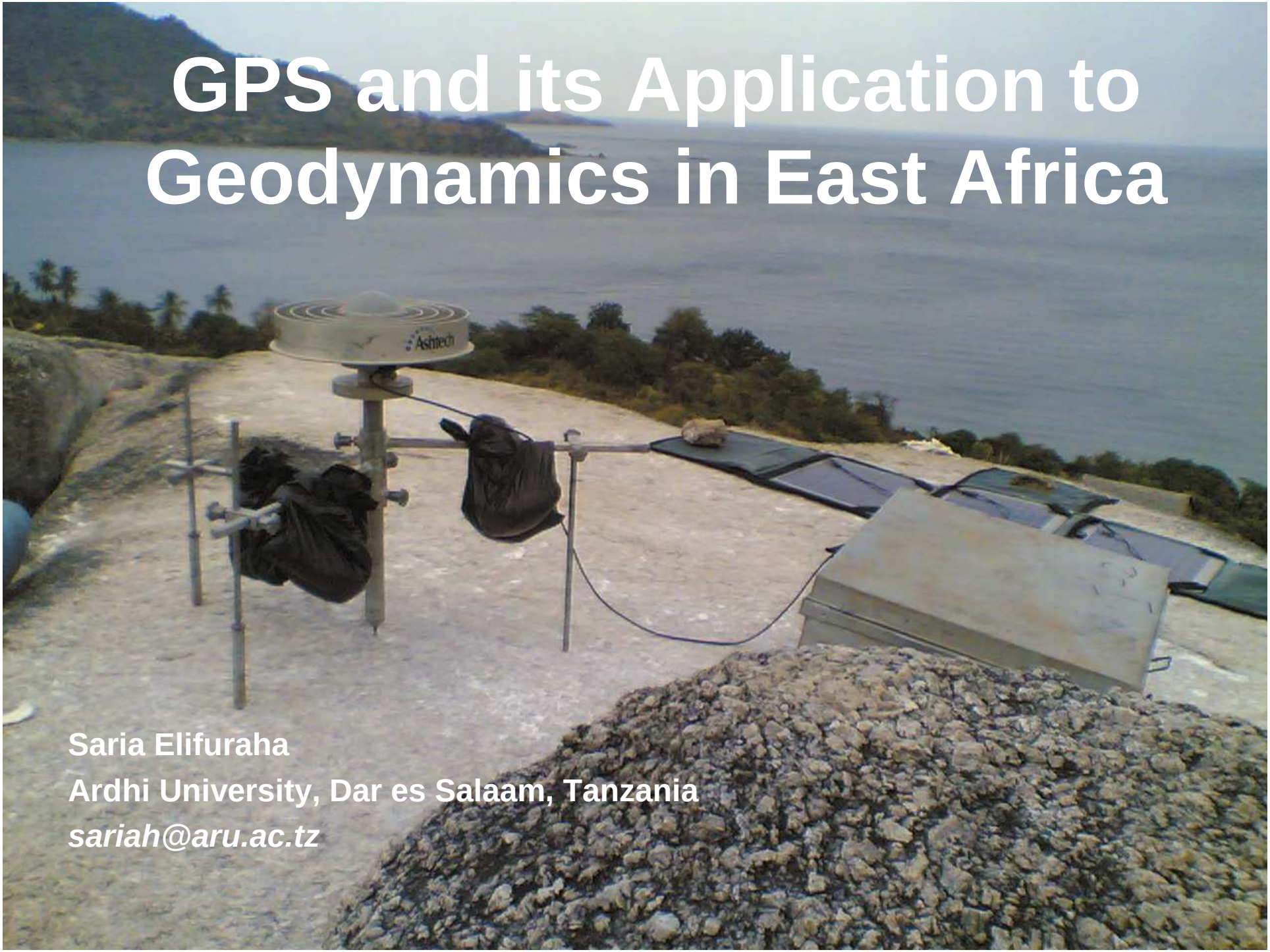
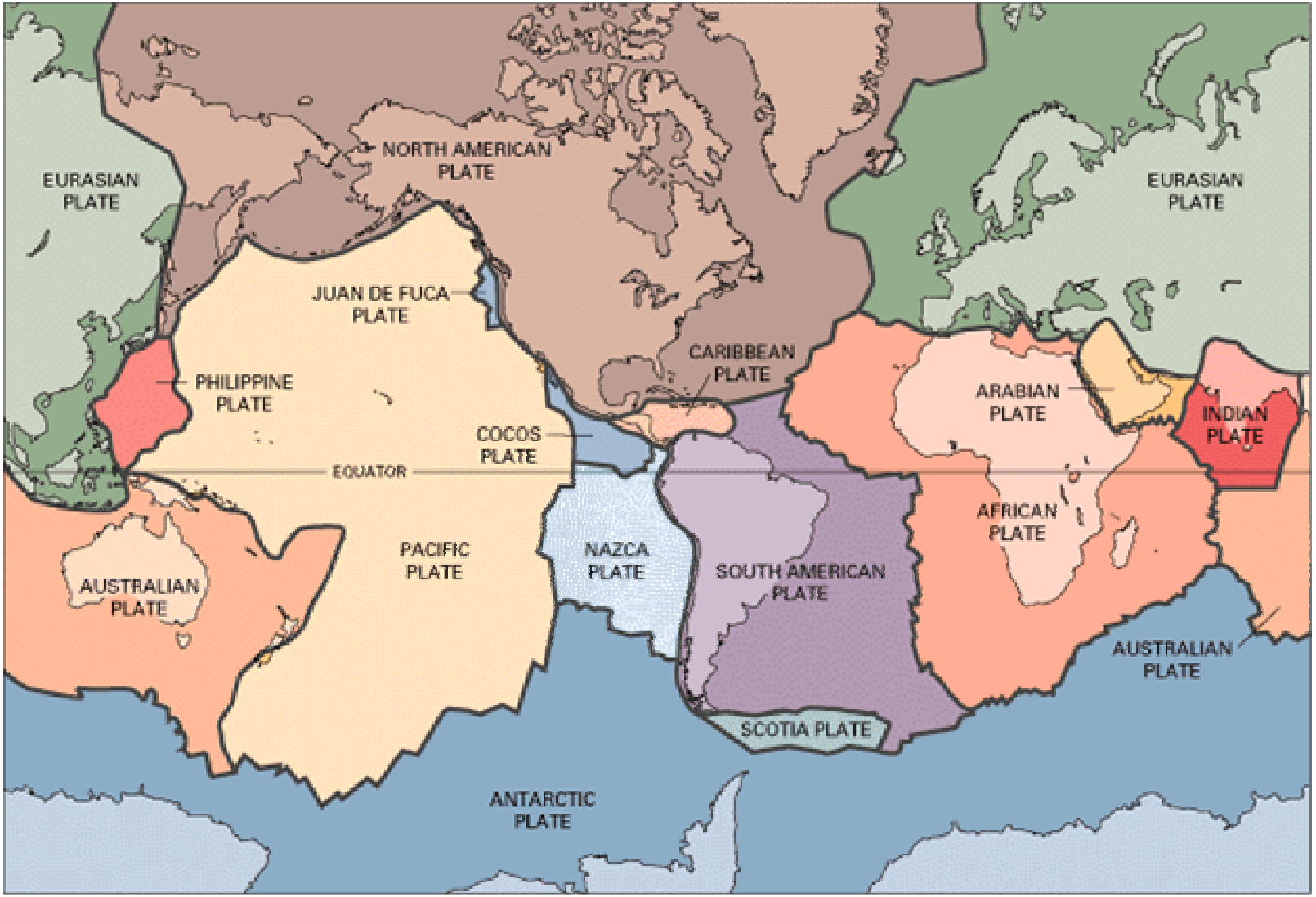
GPS and its Application to Geodynamics in East Africa



