Seasonal Slow-Moving Landslide and Hazard in Aizawl, India Revealed from InSAR

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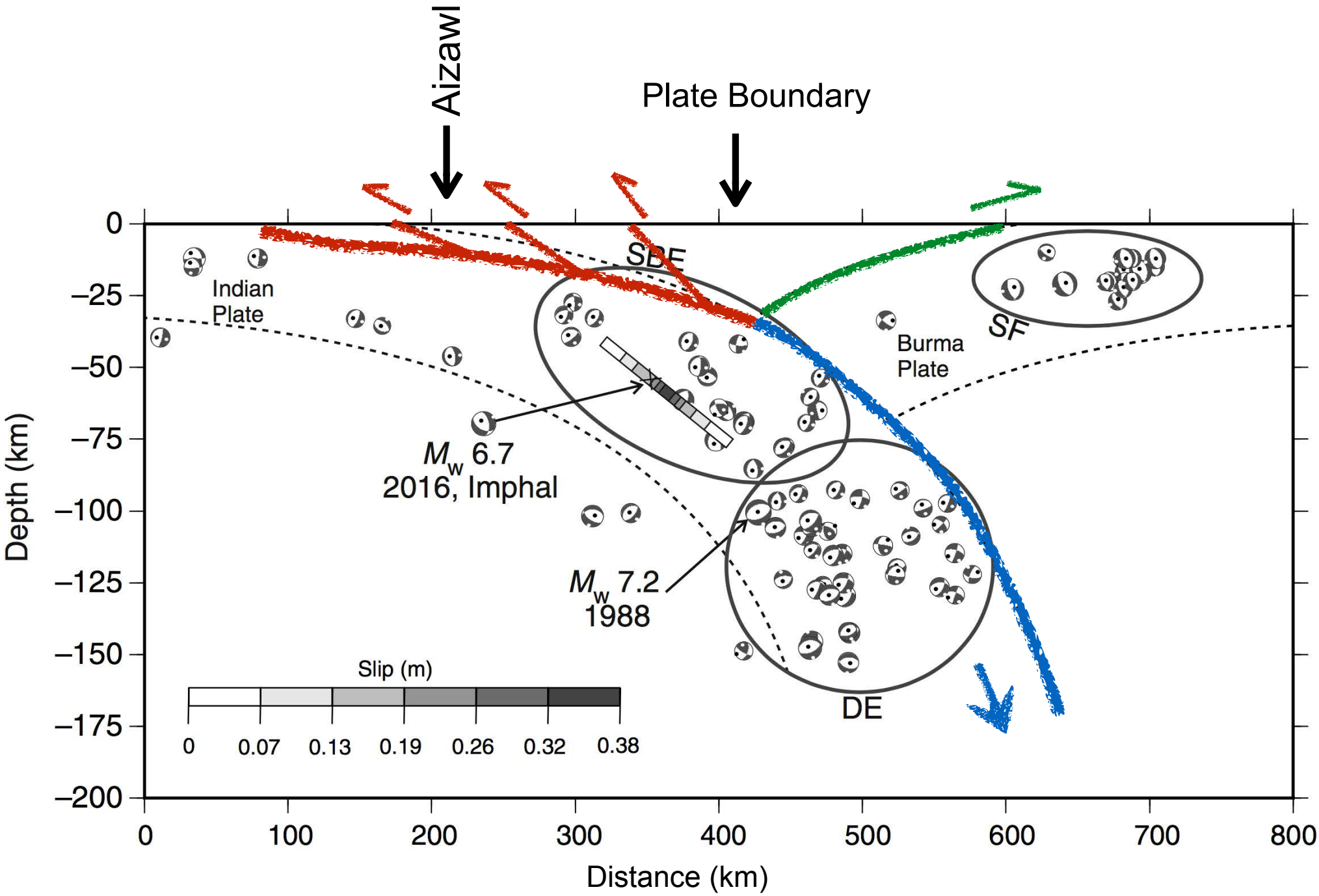
WEST BENGAL
CHHATTISGARH
Myanmar (Burma)
ODISHA
MAHARASHTRA
TELANGANA
GOA
KARNATAKA
ANDHRA PRADESH
Bay of Bengal
TAMIL NADU
Andaman Sea
KERALA
Sri Lanka
Laccadive Sea
ACEH



After Parameswaran and Rajendran, *BSSA*, 2016

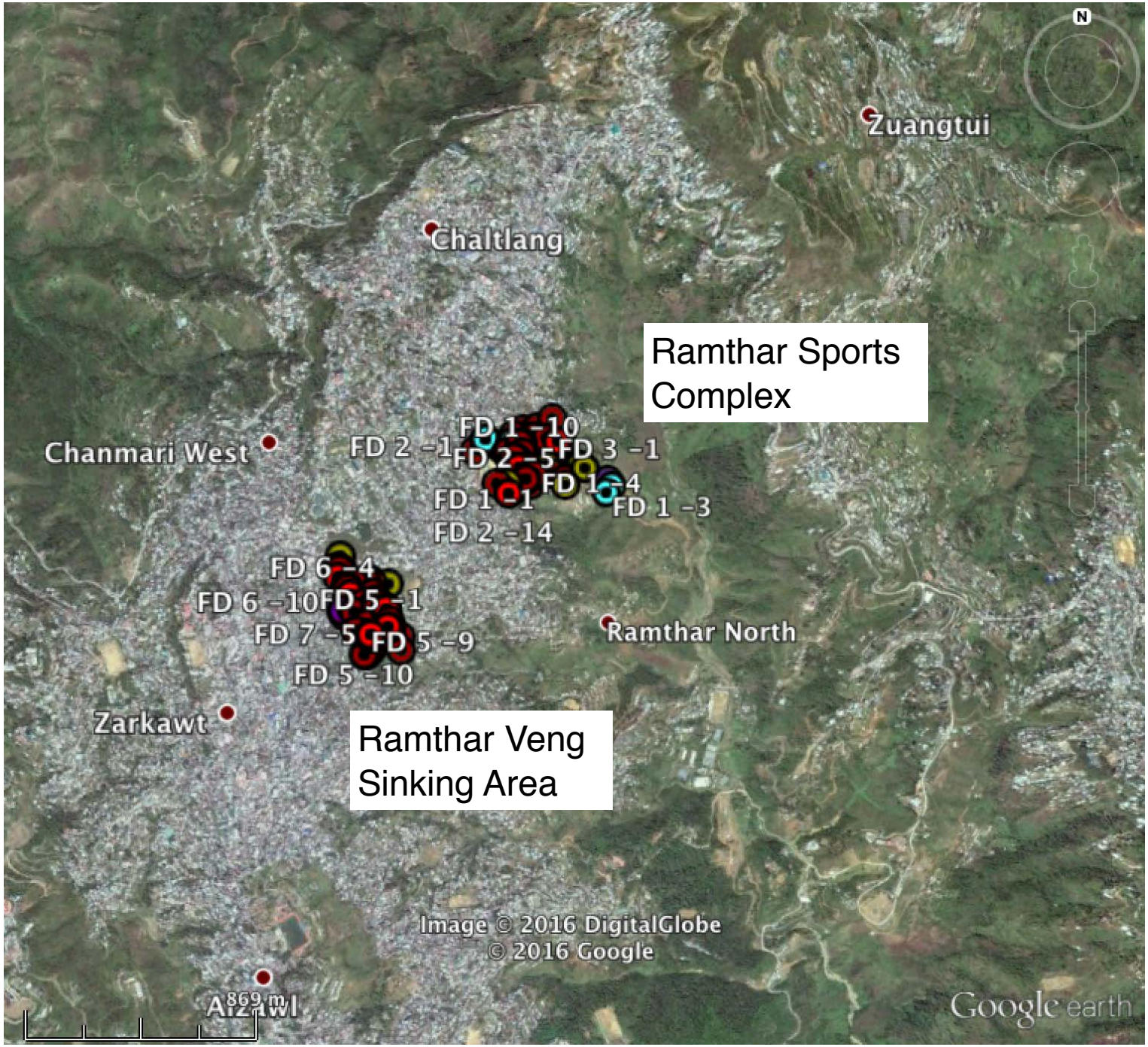
Aizawl

Population: > 300,000
No instrumental measurements
Photo by Carly Schaeffer and Aurora Smedley

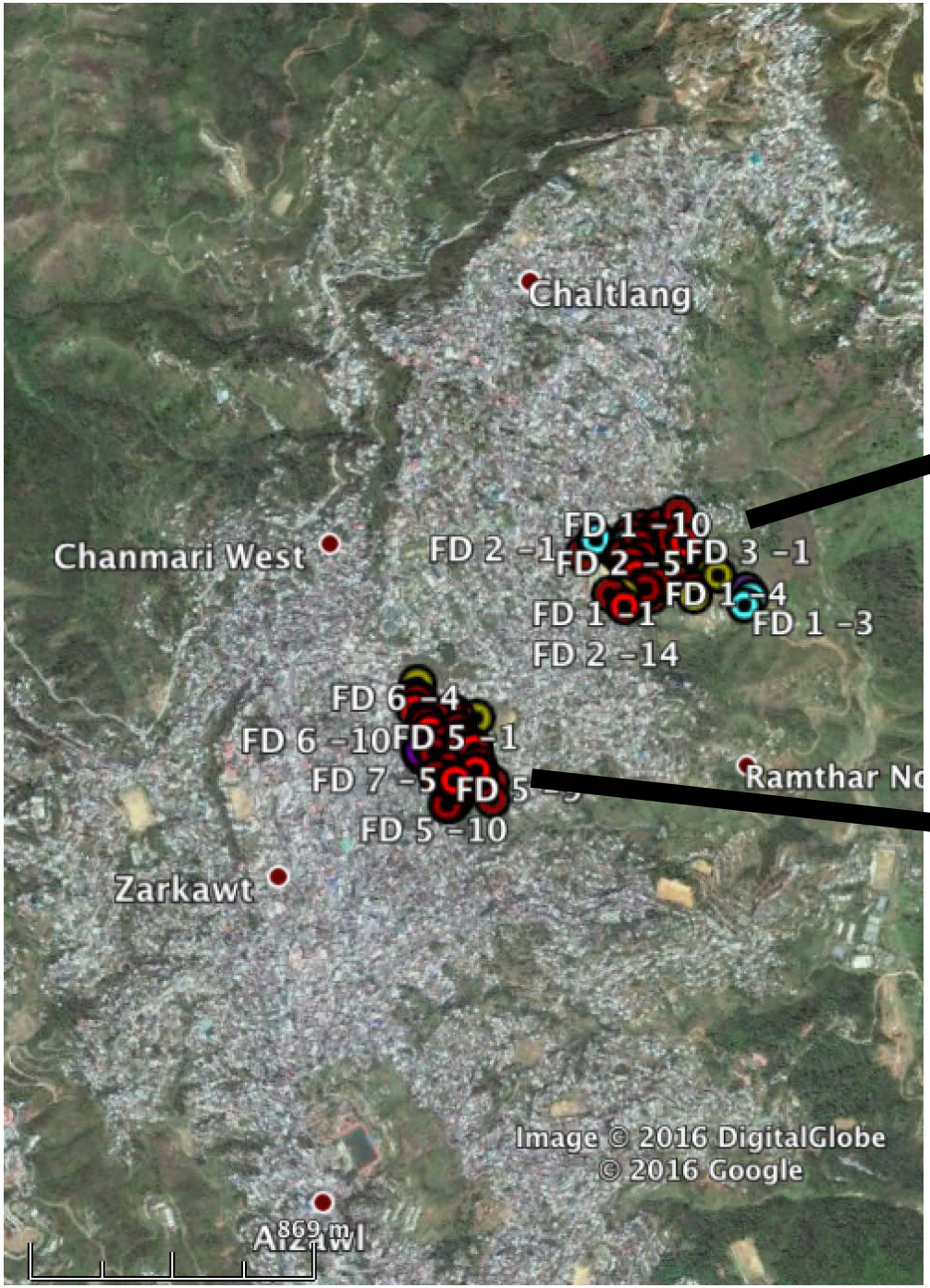
Photos from the Field (2014)

