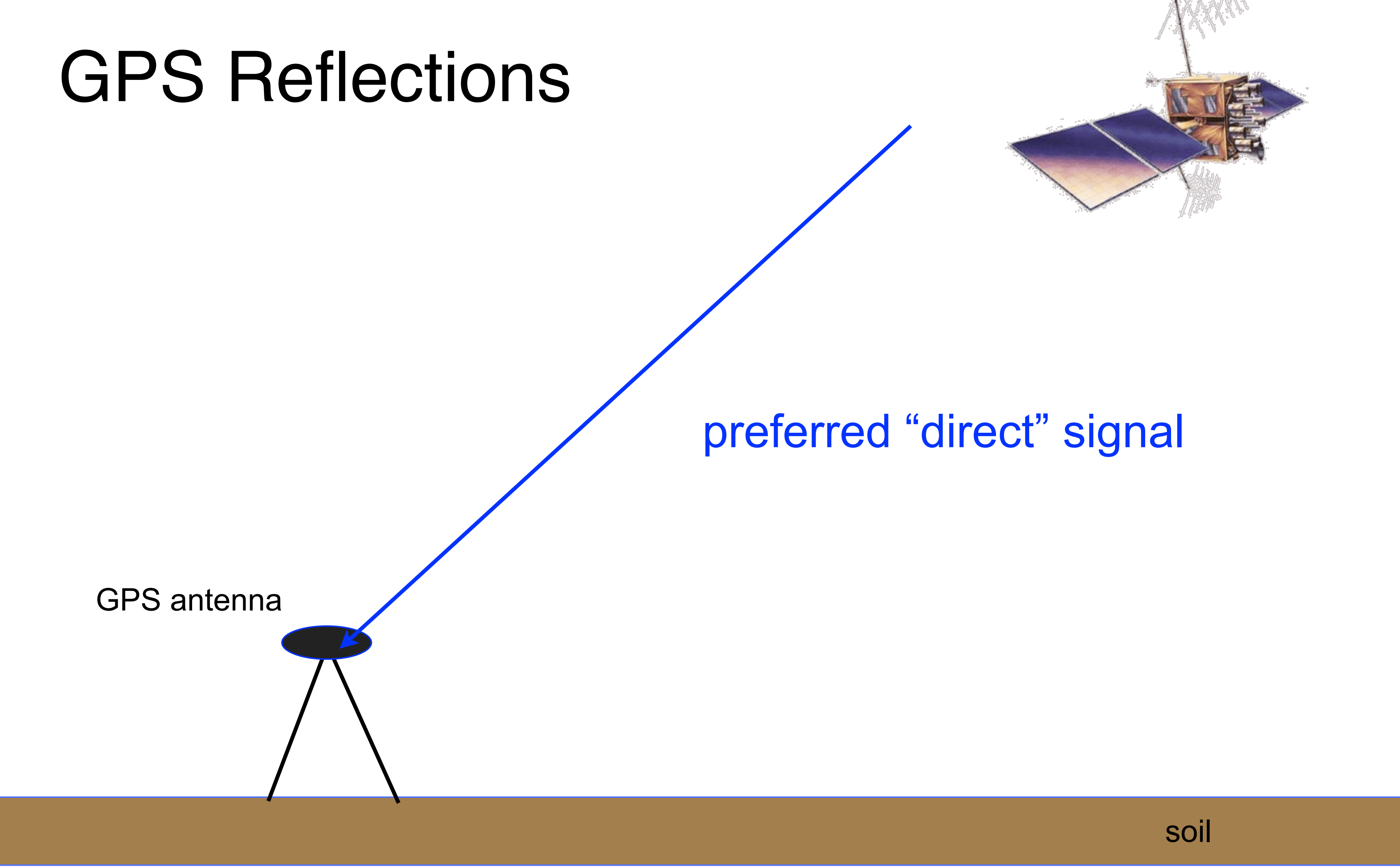
diffuse
multipath



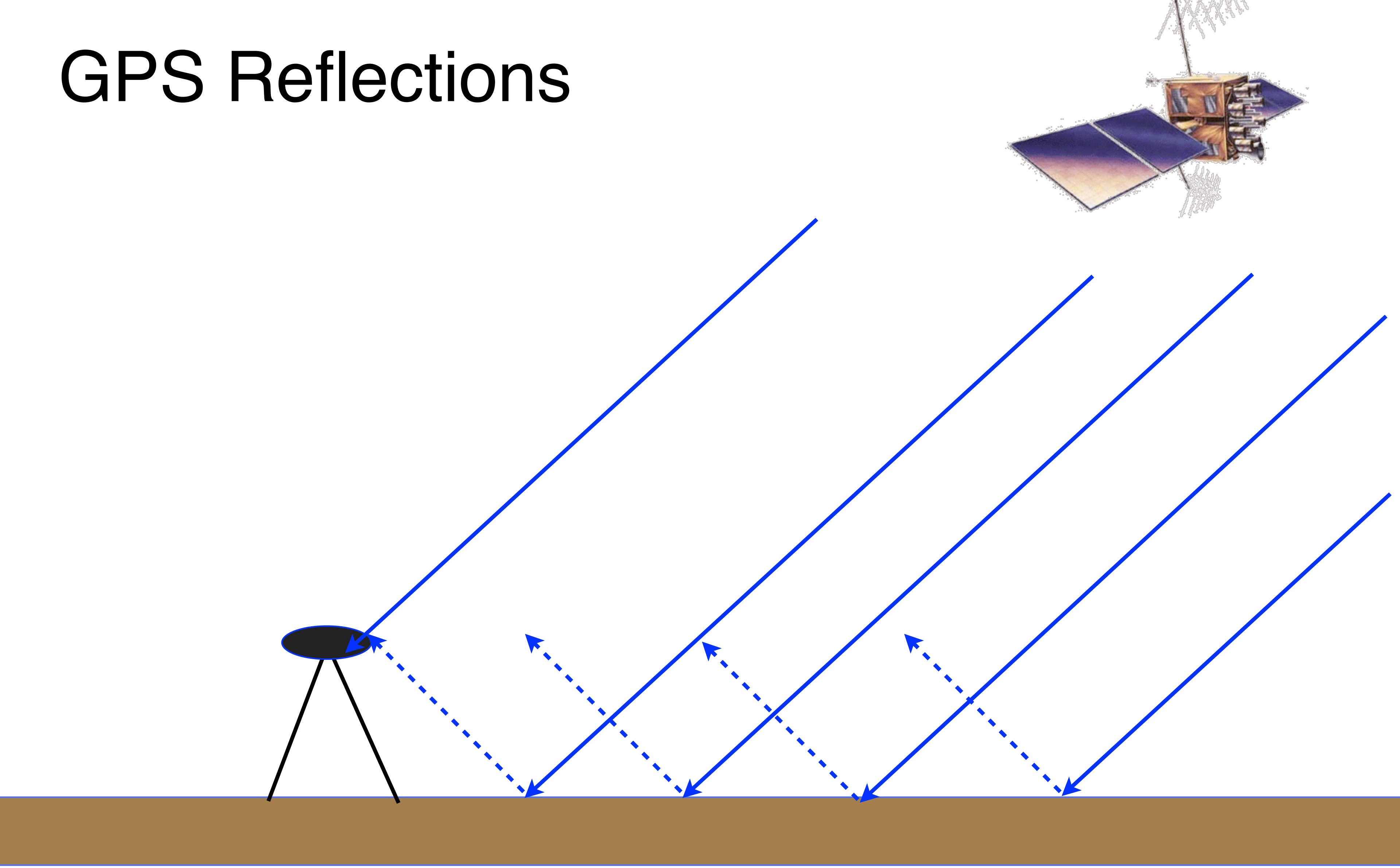
use for vegetation

for details: go to my website, click on “reflections.”

