MULTIPURPOSE NETWORK OF GNSS MONITORING STATIONS FOR IONOSPHERE CHARACTERISATION AND SBAS PERFORMANCES EVALUATION IN AFRICA

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AFI AIR NAVIGATION SERVICE PROVIDERS (ANSP) MEETING, LOMÉ, 28 MARCH TO 1ST APRIL 2022

Date : 24/04/2019
Ref : 83231024
Ref Modele : 83230347-DOC-TAS-FR-006

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Ref : xxxxx
Ref Modele : 83230347-DOC-TAS-FR-006

INTRODUCTION

/// A Network of GNSS monitoring stations contributes to several objectives :

- **IONOSPHERE CHARACTERIZATION**
- **SBAS PERFORMANCE ASSESSMENT AND DEMONSTRATION**
- **INDEPENDENT ASSESSMENT OF SBAS SYSTEMS PERFORMANCE**
- **ASSESSMENT OF RECEIVERS ROBUSTNESS**
- **RESEARCH ACTIVITIES CONTRIBUTING TO INTERNATIONAL STANDARDIZATION**
- **SHARING DATA WITH SCIENTIFIC AND GEODESIC COMMUNITIES**
- **SBAS SYSTEM PERFORMANCE MONITORING**

/// SAGAIE project GNSS monitoring stations network has in particular provided decisive improvement in equatorial ionosphere activity knowledge in West and Central Africa.

- **IMPROVING KNOWLEDGE OF EQUATORIAL IONOSPHERE IS THEN A KEY CONCERN IN ORDER TO OPTIMIZE CORRECTION ALGORITHM AND PROCESSING SET FOR SBAS-ASECNA SYSTEM.**

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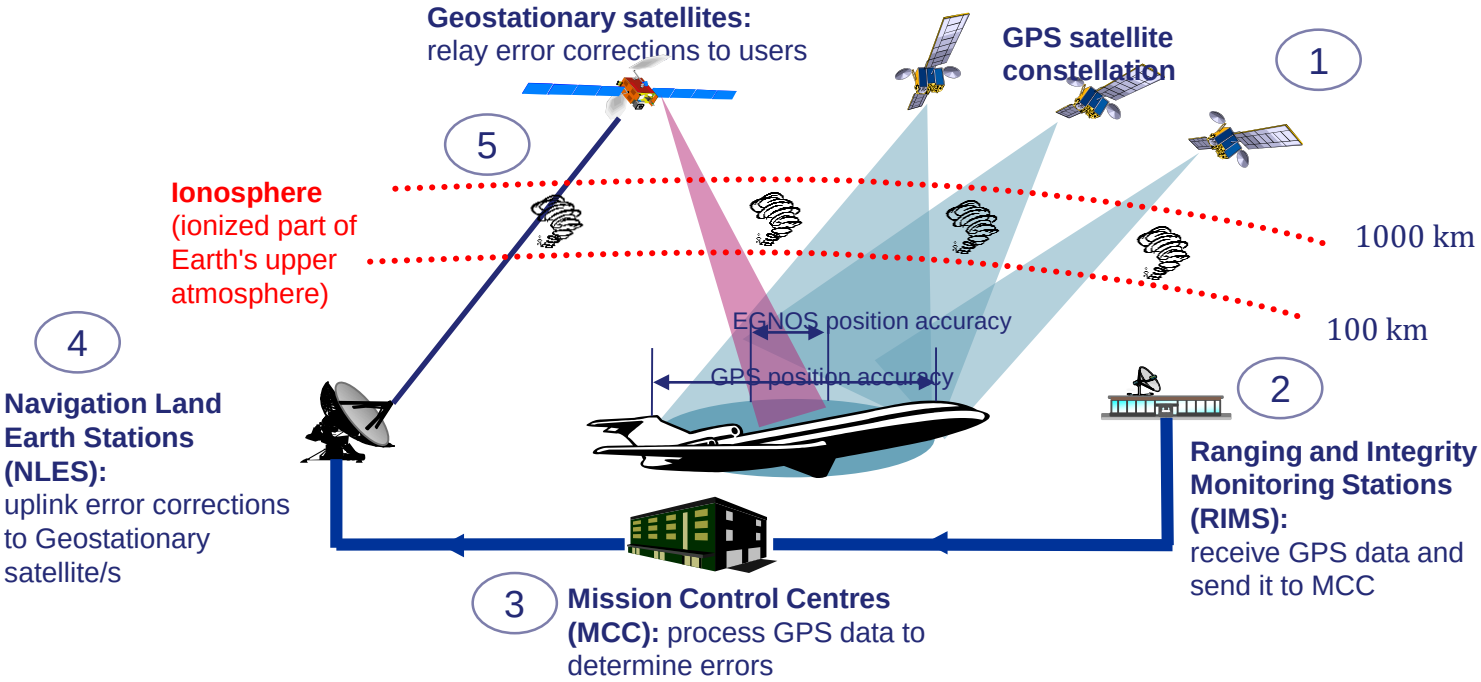
INTRODUCTION