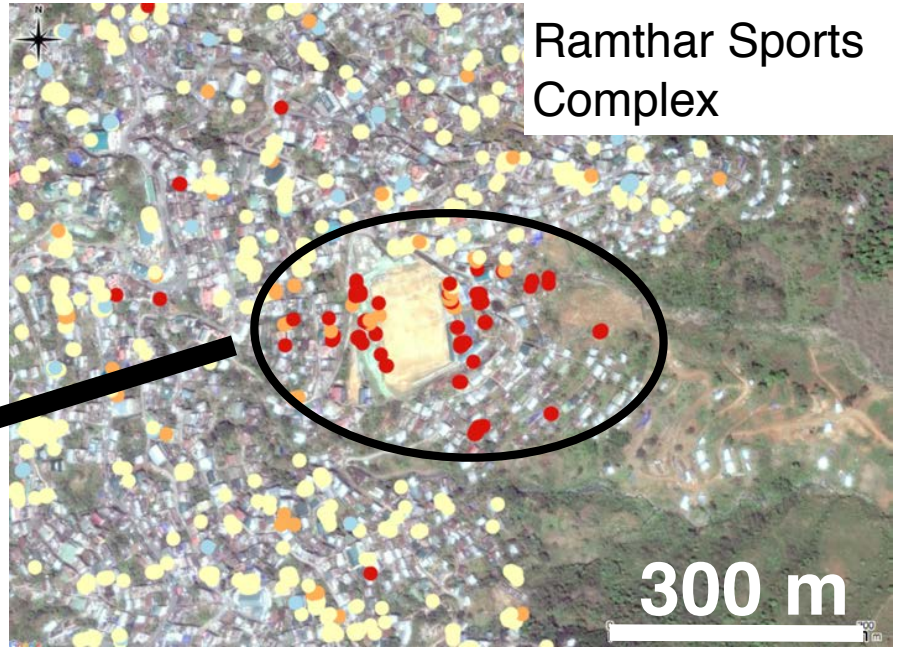
Photo by Carly Schaeffer and Aurora Smedley

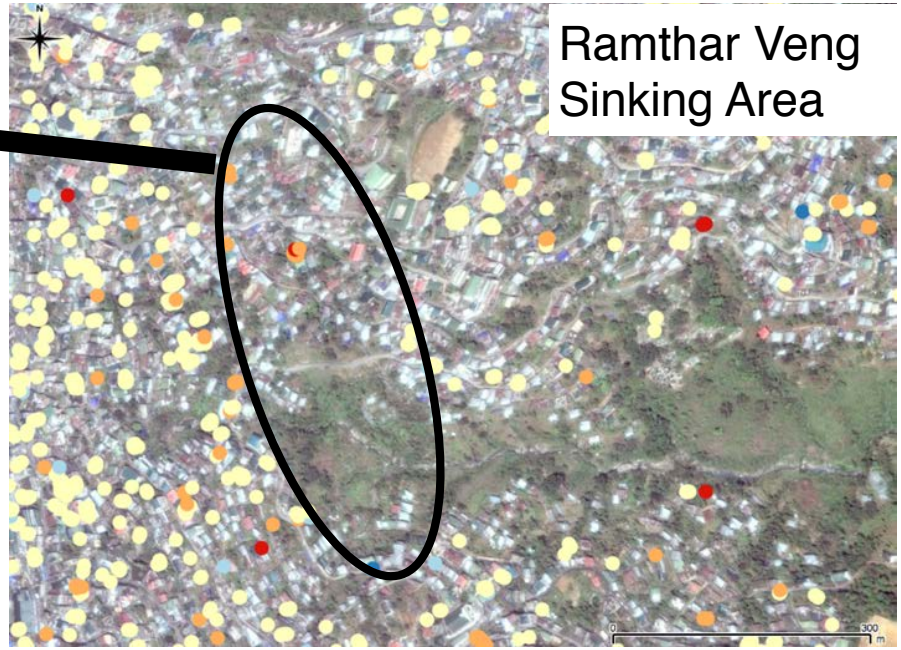
Observed creeping and landslide in the field (summer 2014)



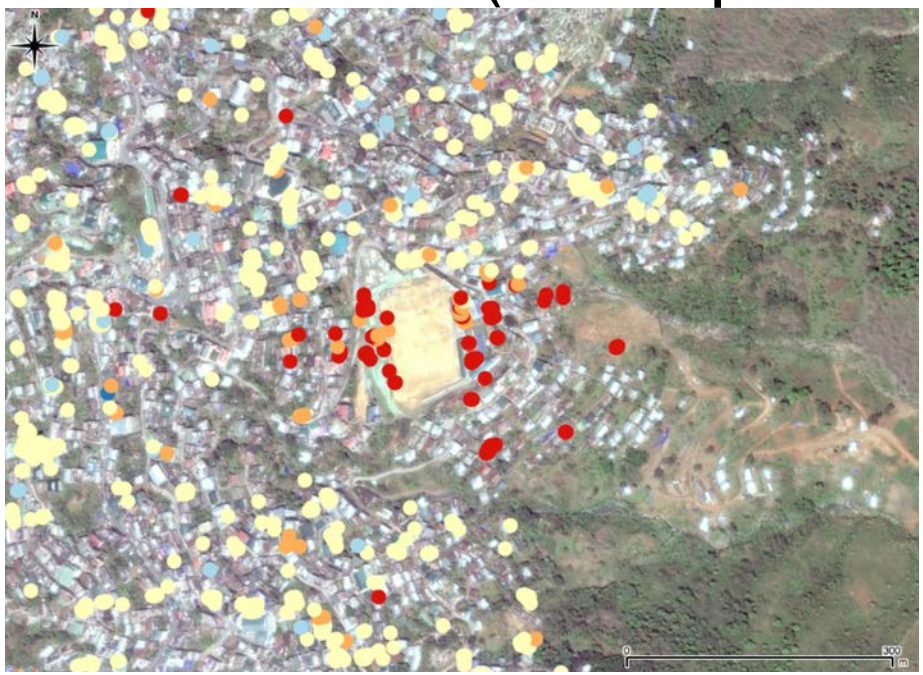
ALOS ascending track (2007 - 2011)