GPS Reflections

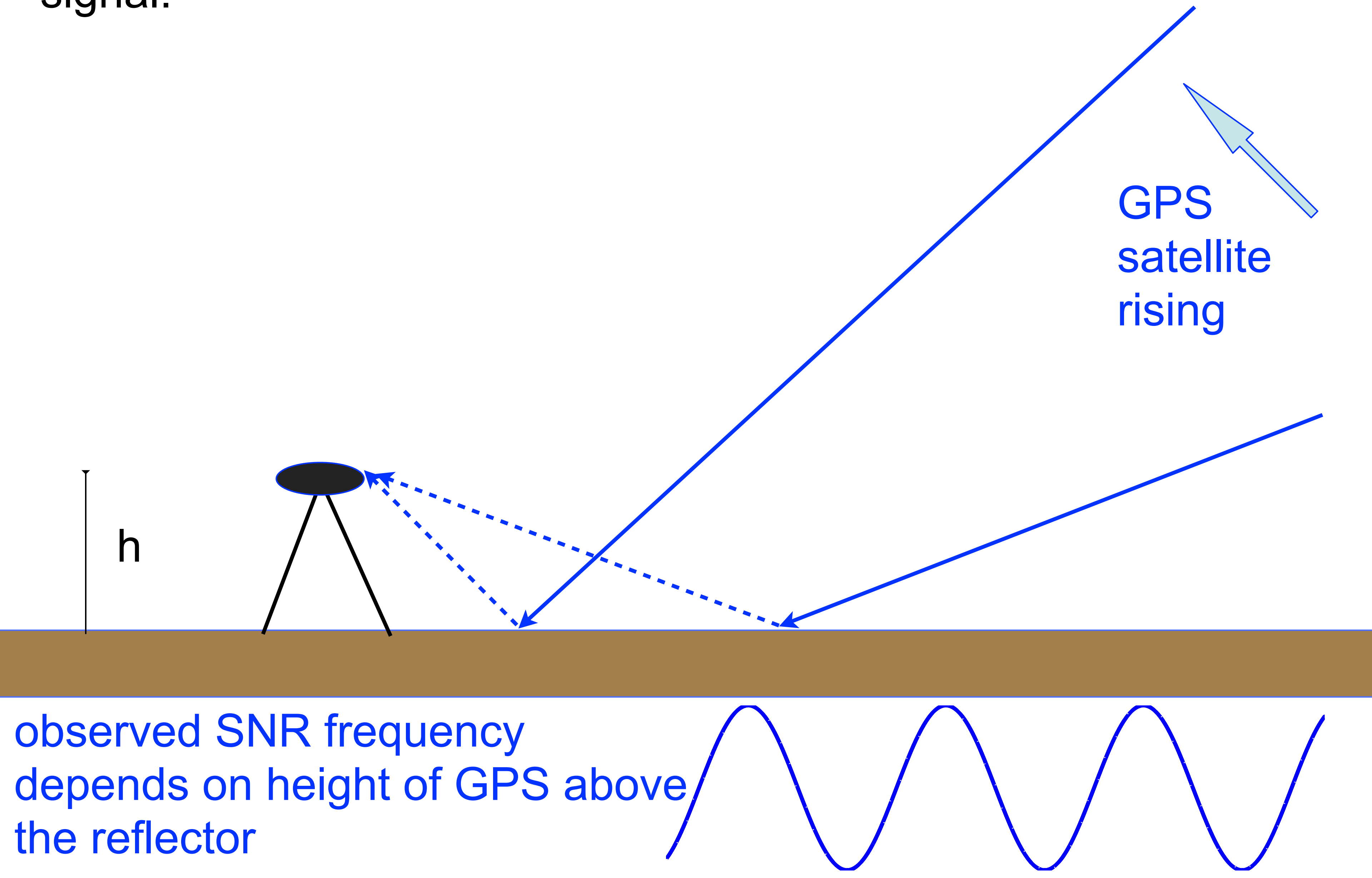


GPS Reflections

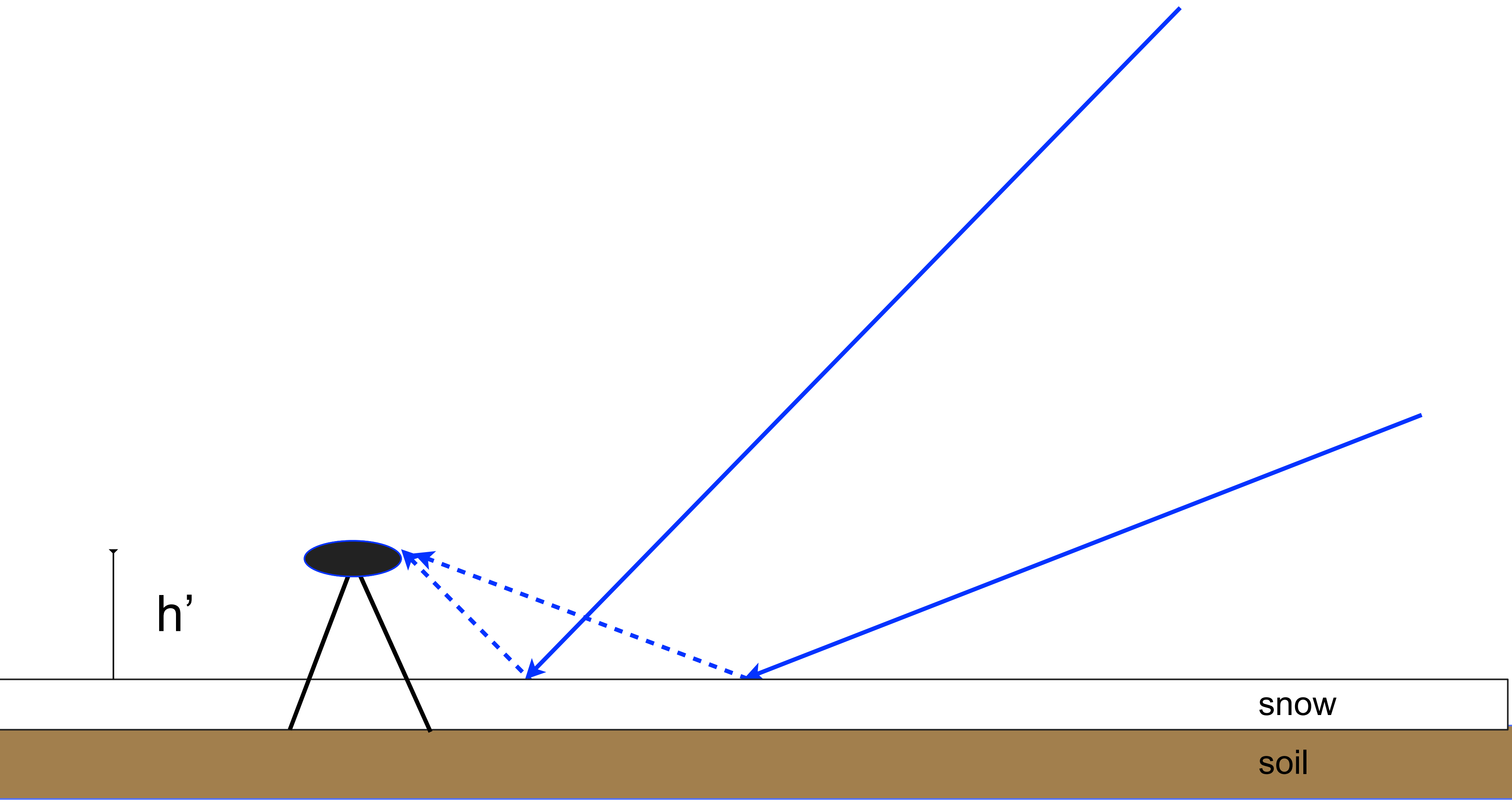


some - but not all - of the signals will be reflected to the antenna.

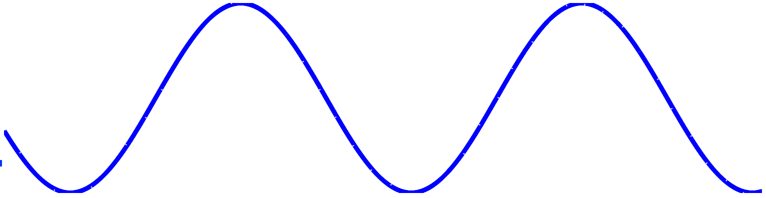
GPS signal to noise ratio - SNR - data are directly related to the interference of the direct and reflected signal.