/// Ionospheric errors are the main contributor to error measurement impacting SBAS performances (accuracy mainly), particularly in equatorial region where ionospheric activity is much stronger.

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PROJECT PRESENTATION

Joint initiative (since 2013):

complemented by

SAGAIE station (Dakar)

/// Deployment & exploitation of a network of GNSS stations, collection of GNSS raw data for ionospheric studies.

/// SAGAIE project main outcomes :

- **CHARACTERIZATION OF THE PHYSICAL PHENOMENA OF THE IONOSPHERE**
- **DEFINITION OF IONOSPHERIC MODELS ADAPTED TO SBAS SERVICE AREA**

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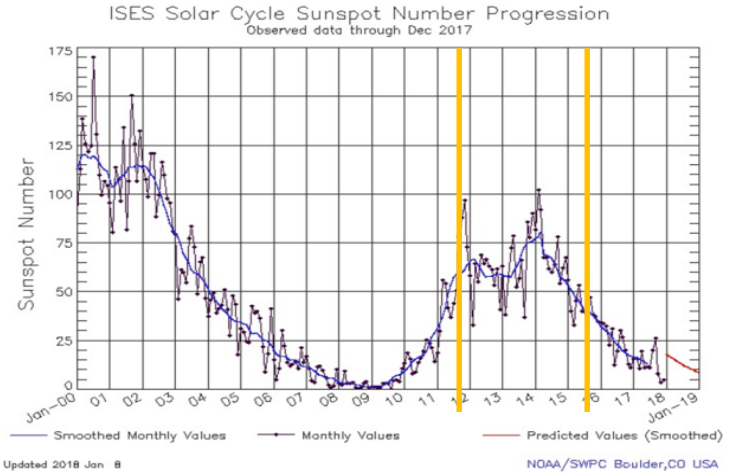
/// Ionospheric characterization studies:

- **PROCESSING OF SAGAIE DATA FOR THE 2013-2017 TIME PERIOD, COMPRISING BOTH TURBULENT AND QUIET IONOSPHERE PERIODS.**
- **ANALYSIS OF SCINTILLATIONS, PLASMA'S BUBBLES AND S4 VALUES (AMPLITUDE SCINTILLATION PARAMETER)**
- **COMPLETE STUDY OF THE TOTAL ELECTRONIC CONTENT (TEC) AND ASSOCIATED SPATIAL AND TEMPORAL GRADIENTS**

Solar Cycle with SAGAIE main data collection period



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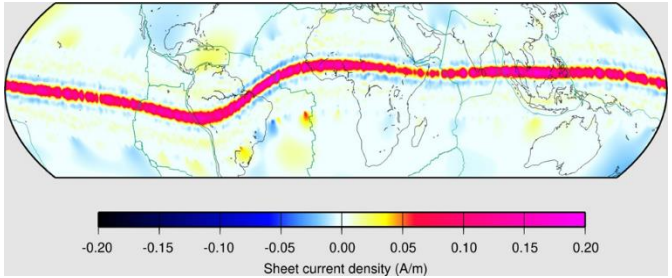
IONOSPHERIC CONDITIONS IN AFRICA – GENERAL PRESENTATION

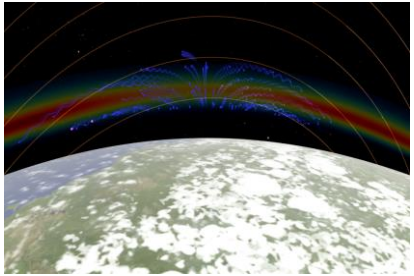
/// Special geometry of the magnetic field lines