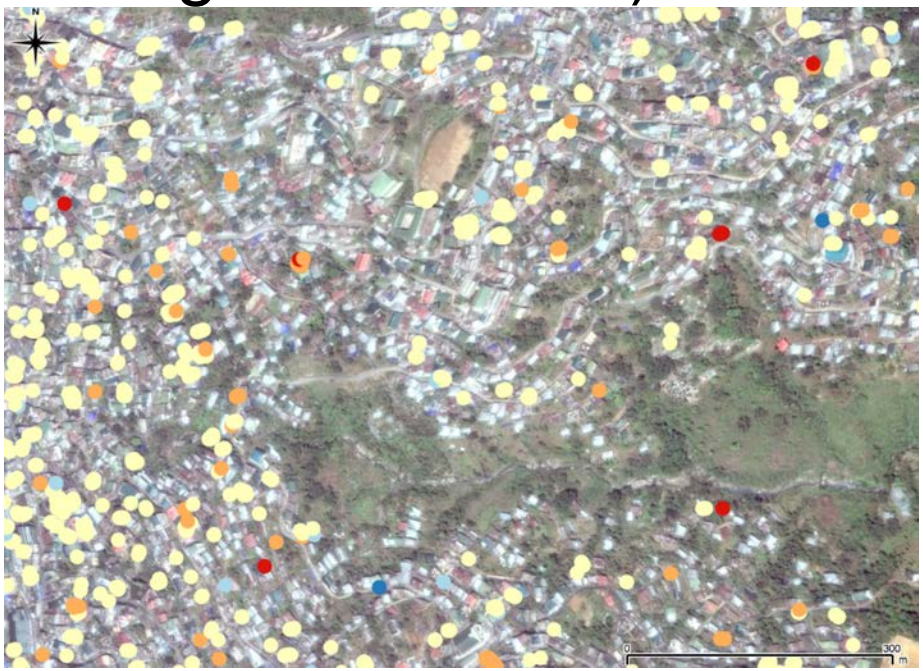




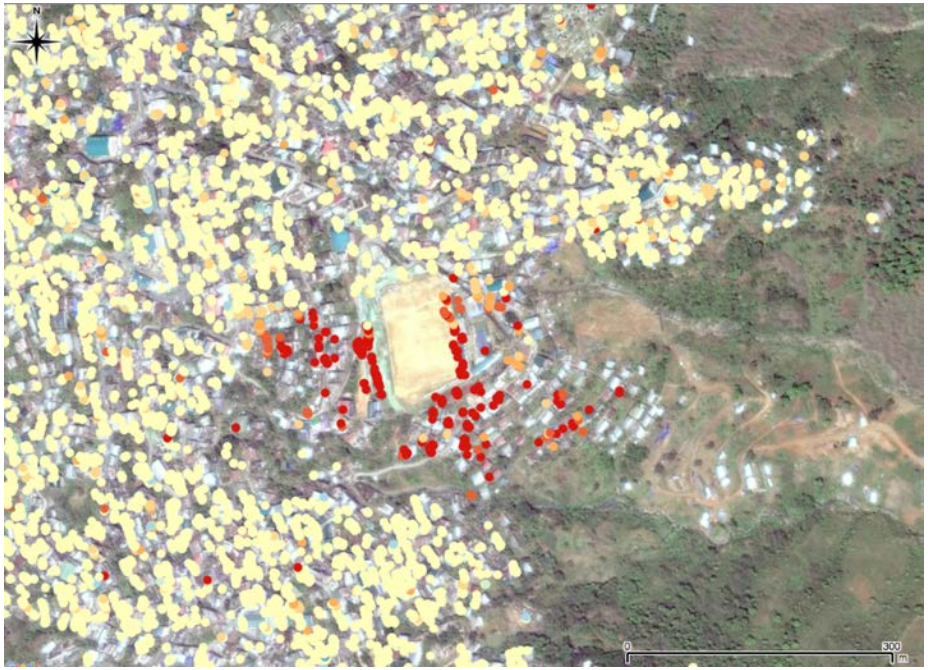


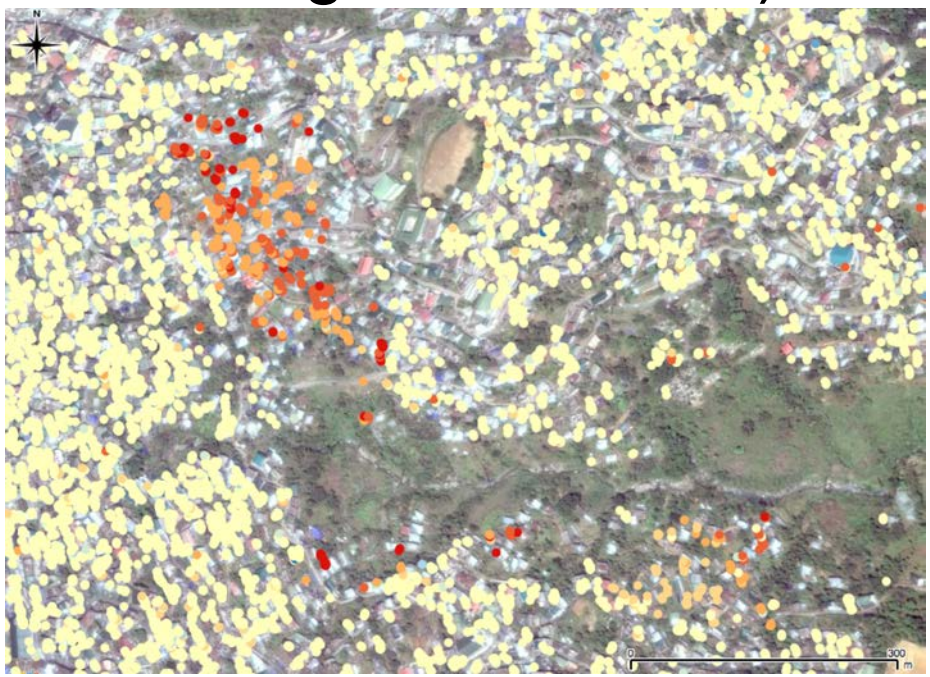
ALOS PALSAR (18 acquisitions during 2007 - 2011)

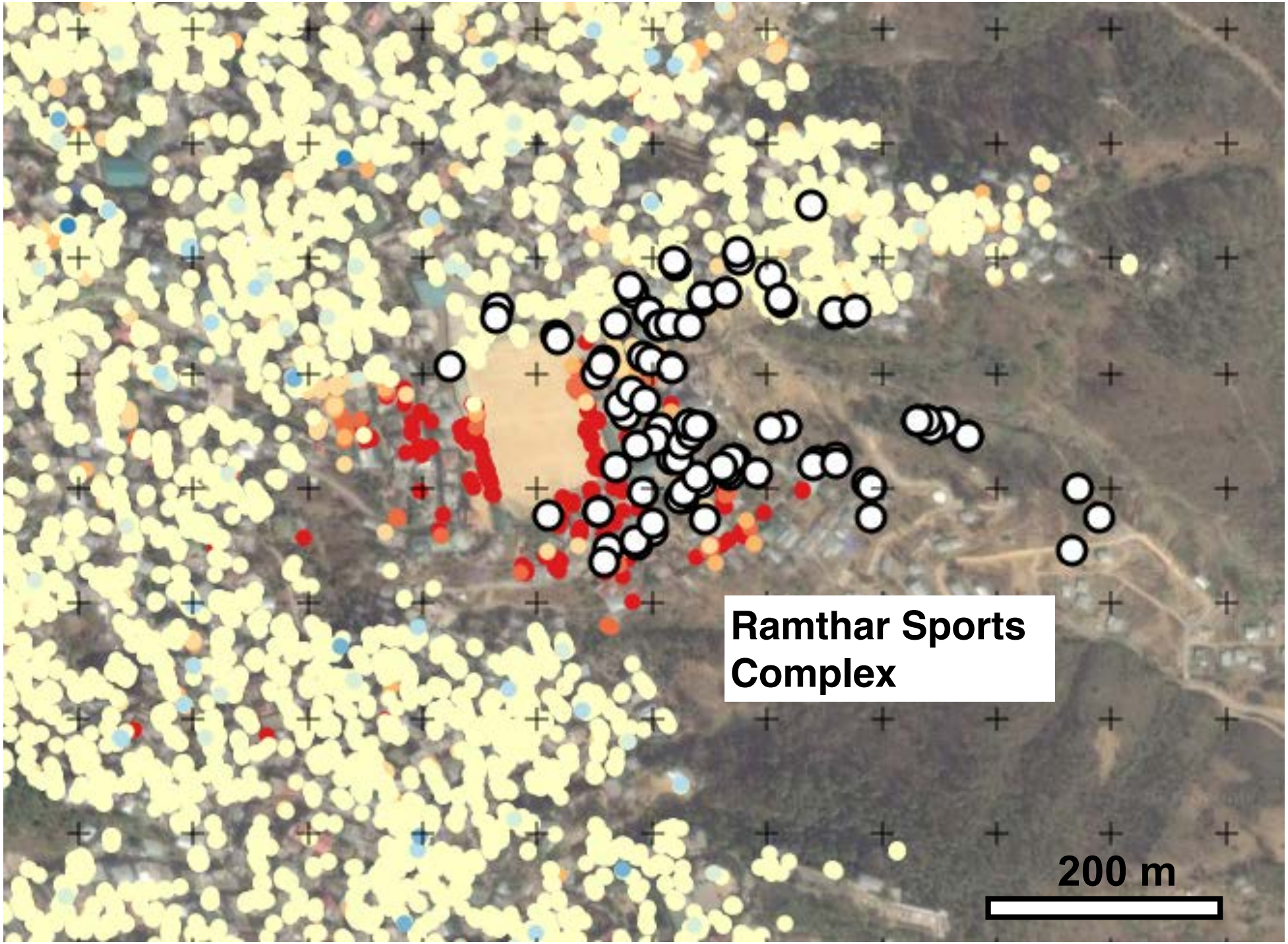


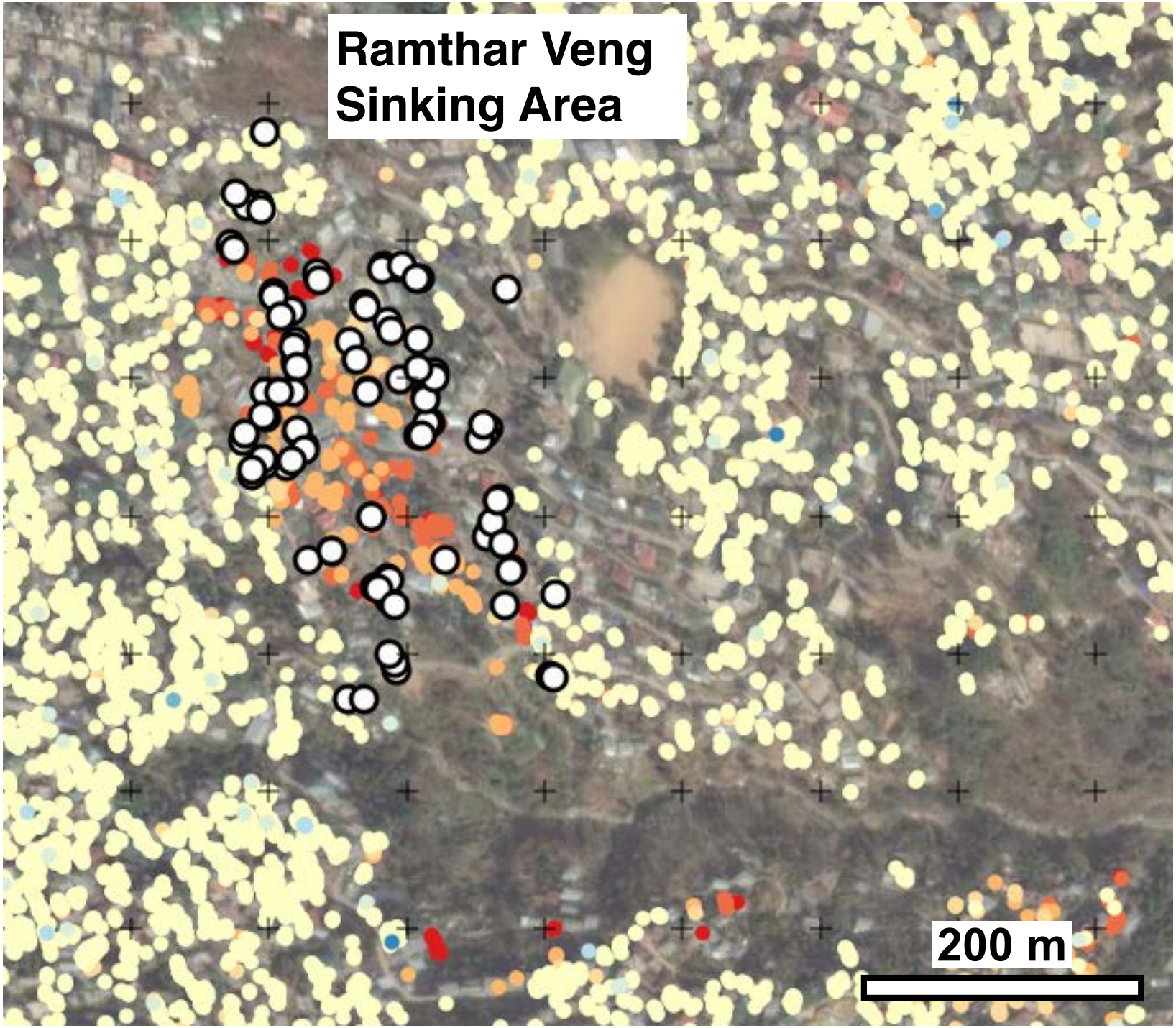


COSMO Sky-Med (243 acquisitions during 2011 - 2015)