Saria Elifuraha
Ardhi University, Dar es Salaam, Tanzania
sariah@aru.ac.tz



The Earth's rigid shell (= lithosphere) is made of ~15 major plates

Notice the lack of plate boundary through East Africa…!

In Summary…

- We know:
  - Plate tectonics as a kinematic theory that describes the motion of (rigid) plates at the surface of the Earth
- We do not know:
  - The present-day motion of all plates
  - Why plates move the way they do (dynamics)
- We need:
  - Accurate techniques to measure present-day motions of the Earth's lithosphere=GPS

Principle of GPS positioning

- GPS phase equation (units of cycles):

$$\Phi_i^k(t) = \rho_i^k(t) \times \frac{f}{c} + \left(h^k(t) - h_i(t)\right) \times f + ion_i^k(t) + trop_i^k(t) - N_i^k + \varepsilon$$

- Range model:

$$\rho_i^k = \sqrt{(X^k - X_i)^2 + (Y^k - Y_i)^2 + (Z^k - Z_i)^2}$$

Φ = phase measurement = DATA
ρ_i^k = geometric range = CONTAINS UNKNOWNS X_i, Y_i, Z_i
X^k, Y^k, Z^k = satellite positions (GIVEN)
t = time of epoch
i = receiver, k = satellite
f = GPS frequency, c = speed of light
h^k = satellite clock error, h_i = receiver clock error
ion_i^k = ionospheric delay, $trop_i^k$ = tropospheric delay
N_i^k = phase ambiguity, ε = phase noise

- Phase equation linearized
- Form a system of *n_data* equations for *n_unknowns* (positions, phase ambiguities, tropospheric parameters)
- Solve using weighted least squares (or other estimation techniques)
- End product: position estimates + associated covariance

Campaign measurements

- Field strategy:
  - Network of geodetic benhmarks perfectly attached to bedrock -- Separation typically 10-100 km
  - 2 to 3 measurement sessions of 24 hours
- Advantages:
  - Large number/density of sites with few receivers
  - Relatively low cost

Antenna setup :

left=Zephyr antenna,

right=Choke ring antenna.

Note the deferent antenna height for the two setups The Choke ring setup uses an adaptor that allows for the rotation of the antenna. The Zephyr antenna is directly mounted to the tribrach plate.

Self centering plates installed on bedrock

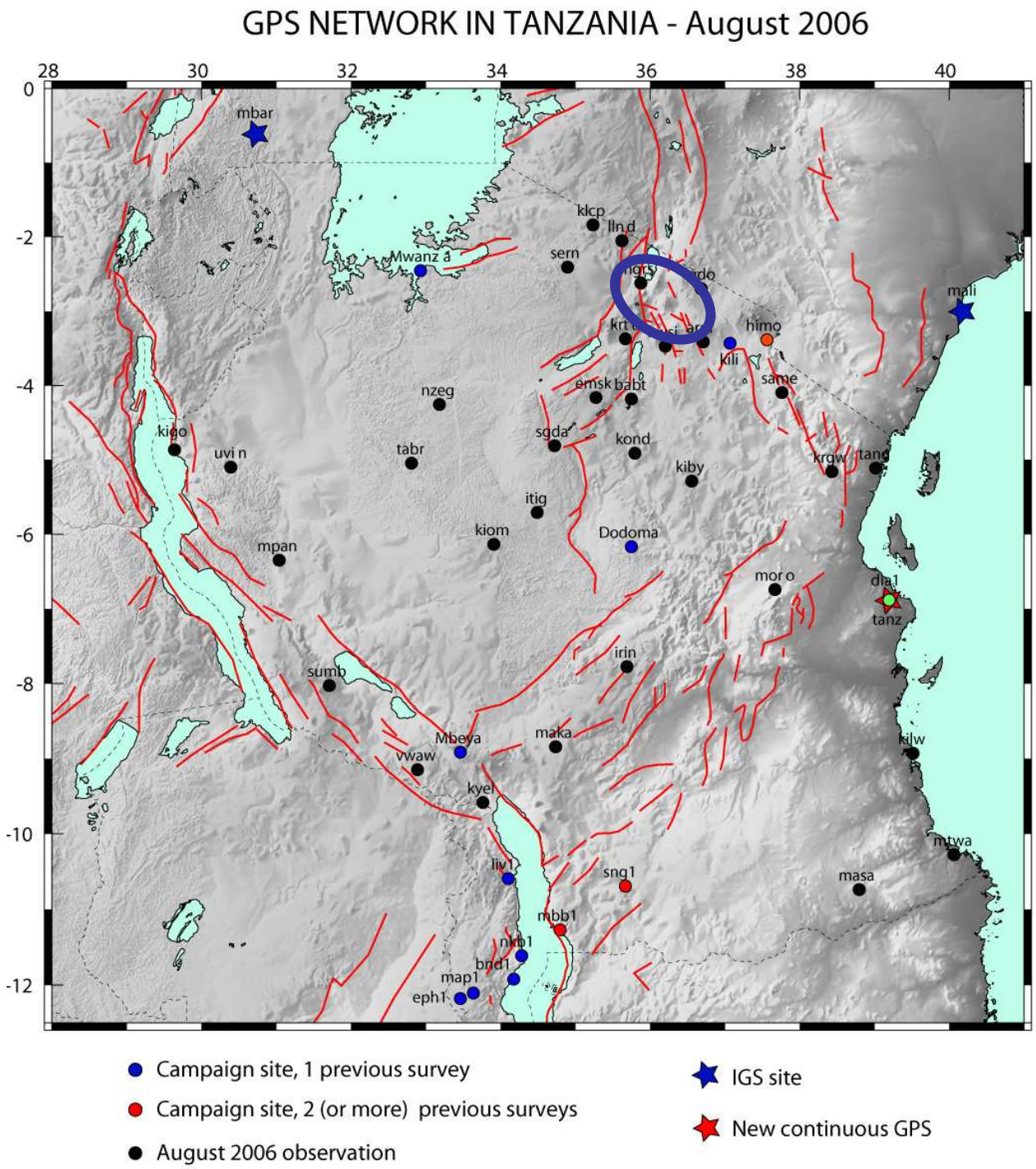
and on an existing triangulation pillar.