/ HORIZONTAL FIBER BUNDLE ORTHOGONAL TO THE GEOMAGNETIC EQUATOR

/ THREE MAIN PHYSICAL EFFECTS IN THE REGION :

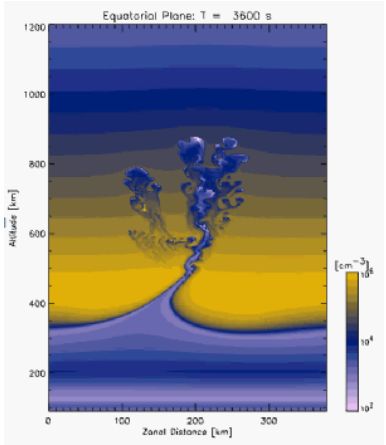
A strong electric current : the equatorial electrojet





The equatorial fountains

The plasma bubbles



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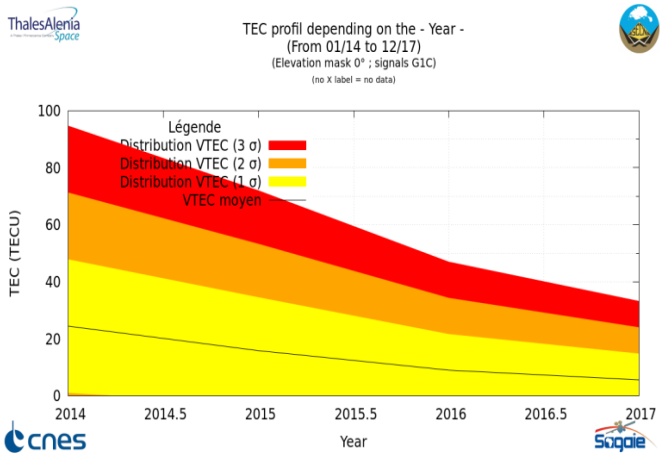
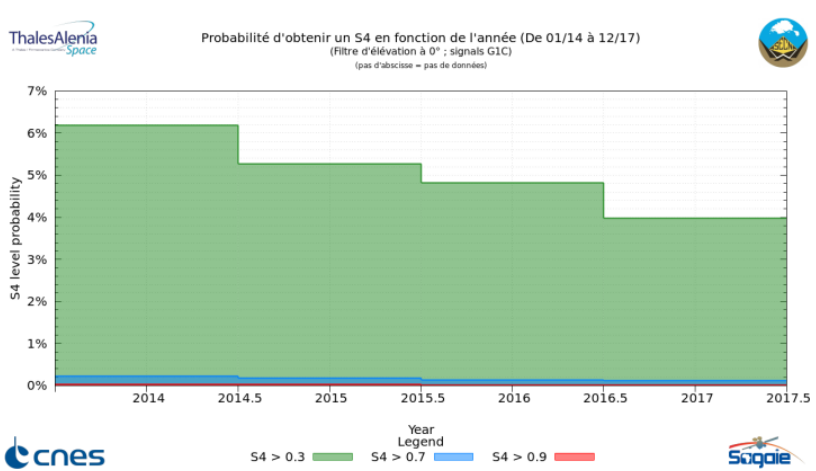
IONOSPHERIC CONDITIONS IN AFRICA – SAGAIE OUTPUTS

Yearly variability





/// TEC and S4 profiles in constant decrease over the years, in coherence with the solar cycle