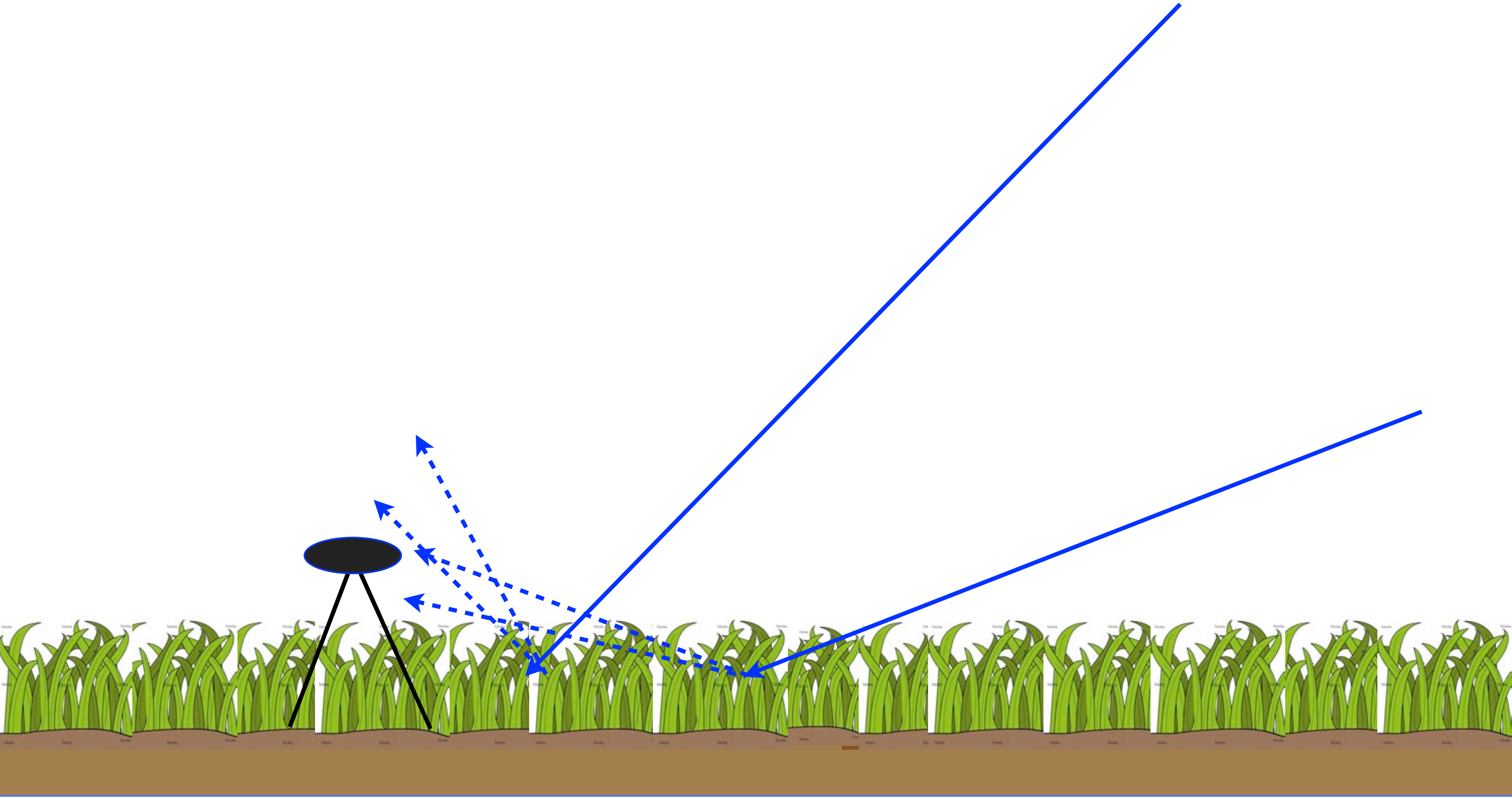
Add a snow layer



The SNR oscillations will now have a lower frequency because h’ is smaller.