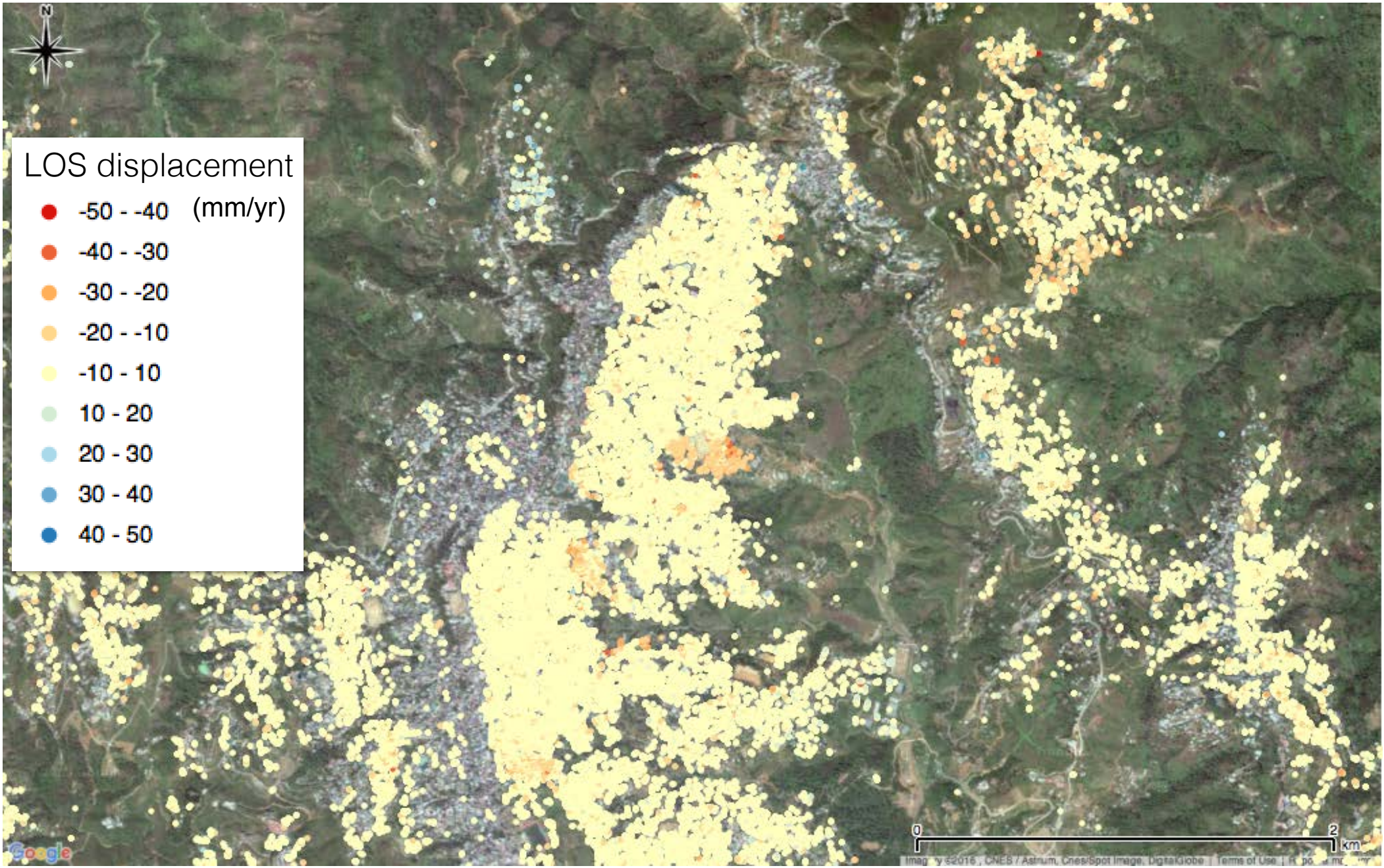




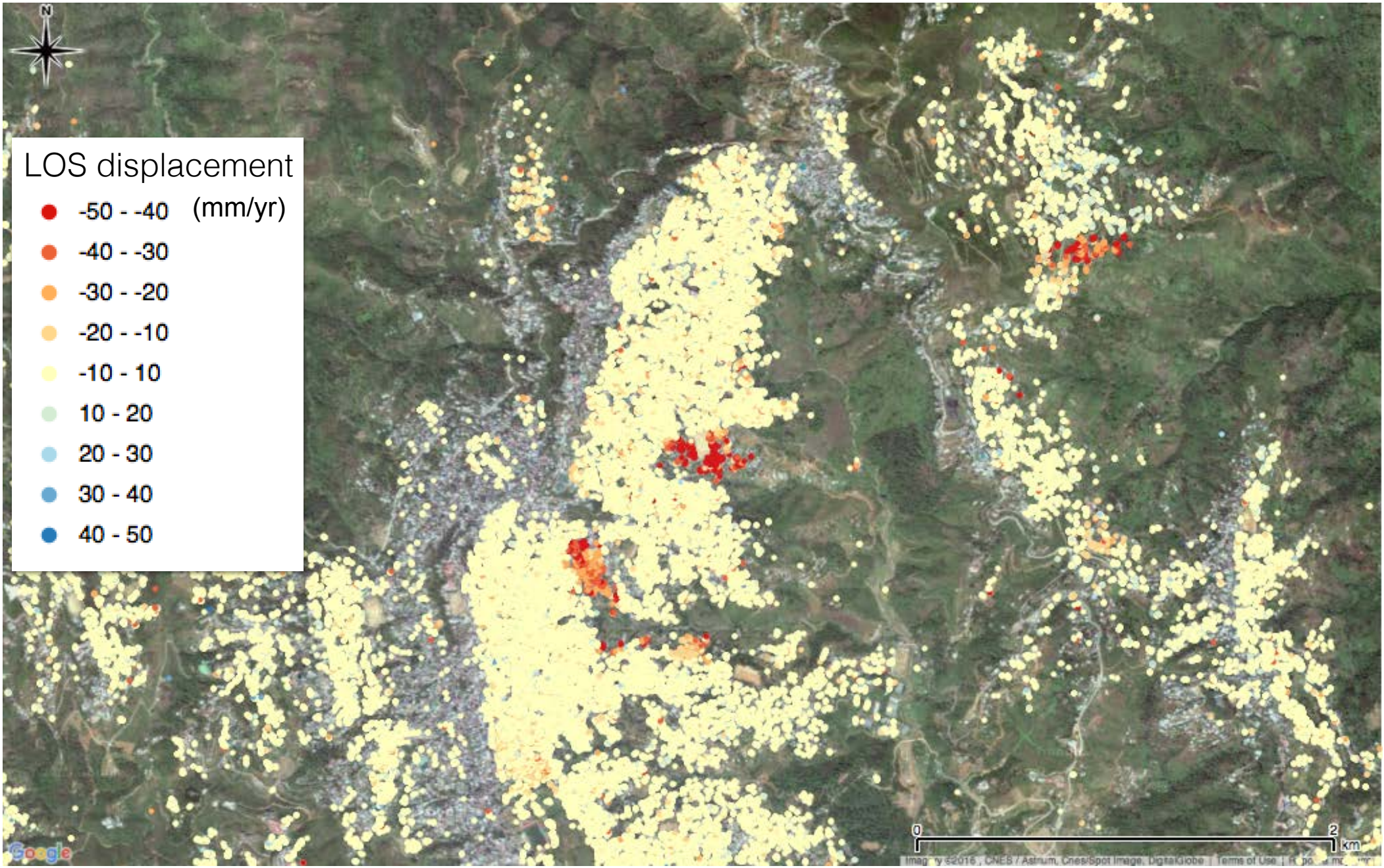

Ramthar Sports Complex
200 m


Ramthar Veng
Sinking Area
200 m

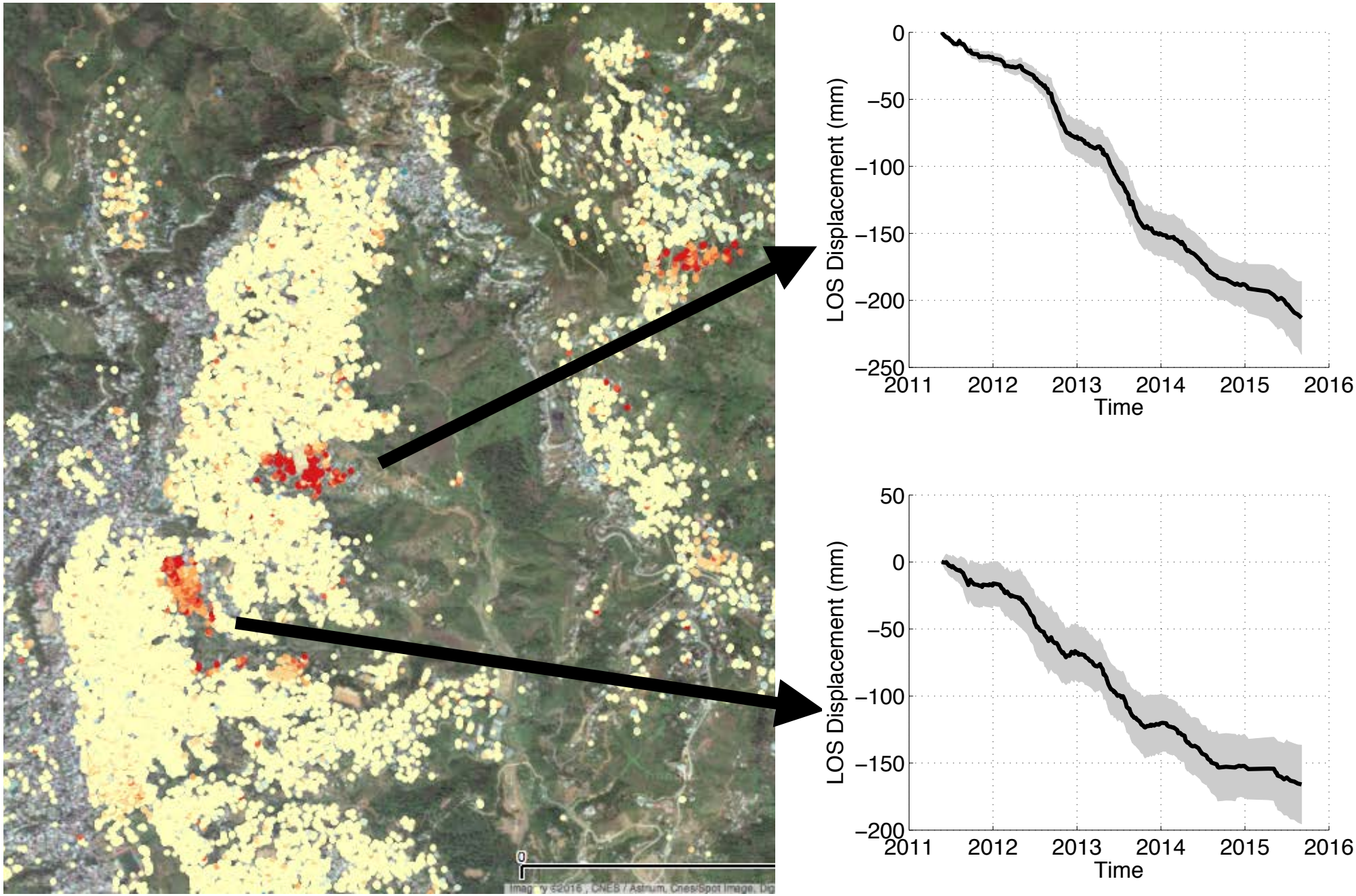
Dry Seasons (-50 - 50 mm/yr)