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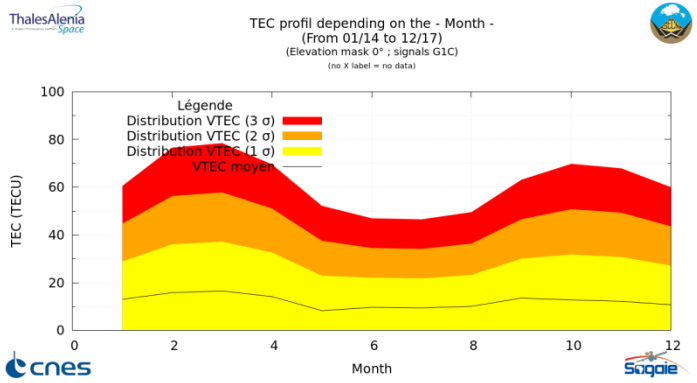
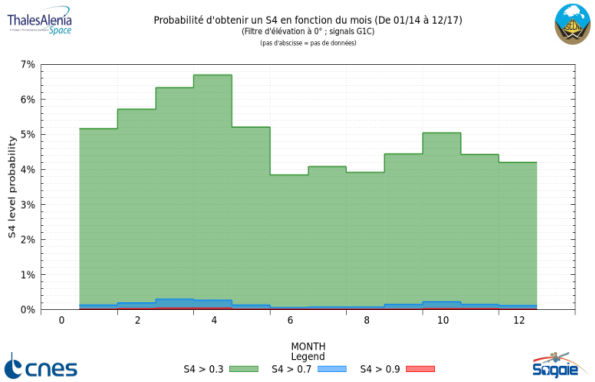
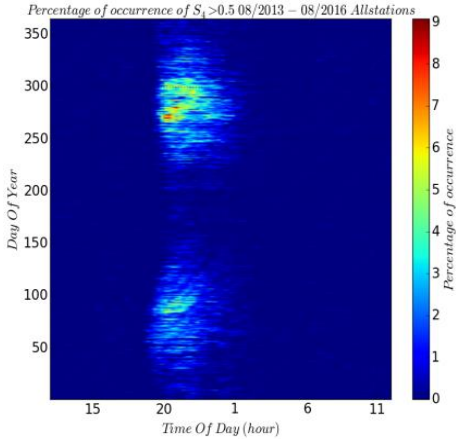
IONOSPHERIC CONDITIONS IN AFRICA – SAGAIE OUTPUTS

Seasonal variability







/// S4 > 0.5 values representative of high amplitude scintillation conditions are mainly observed at spring and fall equinoxes

/// The solstices, both winter and summer, are periods of lower ionosphere intensity

/// TEC values present similar seasonal variability than S4 values

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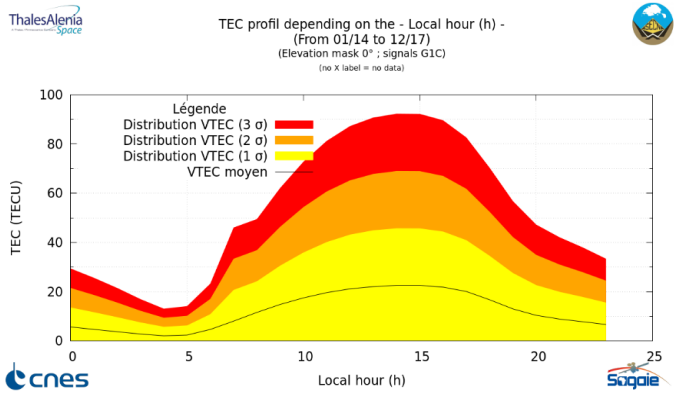
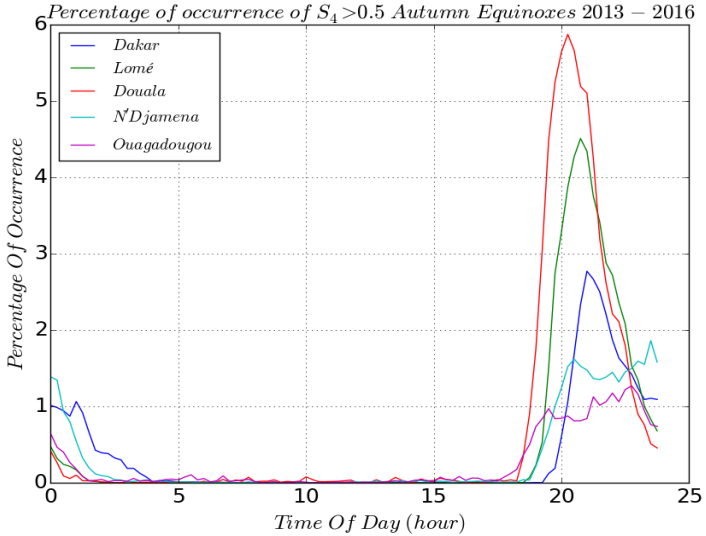
IONOSPHERIC CONDITIONS IN AFRICA – SAGAIE OUTPUTS