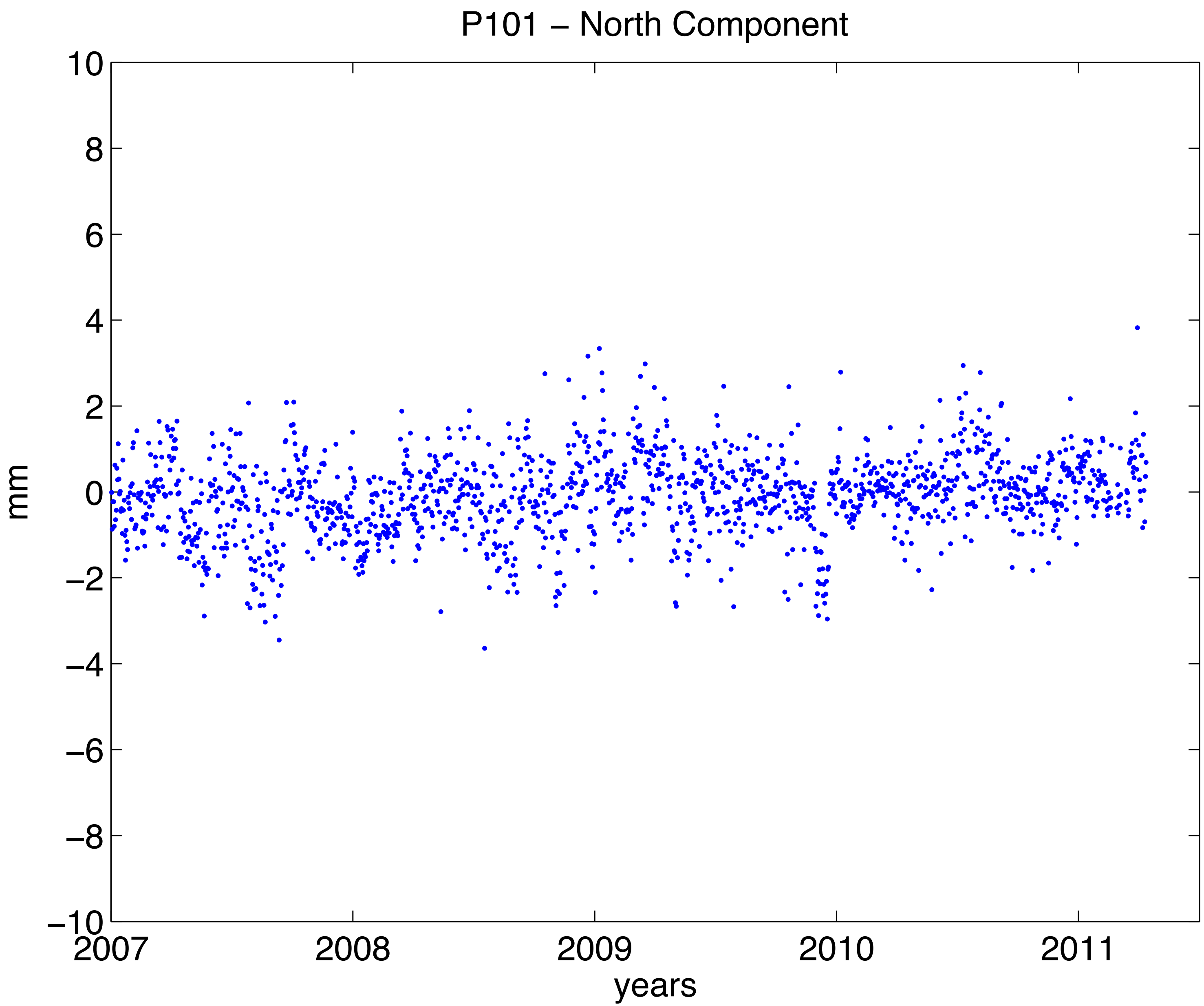


Add a vegetation layer

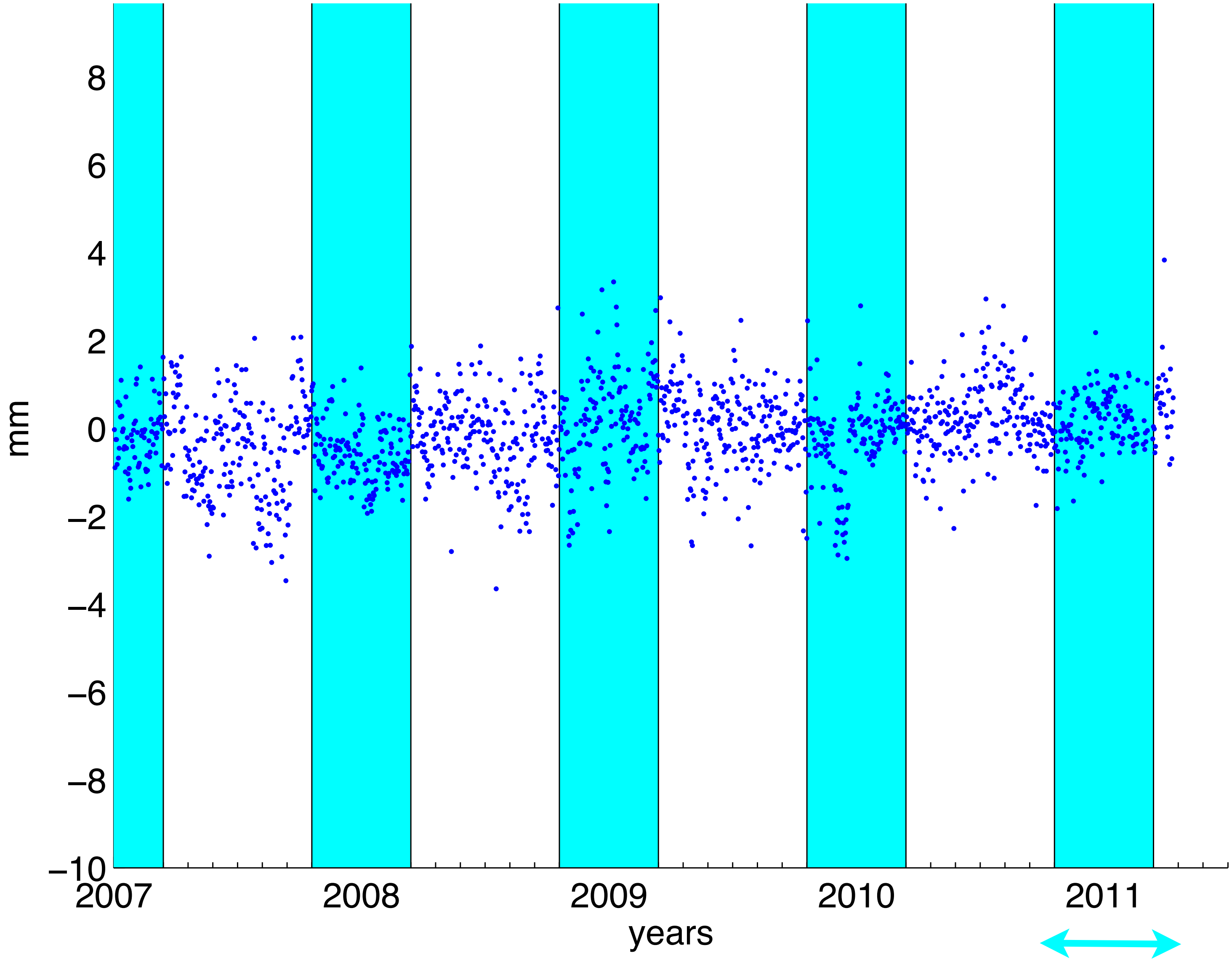


SNR oscillations will now have a lower amplitude. And they will be more “scattered.”

Positioning data typically look like there are no seasonal variations at a site.



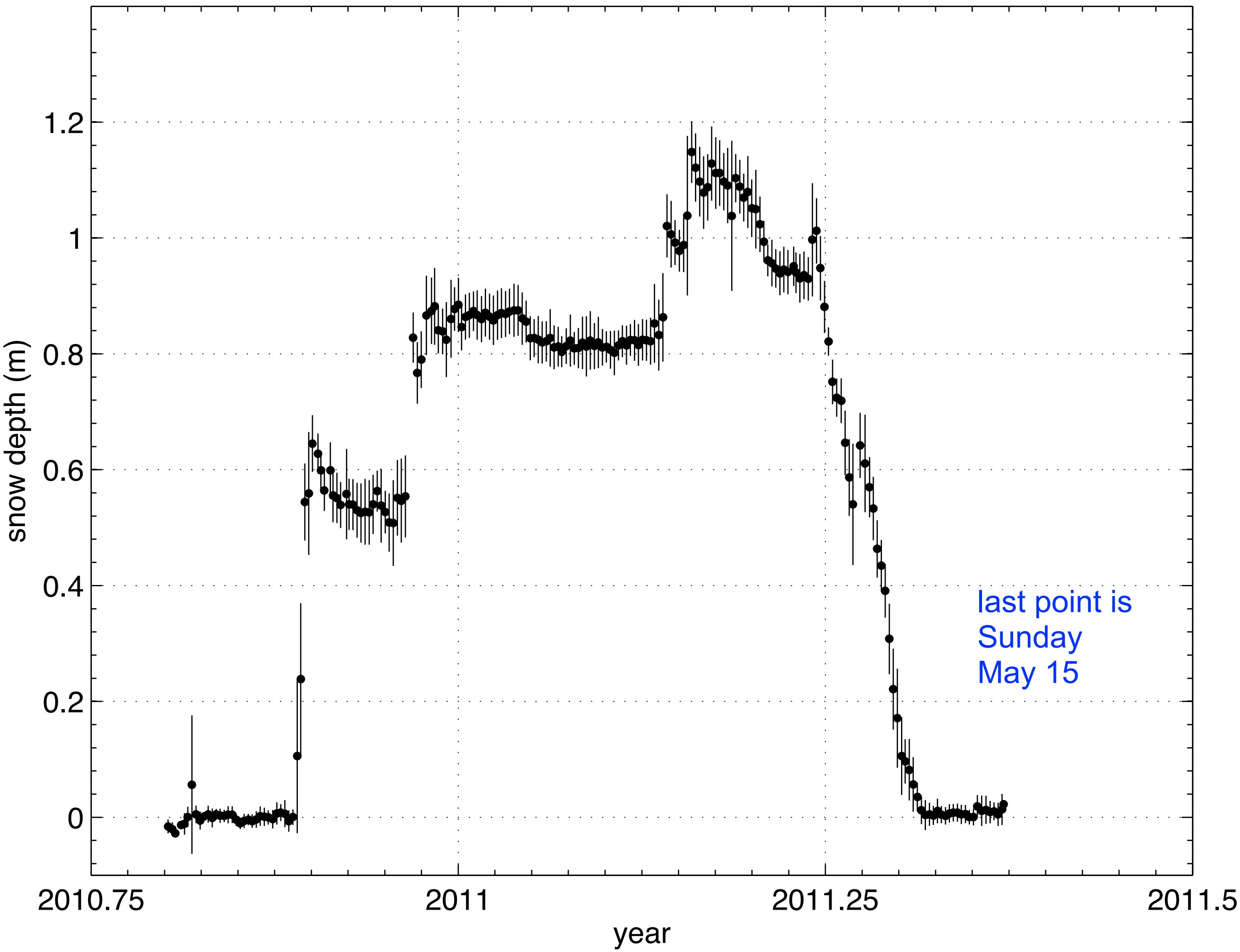
Use the same GPS data that produced this positioning time series to look at multipath during winter months.



Convert changes in SNR oscillation frequencies to estimate snow depth.