Continuous measurements TANZ site -Tanzania

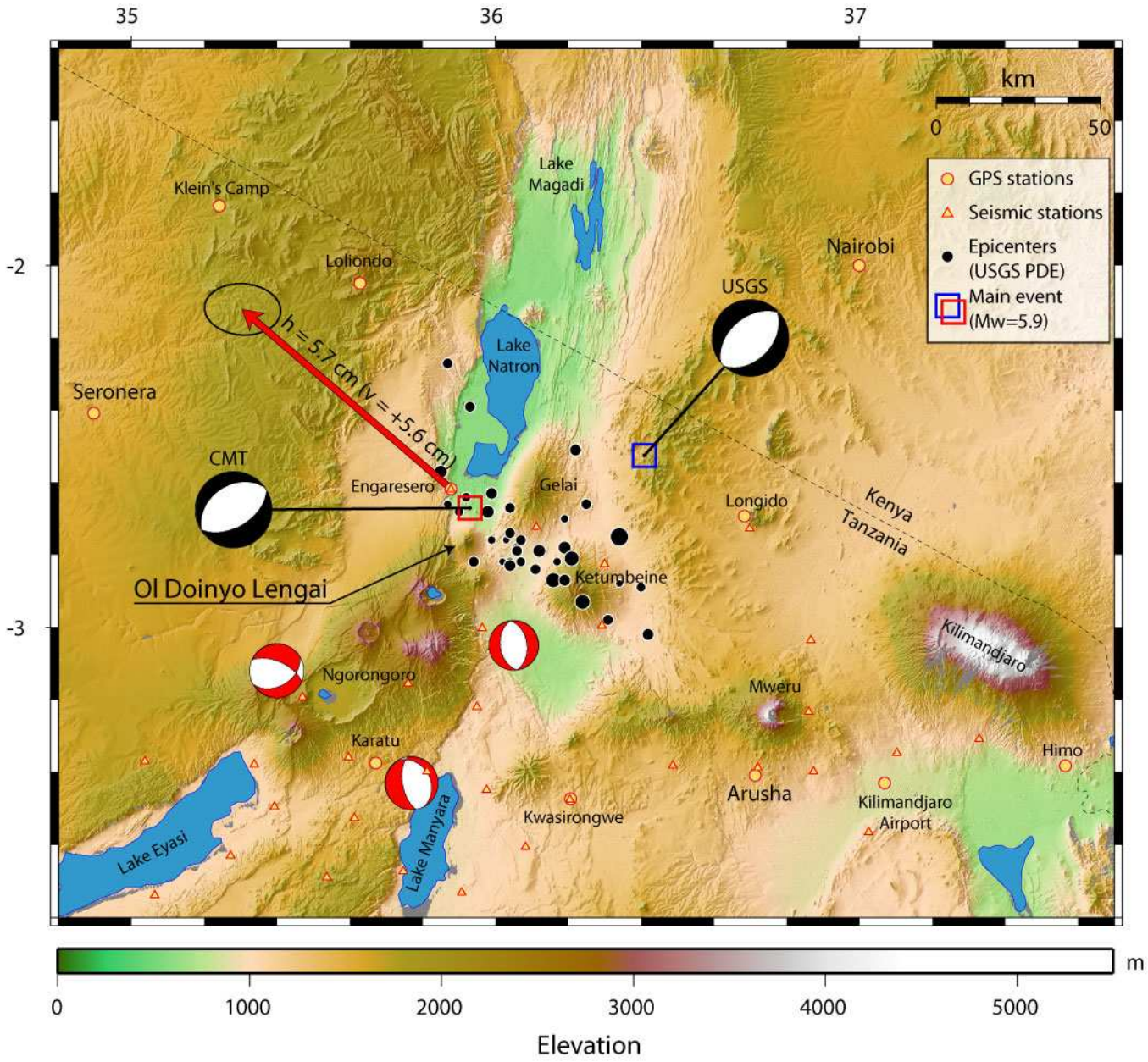
Left: GPS monument (concrete pillar) with Zephyr GPS antenna.

