Characterization of locations and durations of ionospheric irregularities causing GNSS signals scintillation over the low latitude regions in Africa:

Dr. Olwendo Ouko Joseph, Ph.D
Department of Physics.
Pwani University.
P.O Box 195-Kilifi, Kenya.

2nd UN/United Arab Emirates High level forum: Space as a driver for socio-economic sustainable development. 6th-9th November, 2017, Dubai, UAE.
Outline

✓ What is Space Weather?

❖ The Sun-Earth connection: The main Dynamos

✓ Near Earth space environment electrodynamics

✓ Satellite Technology & application in Scientific Research

✓ Results in scintillation observation around the Kenya region

✓ Ionospheric threats to GNSS signals and applications

✓ Why bother about ionospheric scintillation?
Space Weather describes the conditions in space that affect Earth and its technological systems. It is a consequence of the Sun’s behavior, the Earth’s magnetic field and our location in the solar system.
M-I coupling

Solar EUV Effects: No Magnetic Fields

After J. Grebowski

J. Grebowski / NASA GSFC
M-I coupling

Addition of Earth’s Magnetic Field

After J. Grebowski
M-I coupling

Addition of Solar Wind and IMF

After J. Grebowski
M-I coupling gets messy

During Geomagnetic Storms

- Energetic Particles
- Solar Wind
- Magnetic Flux Tube
- Plasmasphere Filling
- Plasma Plume
- Solar-Driven Tides
- Gravity Waves
- Equatorial Anomaly
- Neutral Wind Drags Ions Down Field Line
- Neutral Wind Drags Ions Up Field Line
- Ionosphere Trough
- Ionosphere Crest
- Ionosphere Draining and Heating
- Impulsive Heating-Driven Wind
- Gravity Waves
- Corotation
- Inequations/Bubbles
- Neutral Wind Drags Ions Up Field Line
- Corotation
- Neutral Upwelling From Heated Region
- Magneticospheric-Driven Ion Connection
- SAID
- Ion-Driven Wind
- Ion/Neutral Escape
- O/N2 Disturbances
- EUV
- Magnetic Flux Tube
- Magnetic Flux Tube
- E-Driven Downward Flow
- Ions
- Neutrals

J. Grebowsky / NASA GSFC
Near earth space weather events

- Courtesy of Prof. Patricia Doherty
Ionospheric Measurements from GNSS Observables

Ionospheric Irregularities
Where do scintillation occur and Why?

SATCOM
AURORAL IRREGULARITIES
GPS
PLASMA BUBBLES
GPS
SATCOM
MAGNETIC EQUATOR
DAY NIGHT
EQUATORIAL F LAYER
ANOMALIES
Polar Cap
Patches

Caton, (2012) ISWI Barhbir Dar

Coherent scatter radar scan
From J. M. Retterer

Satellite signals along the bubbles: phase lock
Depletion in TEC are signatures of plasma density irregularities in the ionosphere- Plasma Puffles

Olwoendo et al. 51(2013), 1715-1726.
Spatial distribution of irregularities and the ionization anomaly crests

IPP footprints over E. Africa for Day 001 Year 2011

marked points are receiver positions

Nairobi
2011-03-16
Climatology: Diurnal and Seasonal Variation of S4 index

Olwendo et al., 51(2013), 1715-1726, ASR

Olwendo et al., 138-139(2016), 9-22, JASTP
March equinox and December solstice: Post-midnight scintillation occurrence

Why would scintillation not occur on day 82 when $K_p>3$ and again why would it occur on day 85 when $K_p$ is nearly $\sim 0$?

Olwendo et al., 138-139(2016), 9-22, JASTP
Why should we bother with scintillation? - Errors in Precise Positioning

Positioning errors in Dual Frequency reference receiver

---

solar max 2002 16, March, Ascencio Island station

---

Time series from SCINDA file 110309_180000.psn

---

Courtesy: Patricia Doherty, 2009, ICTP workshop
Summary on Ionospheric threats:

• Daytime spatial and temporal gradients over low latitude.

• Depletions – spatial and temporal gradients that induce ranging errors (post-sunset).

• Scintillation - patches of irregularities that can induce ranging errors and loss of lock (post-sunset).

• Other spatial gradients: Post-midnight enhancements, Geomagnetic storms

• All threats are highly variable in Local time, day-to-day, season, geographic location, geomagnetic activity, SOLAR ACTIVITY!
How do we handle ionospheric Threats?

- Work on space weather specification, modelling and forecasting remains a basic research with great public purpose and societal benefits.
- Future space exploration and most modern human endeavors will require major advances in physical understanding and improved transition of space research to operations.
- We need to improve on infrastructure that will support Forecasting and now casting of space environment in near real time to the users - more work needed.

THE END! Thank you for listening.