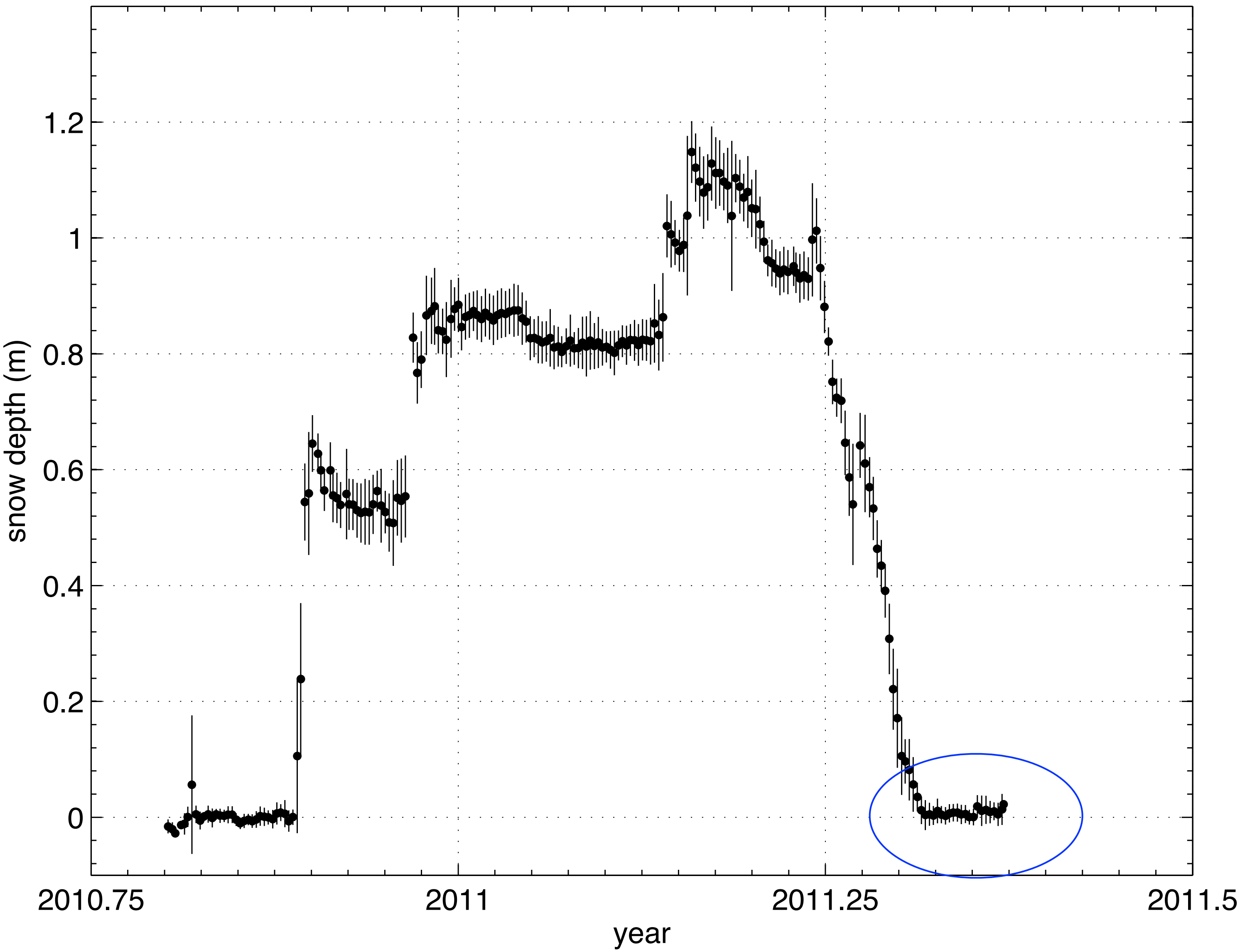
Snow Depth 2010-2011

p101

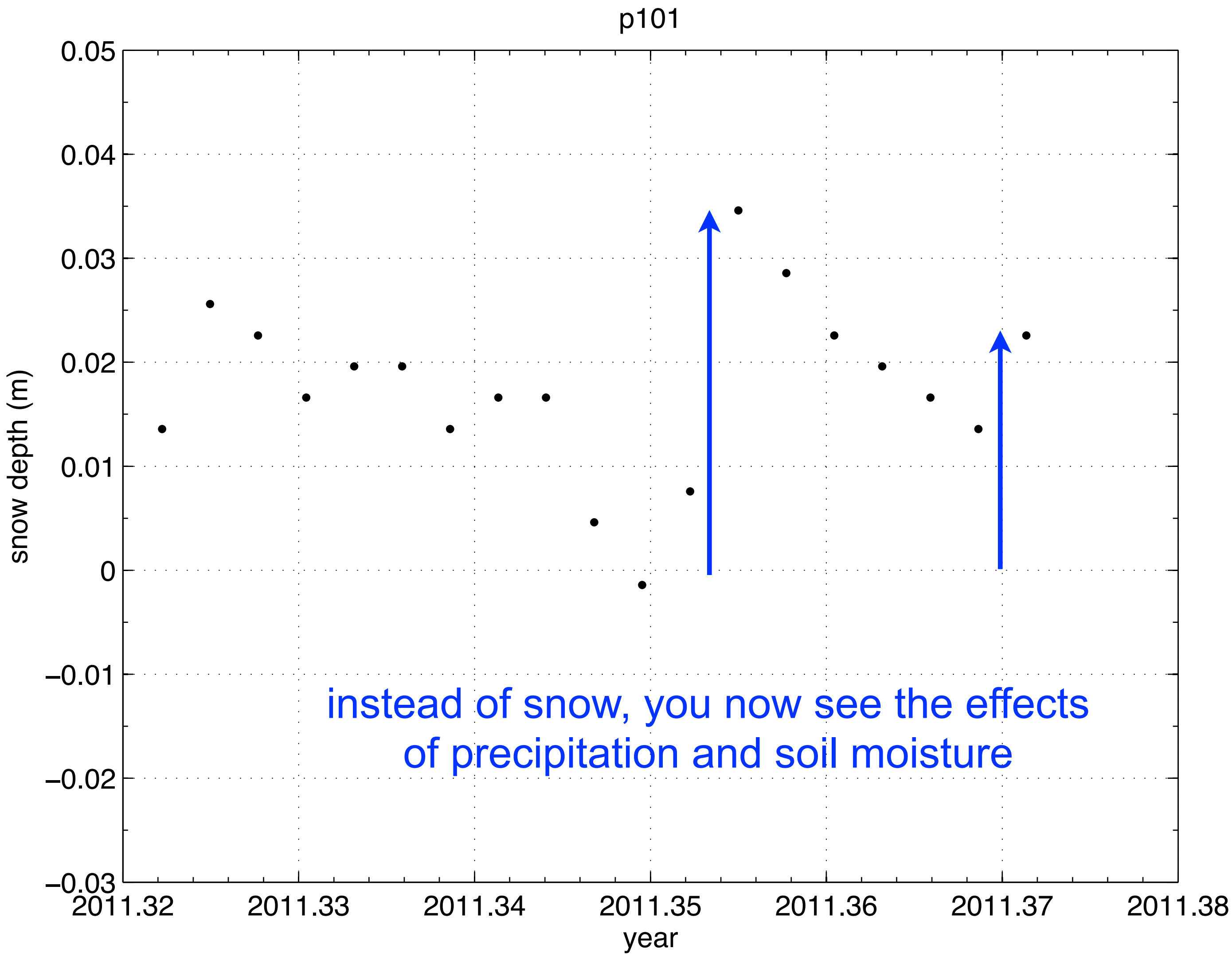


Snow Depth 2010-2011

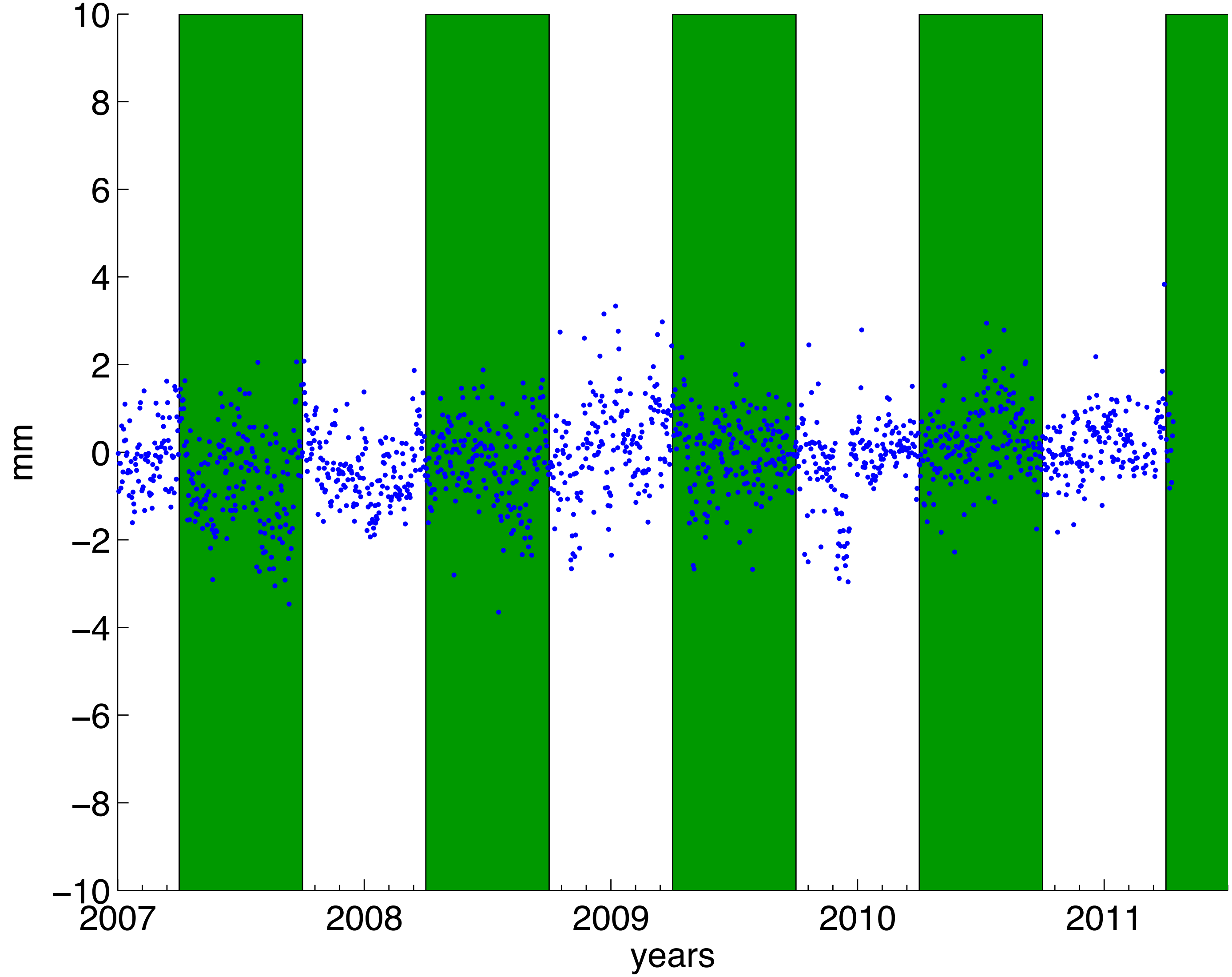