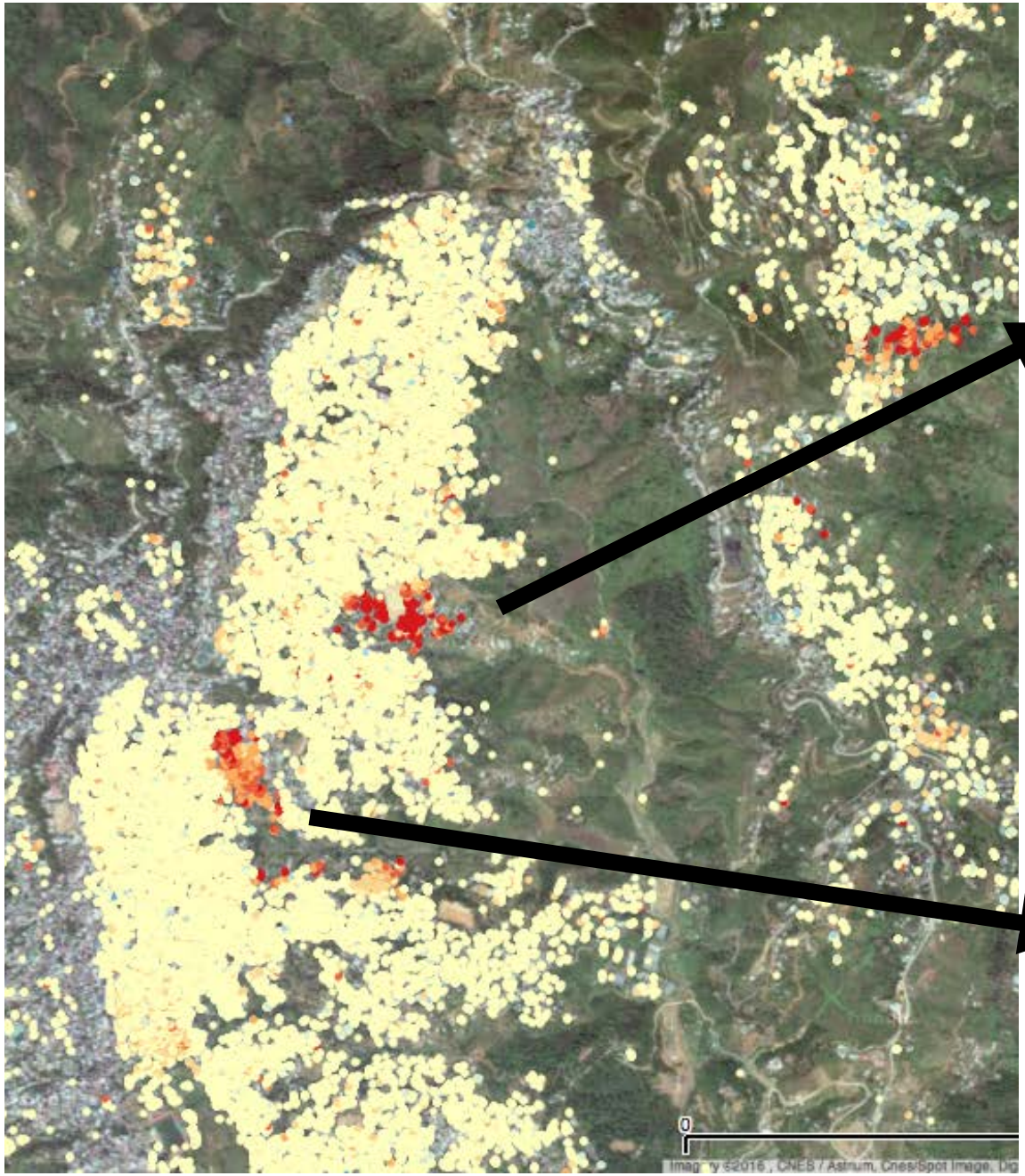
Wet Seasons (-50 - 50 mm/yr)

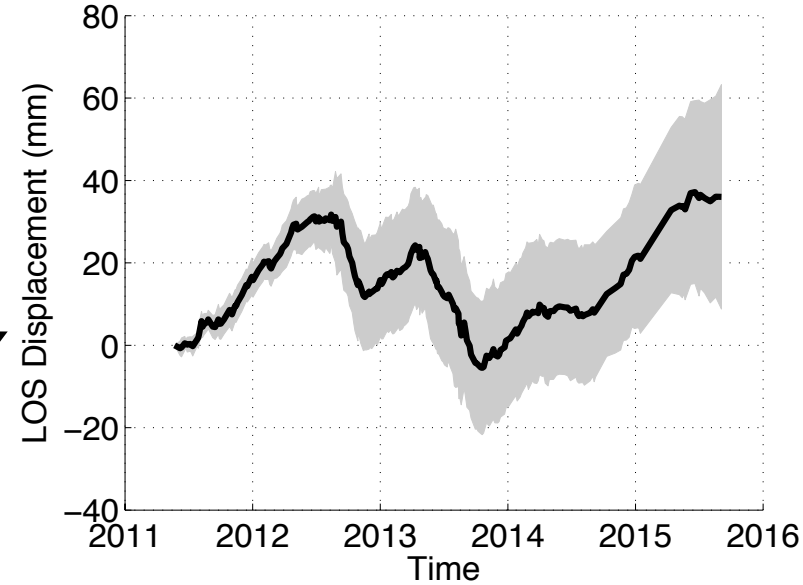


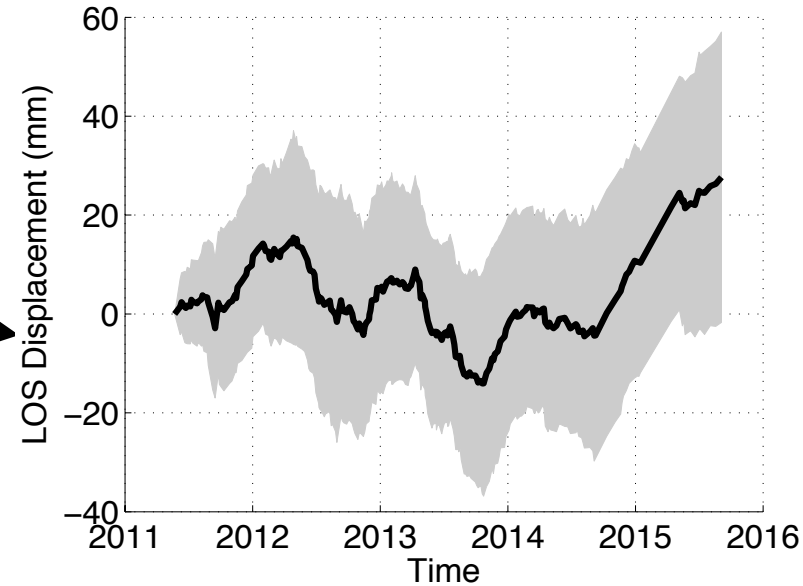
Time series


0
−50
−100
−150
−200
−250
LOS Displacement (mm)
2011
2012
2013
2014
2015
2016
Time
50
0
−50
−100
−150
−200
LOS Displacement (mm)
2011
2012
2013
2014
2015
2016
Time

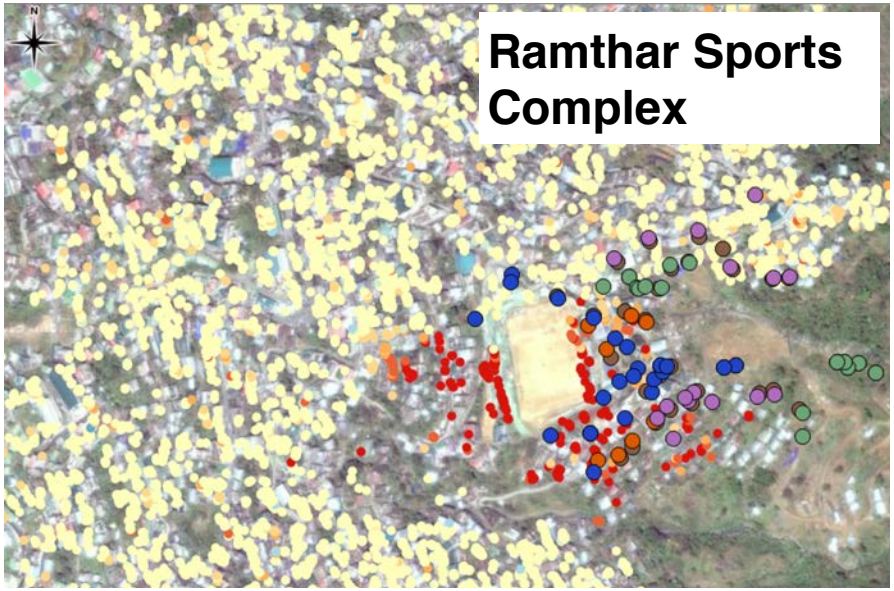
Time series (de-trend)