Daily variability





/// The rise of TEC in the morning corresponds to the beginning of the solar beam from 6am

/// It then increases continuously until reaching a maximum, close to 3pm

/// It is followed with a decrease of TEC during the night

/// Strongest S4 values appear during TEC decrease (from 6pm to 4am)

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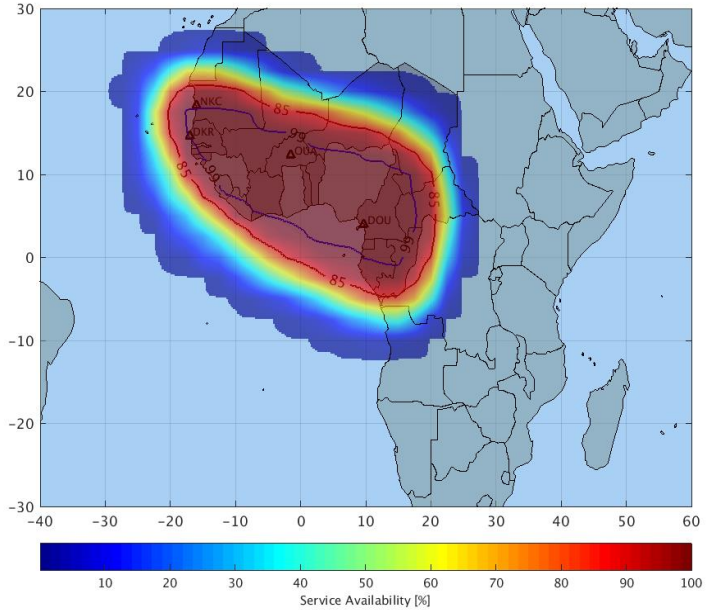
SBAS PERFORMANCES EVALUATION WITH THALES ALENIA SPACE ALGORITHMS ON SAGAIE MEASUREMENT

APV-1 service availability



Simulation conditions: Run NACA with 12 stations, one day analysed : 22 June 2015

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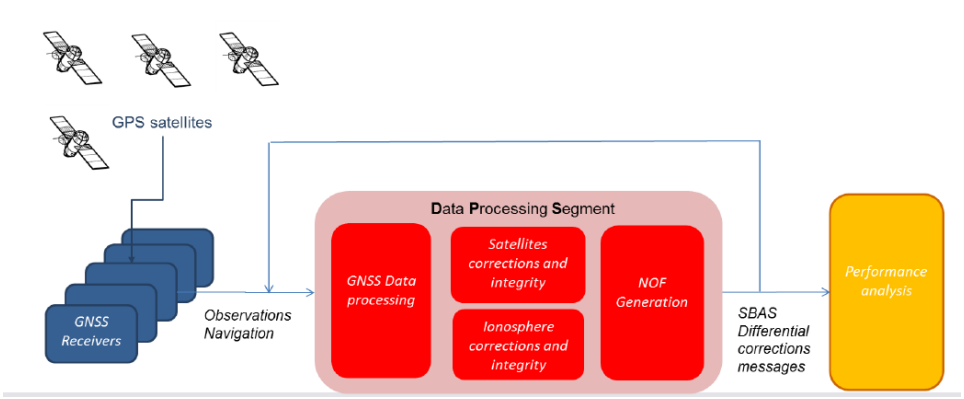
OTHER EXAMPLE : ATNS GNSS MONITORING NETWORK



/// ATNS GNSS monitoring network deployment achieved in Q1 2021 (provided by Thales)

- **GNSS PERFORMANCE ASSESSMENTS IN SOUTH AFRICA**
- **SBAS PERFORMANCE ASSESSMENTS**

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CONCLUSION

/// Thanks to SAGAIE and the enabled analyses,

- Sub-Saharan ionosphere has been precisely characterized,
- L1 SBAS algorithms have been developed and demonstrated their ability to cope with the ionosphere conditions,
- **The feasibility of a L1-SBAS operating in the region has been extensively demonstrated**,
- **Field trials with real L1-SBAS signal in space** have been implemented, especially in Lomé

⇒ ***SAGAIE, a key asset which contributed to demonstrate the feasibility of A-SBAS and to successfully validate the"L1 SBAS service" performances***

/// SAGAIE network will now also contribute to A-SBAS operational phase, by providing an independent performance monitoring solution

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