p101

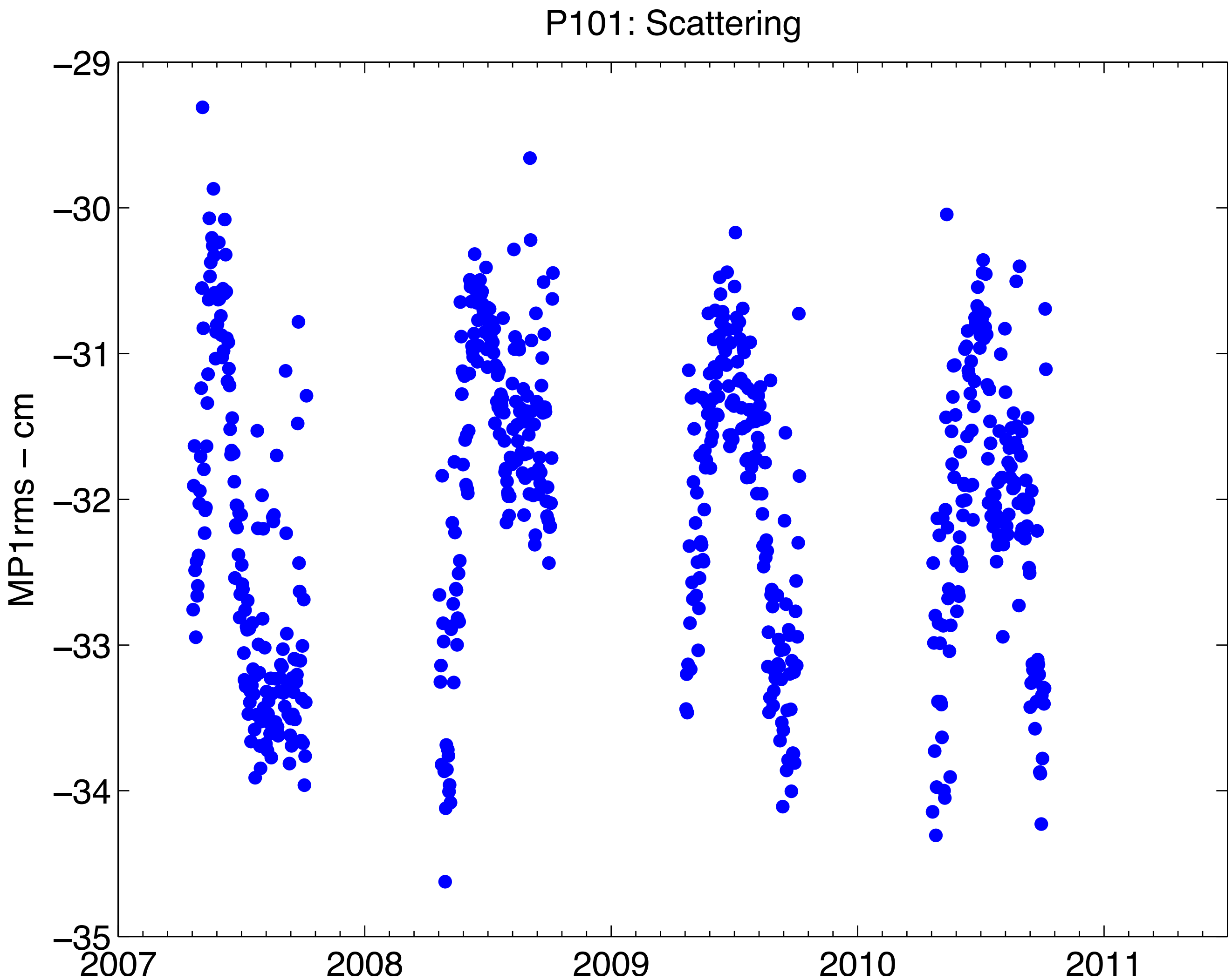


note change in y-axis scale

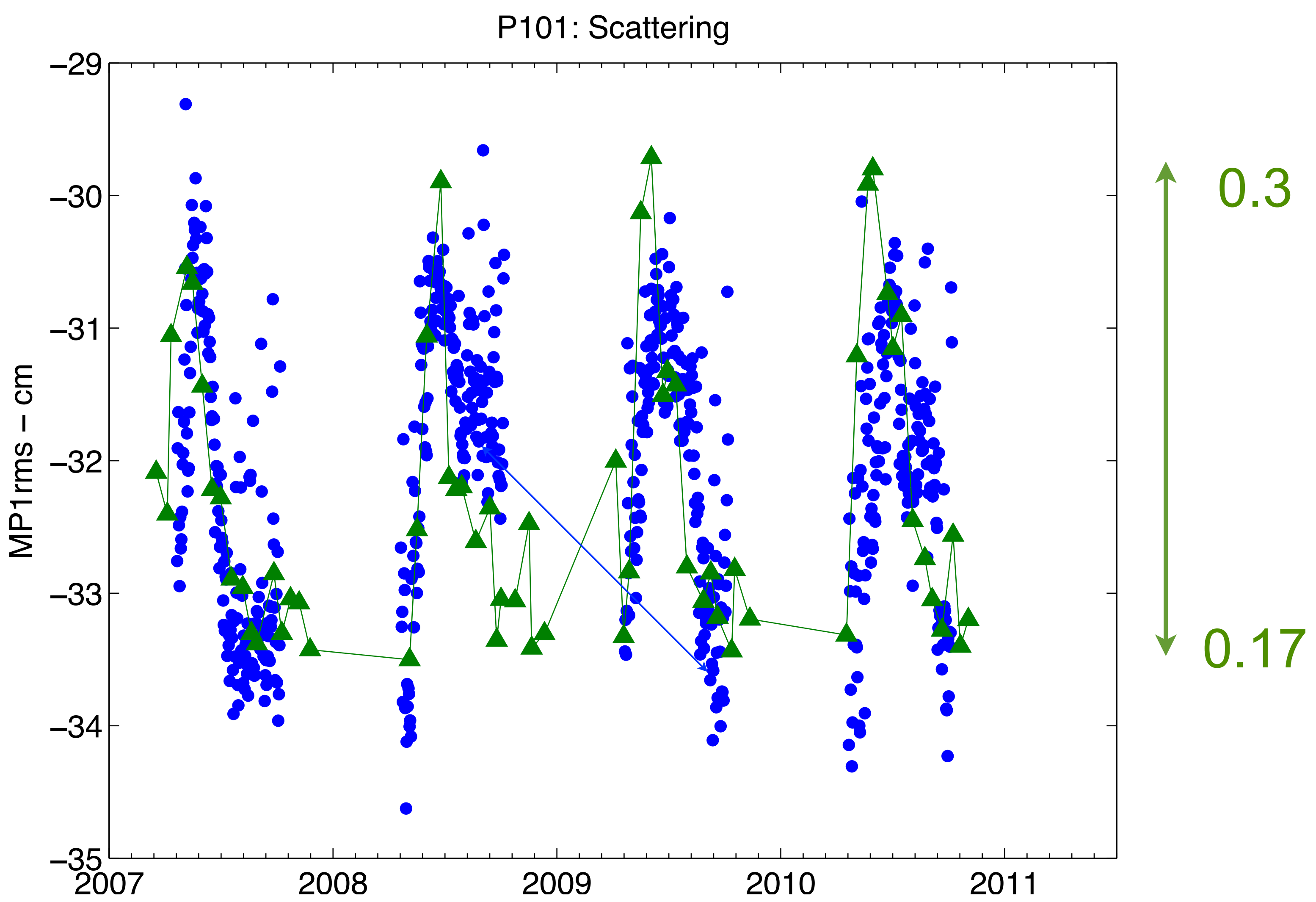


Now look at reflections during the growing months.