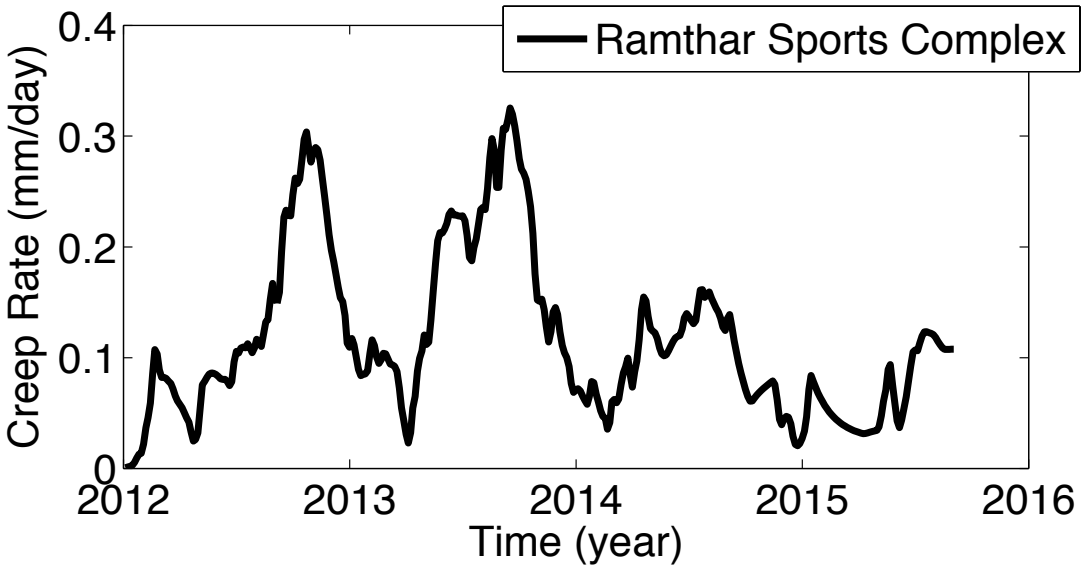


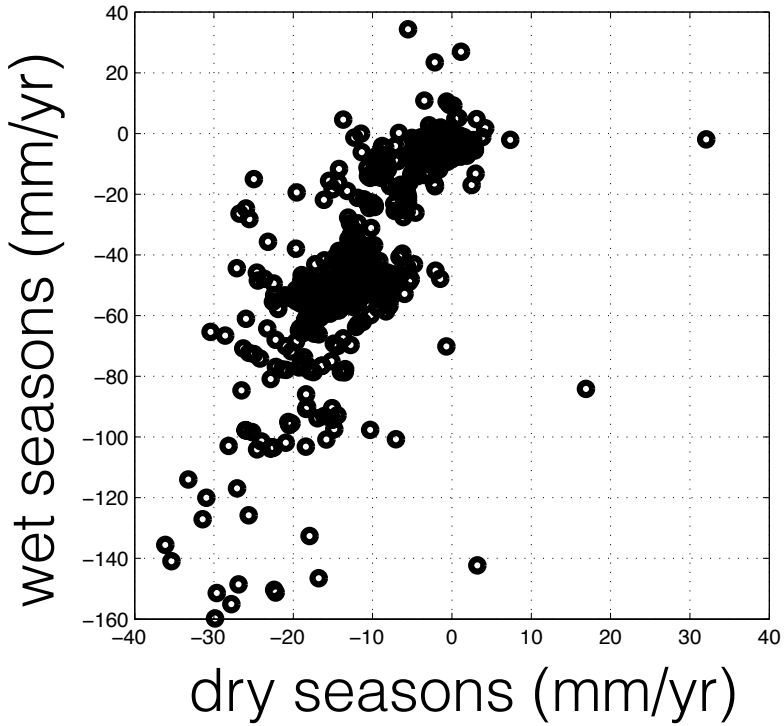


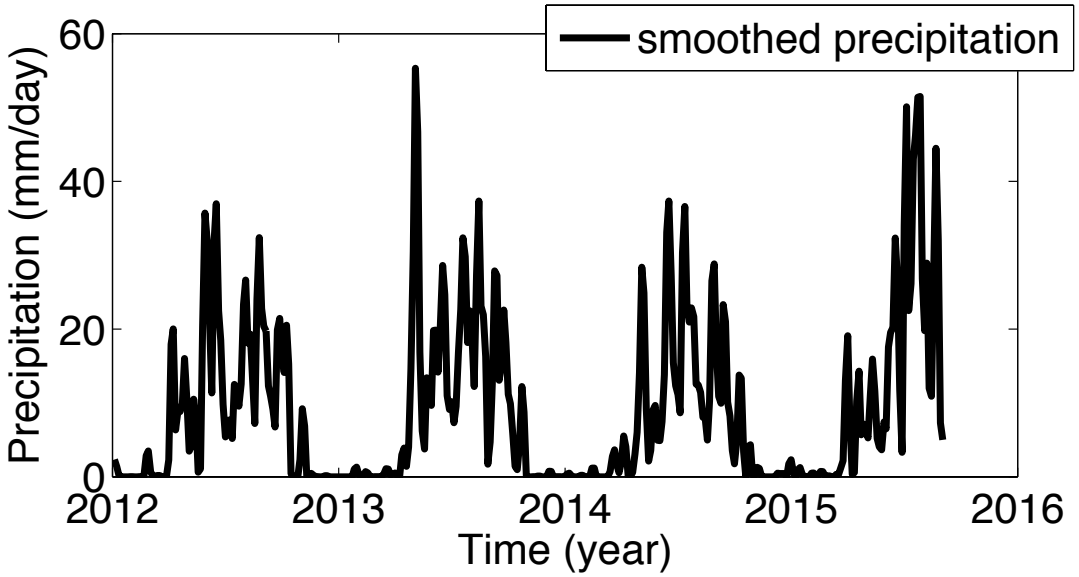


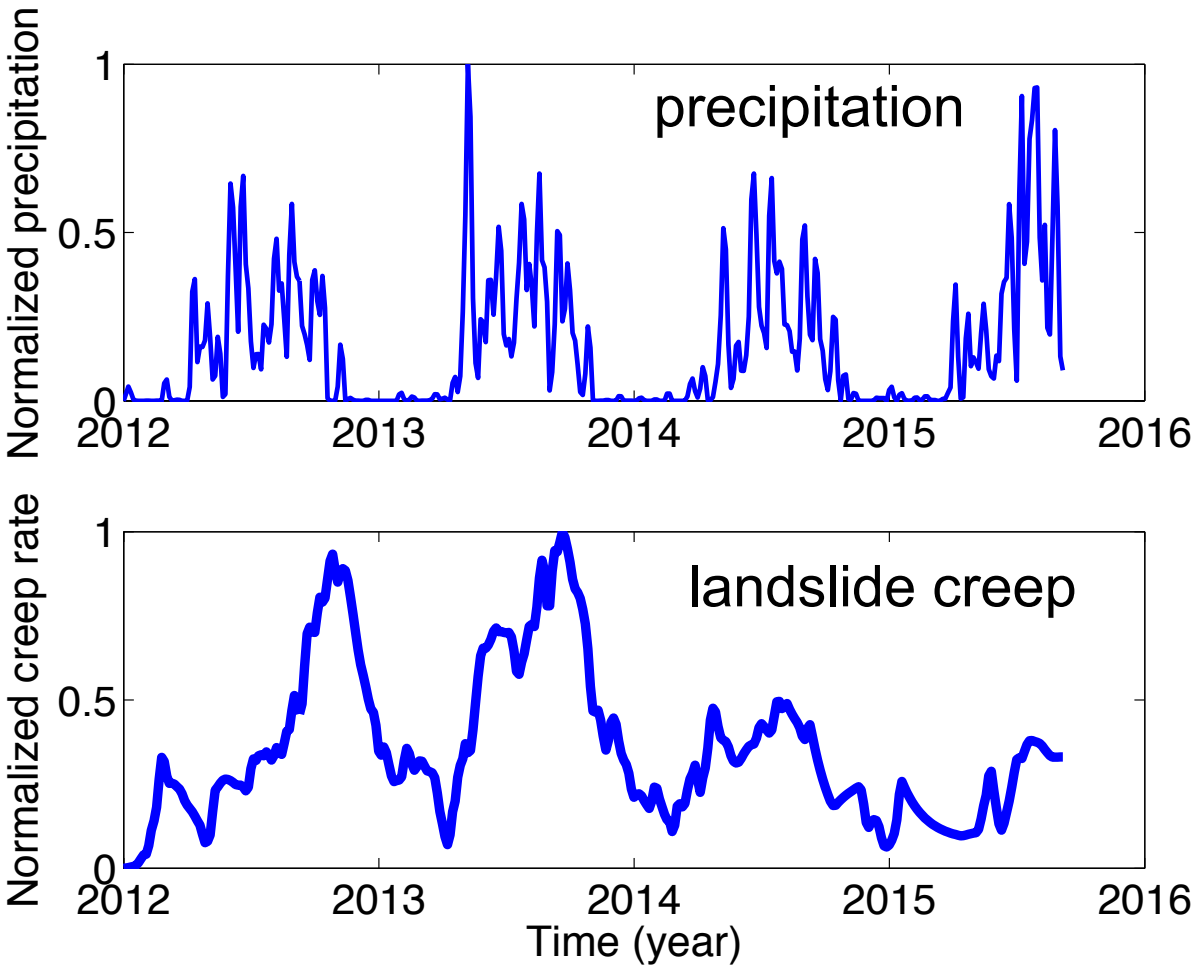
TRMM based daily precipitation (0.25 deg resolution)











Diffusion Eq.

pore-fluid pressure

$$\frac{dP}{dt} = D\frac{d^2P}{dz^2},$$

hydraulic diffusivity

B.C.