Right: Building hosting the GPS receiver and communication equipment.

Enclosure housing
the GPS receiver

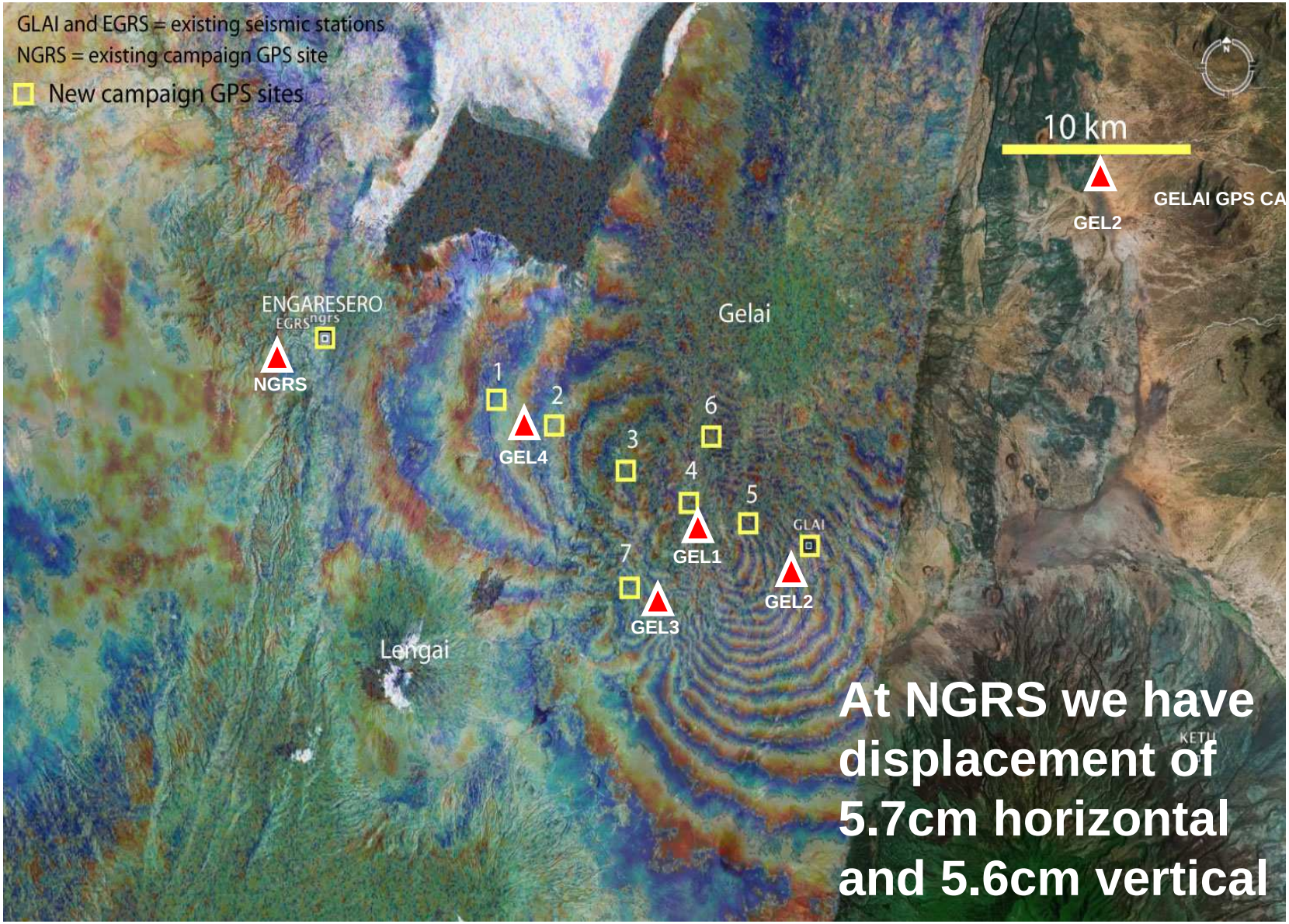


Map of the current GPS network in Tanzania. The sites installed