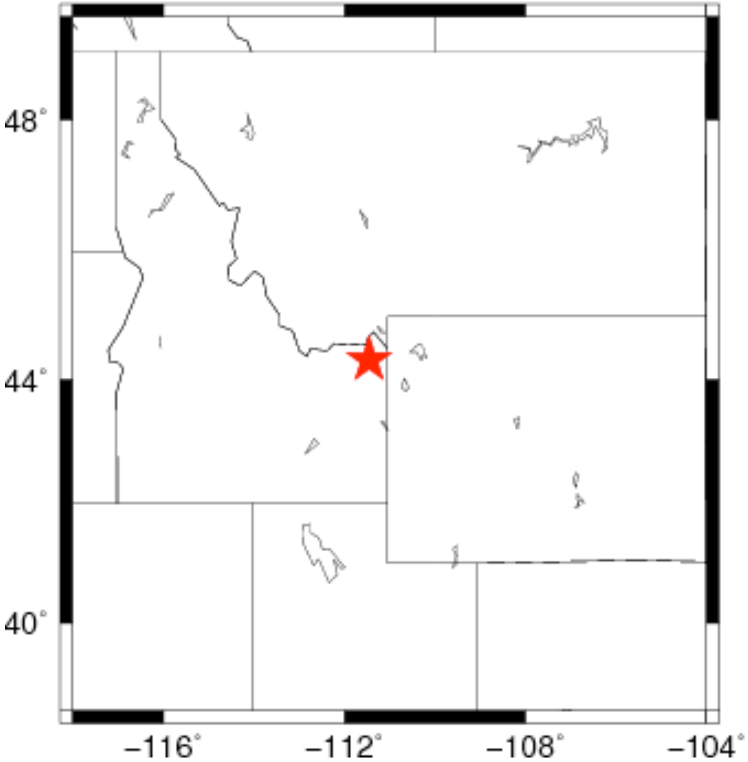


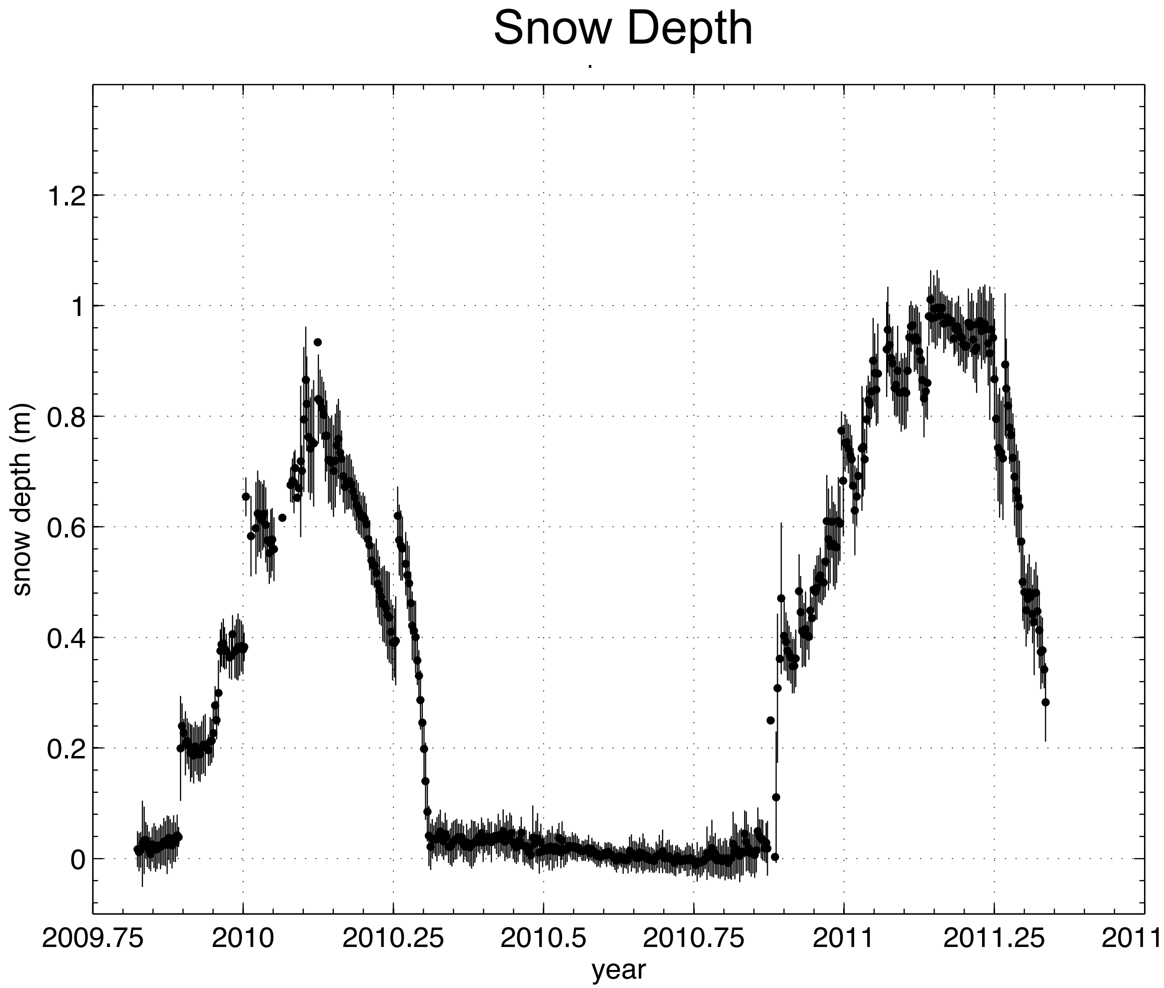
GPS scattering sensitive to water content in vegetation.



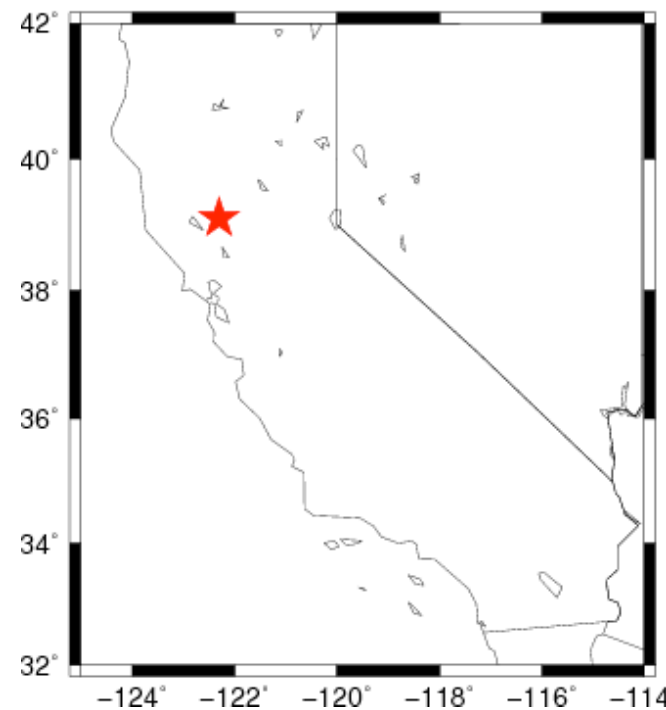
triangles are 16-day optical remote sensing data (NDVI)
measuring “greenness”