precipitation rate

$$P(t, z=0) = sR(t),$$

depth

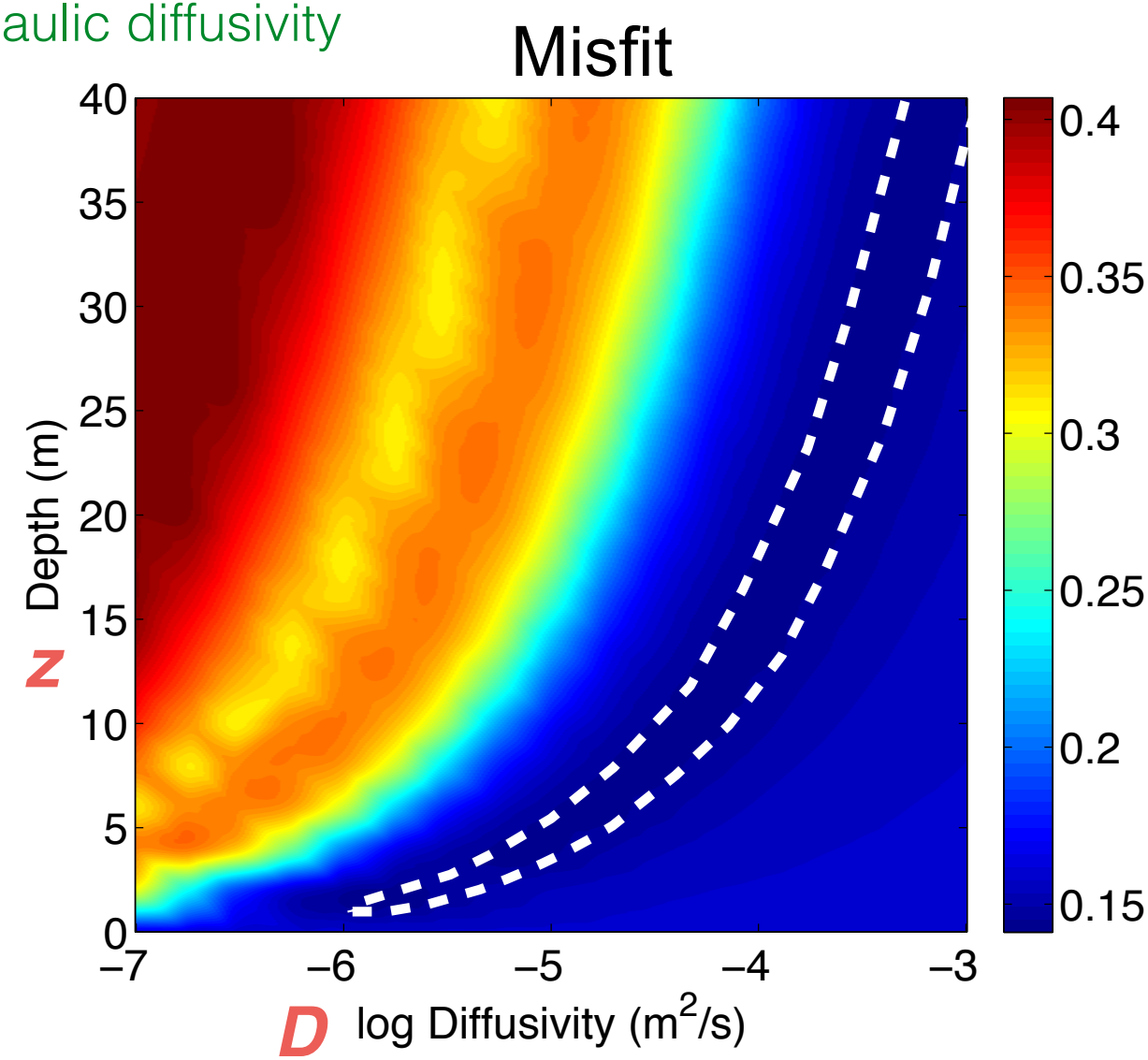
Solution

depth

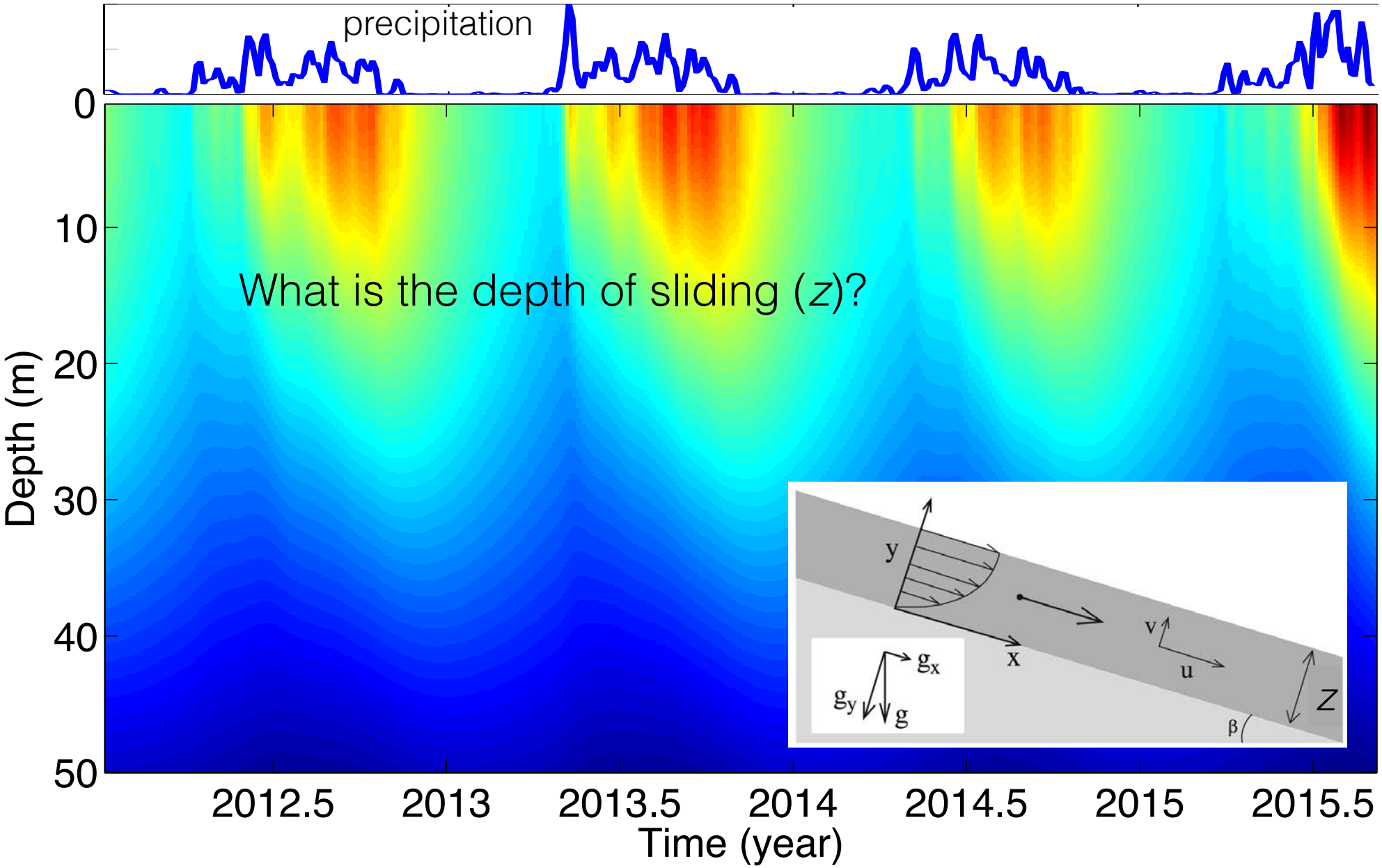
$$P(z,t) = \int_{t_o}^{t} \frac{1}{\sqrt{4\pi D(t-t')}} \exp\left[\frac{-z^2}{4D(t-t')}\right] P(t', z=0)\,dt'$$