and surveyed in 2006 are shown with black circles. Redlines show approximate trace of major active faults



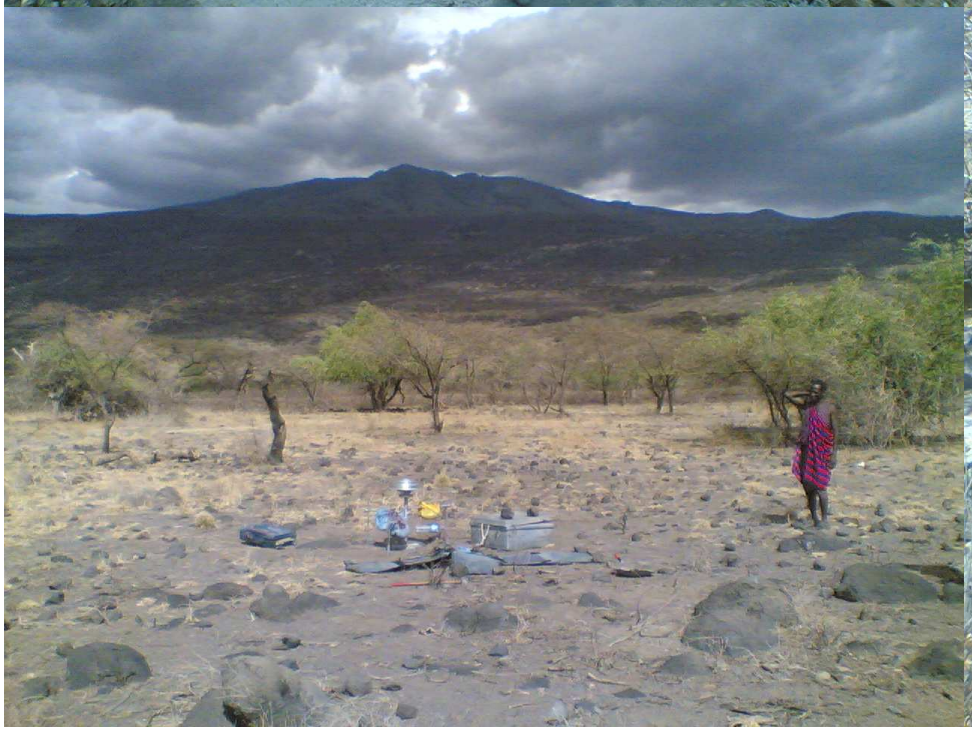
Displacement at Engaresero between August 2006 and August 2007