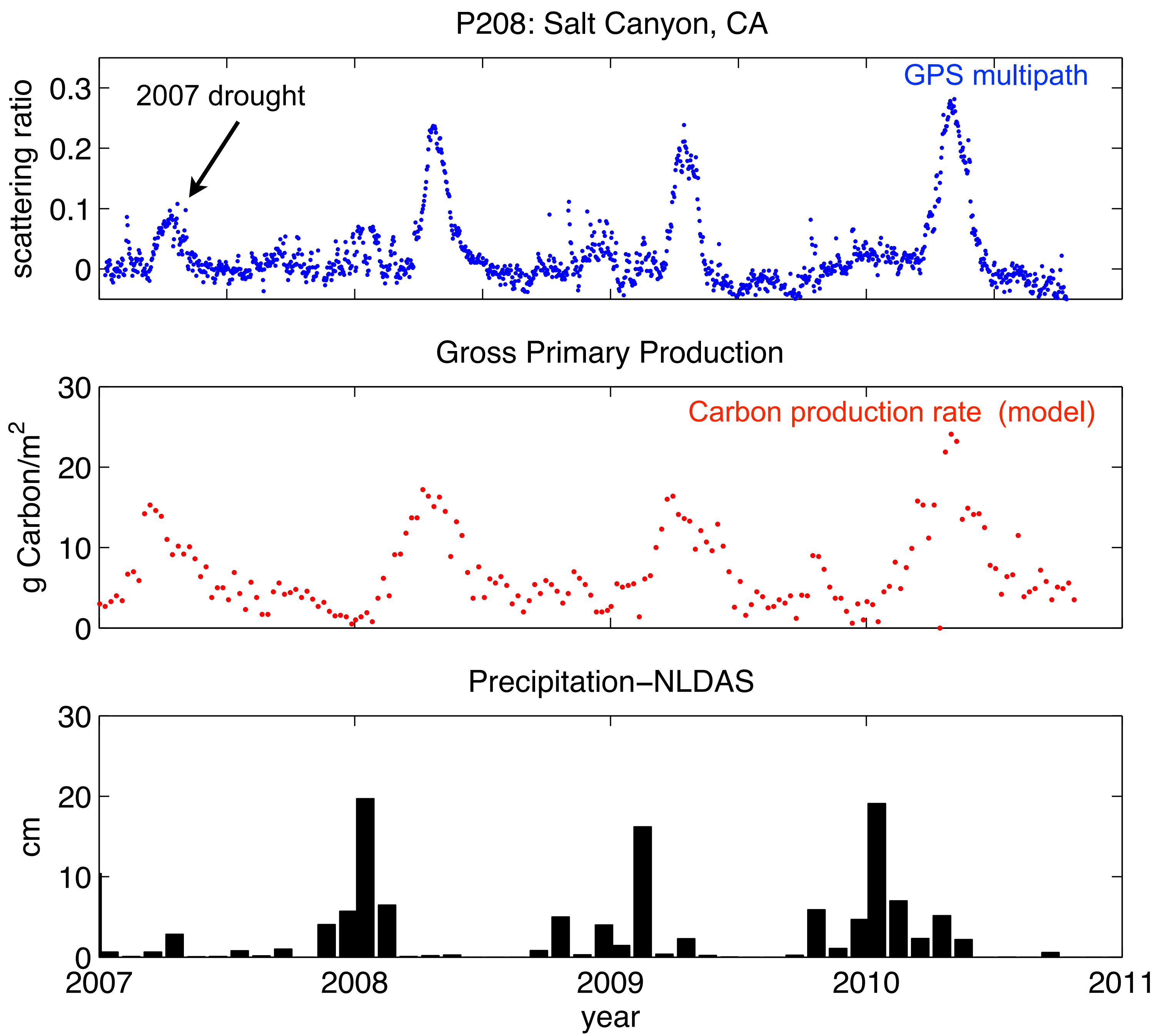
P360, Island Park, ID



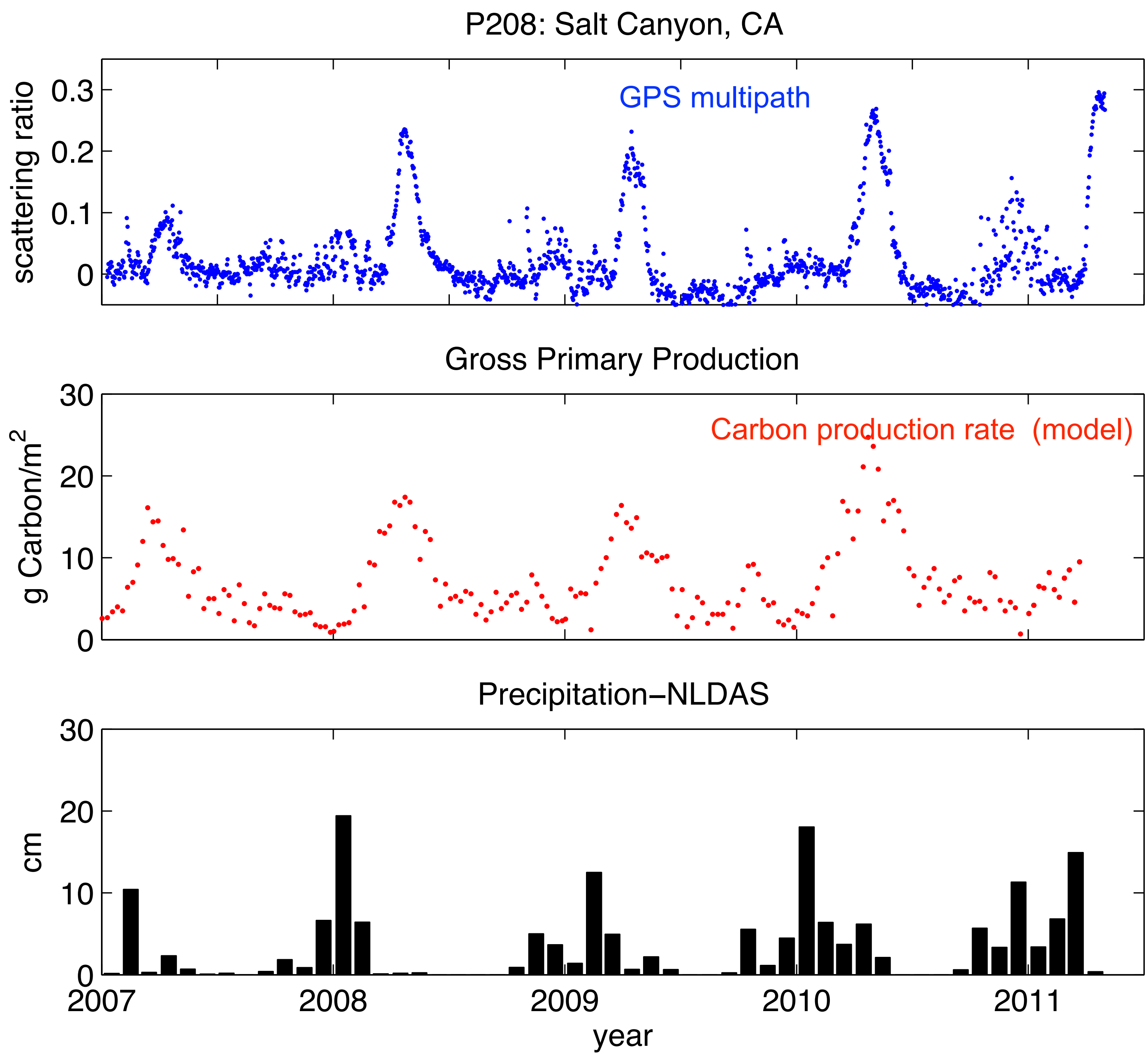


P208: Salt Canyon, CA





P208: Salt Canyon, CA
scattering ratio
0.3
0.2
0.1
0
2007 drought
GPS multipath
Gross Primary Production
g Carbon/m2
30
20
10
0
Carbon production rate (model)
Precipitation–NLDAS
cm
30
20
10
0
2007
2008
2009
2010
2011
year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scattering ratio
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GPS multipath
Gross Primary Production
g Carbon/m^2
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20
10
0
Carbon production rate (model)
Precipitation−NLDAS
cm
30
20
10
0
2007
2008
2009
2010
2011
year

Conclusions

- Soil moisture, snow depth, and vegetation water content variations can clearly be observed in GPS data.
- We are improving and validating the methods used to retrieve these parameters.
- PBO H_2O has the potential to significantly contribute to climate studies in the western United States.