hydraulic diffusivity

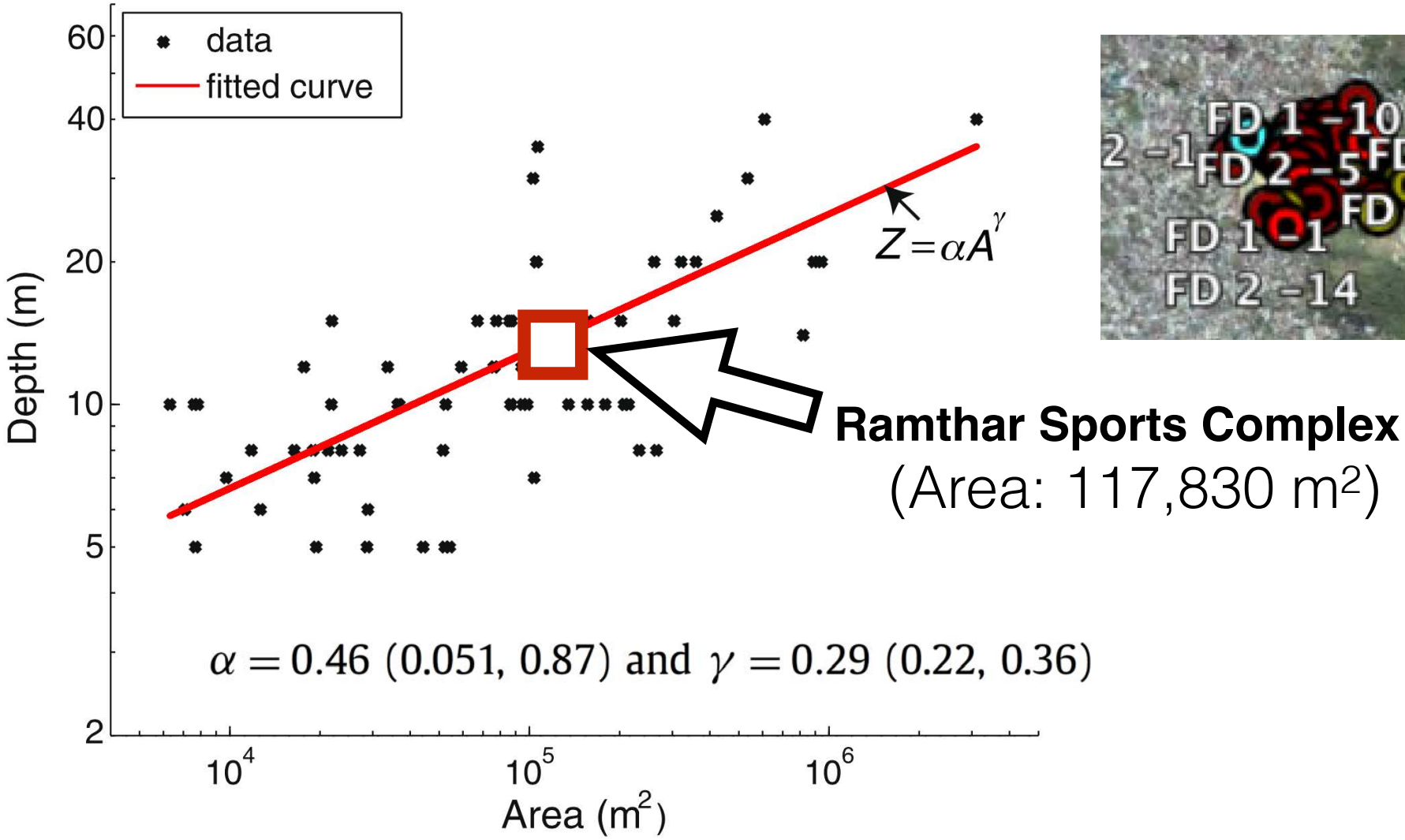
Grid-search of ***z*** and ***D***



Modeled pore fluid pressure



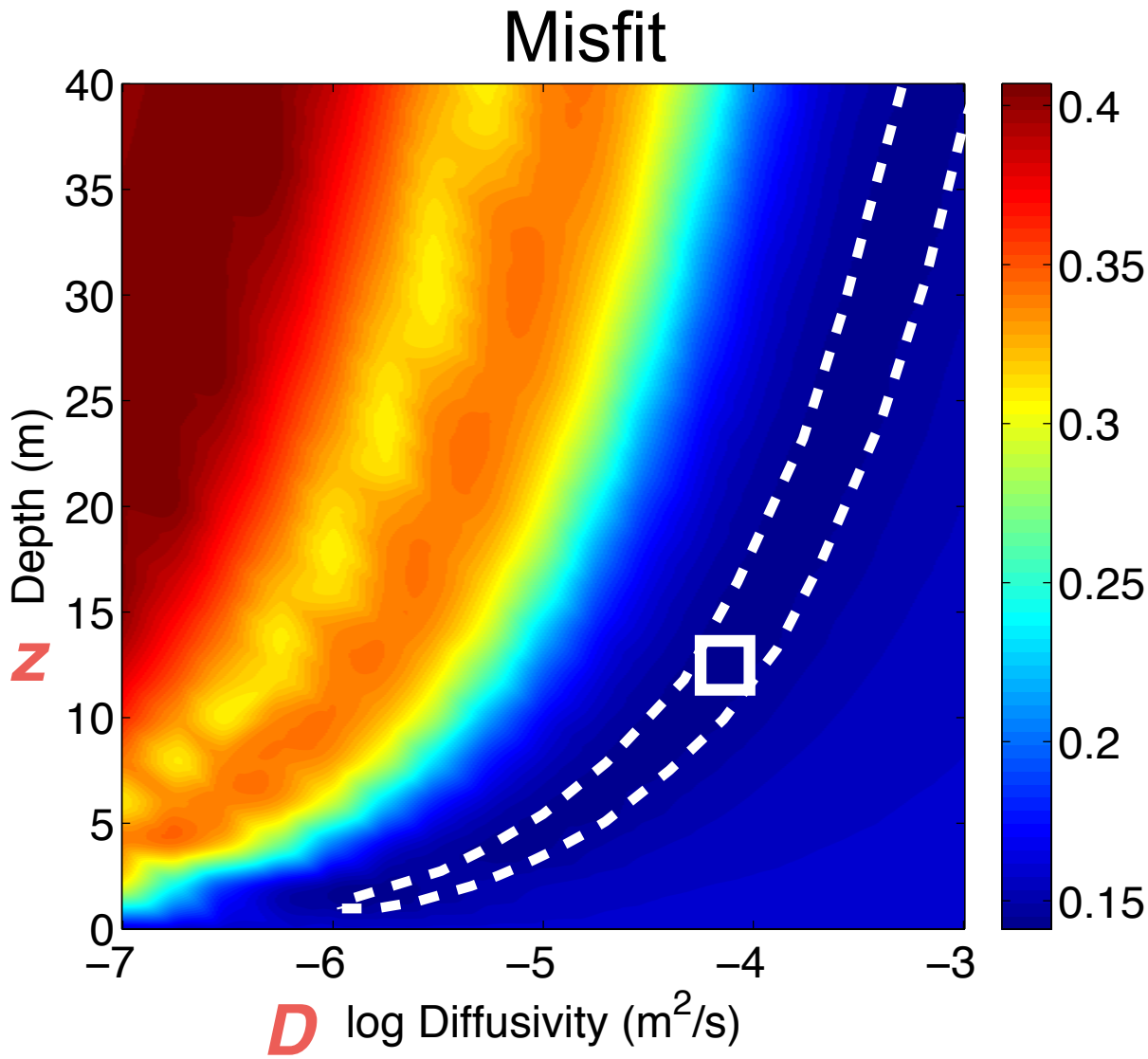
Depth-area plot for 69 landslides in CA



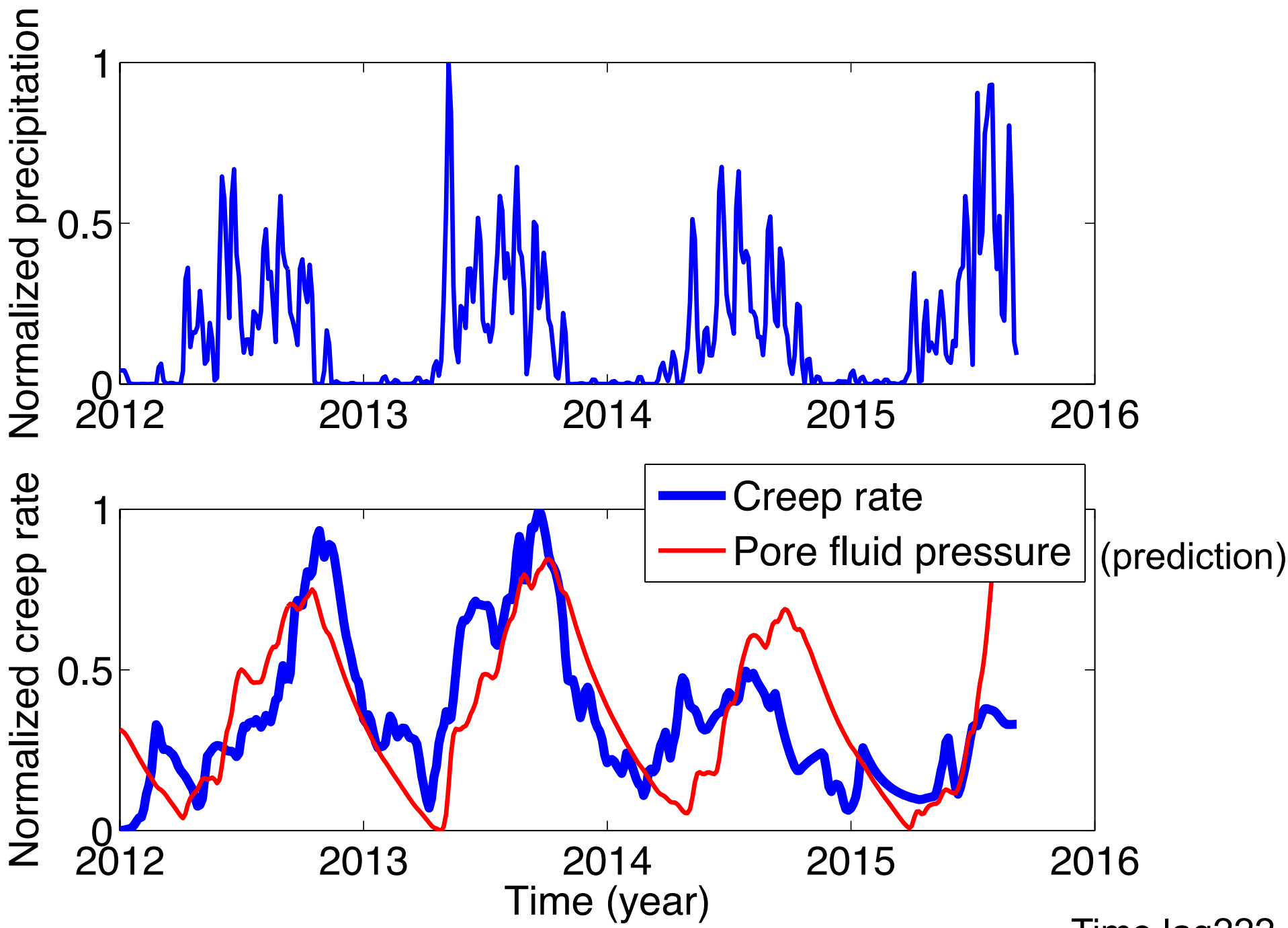
Handwerger et al., EPSL, 2013

$$P(z,t) = \int_{t_o}^{t} \frac{1}{\sqrt{4\pi \underline{D}(t-t')}} \exp\left[\frac{-\underline{z}^2}{4\underline{D}(t-t')}\right] P(t', z=0)\,dt'$$

Grid-search of ***z*** and ***D***

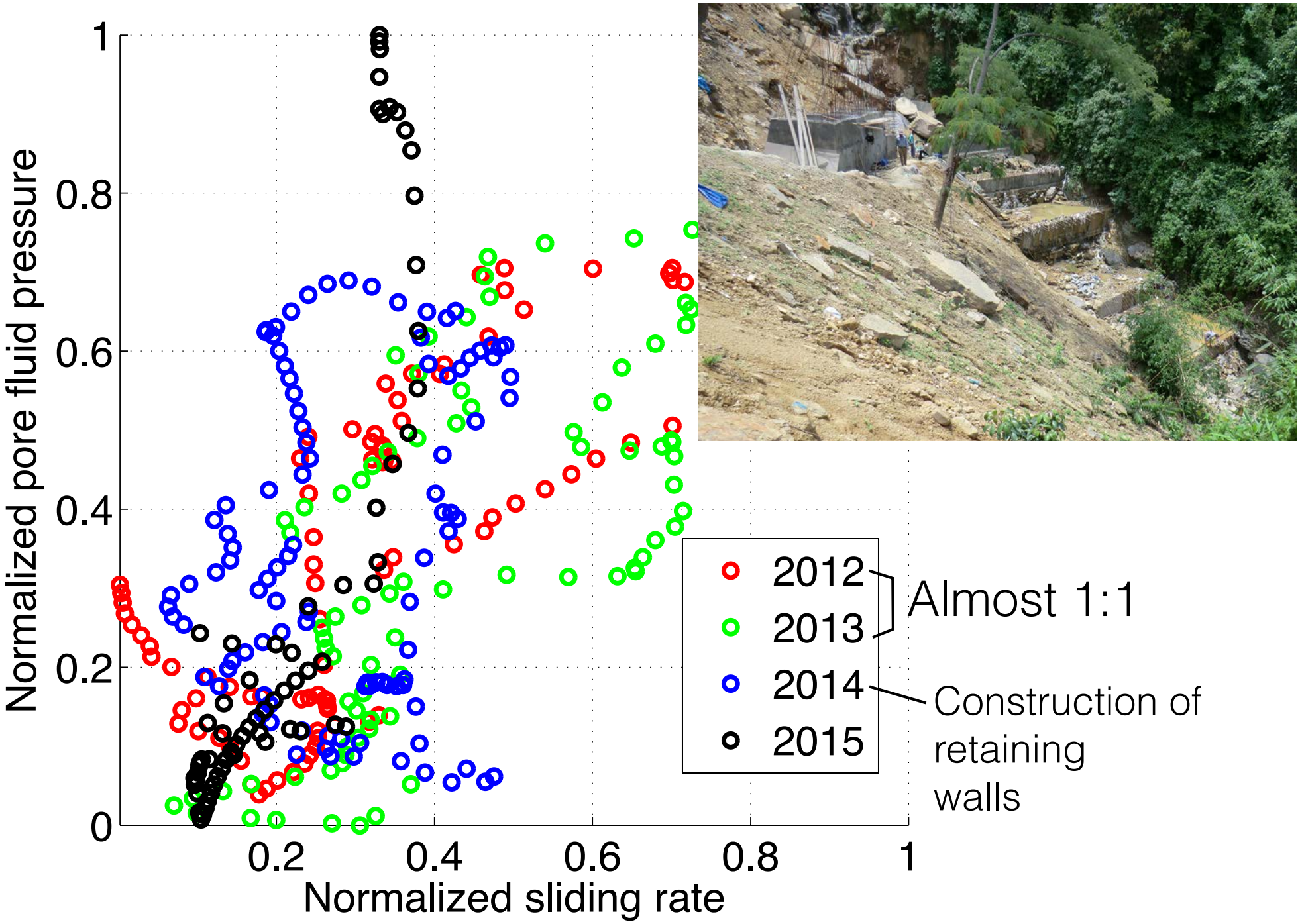


Depth = 10 m; Diffusivity = 4.6×10^{-5} m^2/s



Time lag???

Sliding rate vs. Modeled pore fluid pressure



Summary

- InSAR agrees with field observations
- Seasonal slow-moving landslide:
  - Dry seasons: 1-3 cm/yr
  - Wet seasons: 2-8 cm/yr
- Velocity is related to precipitation with ~20-day lag (rainfall-triggered)
- Change of pore fluid pressure at depth can explain seasonal velocity variation during 2012 - 2014
- Construction of retaining walls by the Indian government may have changed the behavior of landslide since 2014.

Fieldwork supported by GeoHazards International