GELAI GPS CAMPAIGN –OCTOBER 2007



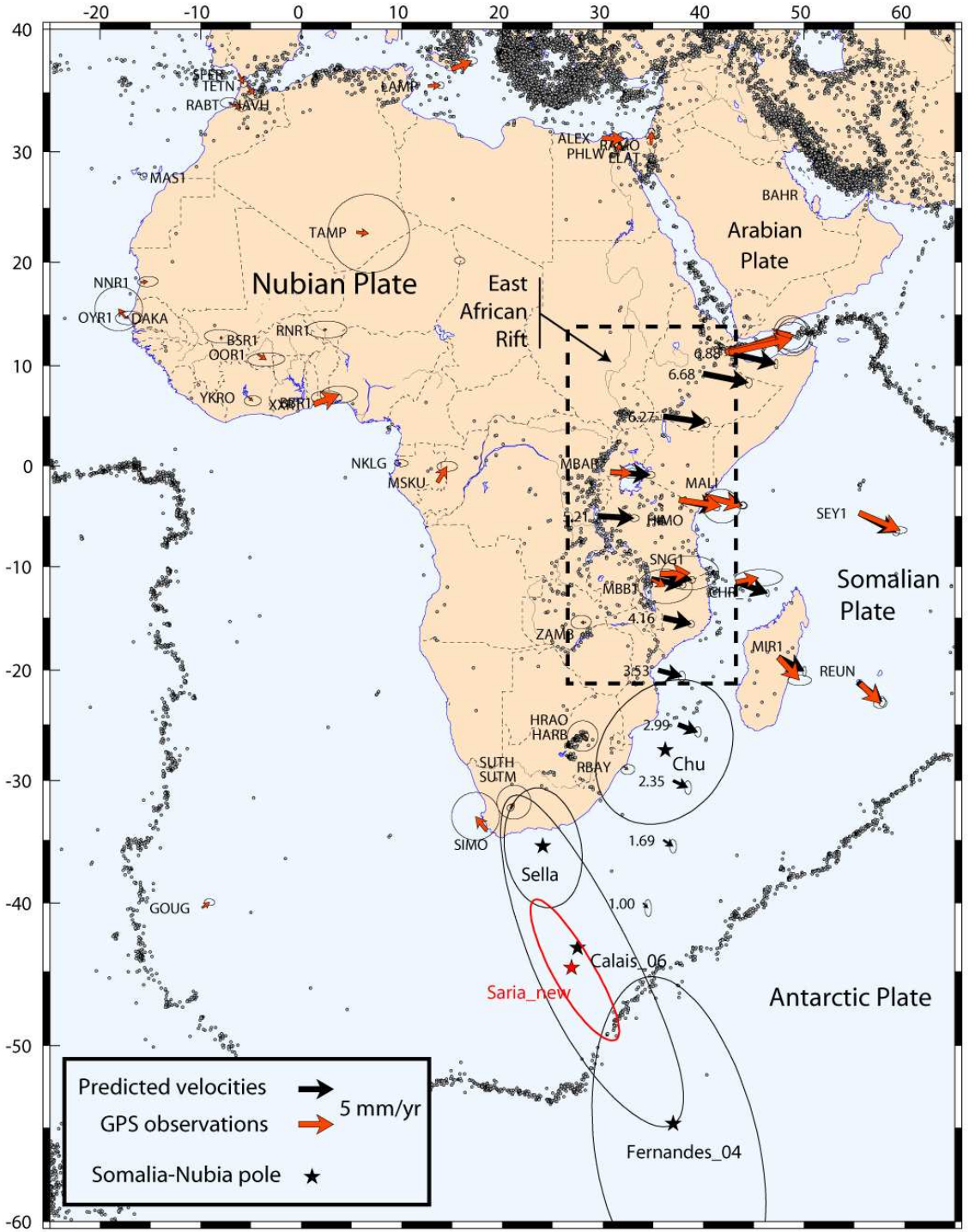

Kahiki Country Club


GEL



Nubia/Somalia kinematics

- Very few continuous GPS sites on Nubian and Somalian plates ⇒ Nubia-Somalia relative motion still poorly constrained
- Two plates:
  - Nubia = MAS1, NKLG, SUTH, SUTM, GOUG (ZAMB, HRAO, HARB)
  - Somalia = MALI, HIMO, SEY1, REUN
- Euler pole between South Africa and SW Indian Ridge ⇒ Nubia-Somalia extension rate increases from S to N
- Discrepancy at MBAR



Conclusions

- **Kinematics**:
  - Combination of (limited) GPS data set + earthquake slip vectors $\Rightarrow$ preliminary kinematic model for Nubia/Somalia + 2 microplates (Victoria and Rovuma)
  - Model will be refined using new GPS data in Tanzania.
  - Next GPS campaigns = August 2008 and 2010.
- **Broader impacts**:
  - Establishment of new national geodetic network
  - Establishment of new IGS site
  - Other research projects: geoid, datum transformations, vertical motions, etc…

Thanks