Nequick Model and Solar flux estimation for IRNSS

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Nequick Model for IRNSS

Grid Based Ionospheric Corrections

- IRNSS single frequency users can operate either on L5 or S frequencies
- Ionosphere: Dominant over Indian region & hence impact the single frequency Rx accuracies (L5)
- New Feature: Grid Based Corrections to provide comparable accuracy for single frequency L5 users
- Currently, servicing 90 grids points over Indian region and broadcasted every 5 min.

Co-efficient (Klobuchar like) Based Ionosphere Corrections

- 8 coefficients ($\alpha_n, \beta_n; n = 0 \text{ to } 3$), are provided in sub-frame 4 of the Navigation data.
- $\alpha_n$ are the coefficients of a cubic equation representing the amplitude of the vertical delay
- $\beta_n$ are the coefficients of a cubic equation representing the period of the model
- Co-efficients are generated and uplink once a using TEC derived from 16 reference stations (IRIMS)
Nequick Model for IRNSS

Galileo like ionosphere coefficients for IRNSS

Objective:
To explore the use of Galileo like ionosphere model for IRNSS single frequency users over equatorial region

Approach:
- Generation of broadcast ionosphere coefficients
  - Different statistical estimation methods
- Performance assessment with IRNSS measurements over Indian Land mass
  - Performance assessment in estimation period
  - Performance assessment in prediction period
- Modification in NeQuick Model parameters
- Comparison with GIM for IRNSS Primary service area
Nequick Model for IRNSS

Base Model:
- NeQuick (a semi-empirical model)
- Input: Time, Month, user receiver position, Satellite position, Solar radio flux (SF)
- Output: Total Electron Content along the line of sight

Methods:
Estimation of ionization parameter with IRNSS measurements using:
- MRMS - Minimum Root Mean Square (Estimation of SF, ESF)
- BWLQ - Weighted Batch Least Square (in terms of 3 coefficients $a_0, a_1, a_2$)
Nequick Model for IRNSS

Comparison with GIM (Global Ionosphere Model) data

Modified coefficients of foF2 of NeQuick-2 model using IRNSS data

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Nequick Model for IRNSS

- IRNSS data ingested to NeQuick for better performance over IRNSS service area.
- Different statistical methods used to estimate broadcast ionosphere coefficients and few parameters of the base model were modified.
- The overall performance of BWLQ method is better than the MRMS.
- However, the base model is not able to capture the shape of the ionosphere peak during noon time in both the methods.
- Further improvement in NeQuick model by ingesting more ionosphere data using different sources over IRNSS service area is planned.
Solar Flux (F10.7) estimation using IRNSS

Objective and Scope

• To estimate Solar radio flux (F10.7), as one of the IRNSS generated ionosphere products

• User can use the estimated flux for various space weather applications

• Can be used to fine tune the ionosphere models which depend on the solar flux values (e.g: NeQuick, IRI etc.) over equatorial region

• It can also be utilized to study behaviour of ionosphere over equatorial region.
Solar Flux (F10.7) estimation using IRNSS

- It is a measure of extreme UV radiation coming from sun and directly responsible for earth’s ionosphere activities
- Iono delay from GNSS signals is a function of SF, season, time of day and earth geomagnetic field
- Thus SF can be generated as a function of day of year from dual frequency ionosphere data
- The algorithm is verified first using GPS ionosphere products and solar flux measured in Penticton Radio Observatory

Observatory solar radio flux (SF), average solar flux (ASF) and processed solar radio flux (PSF) in black, red and green colours respectively for the period January 2012 to December 2016 (in SFU)
Solar Flux (F10.7) estimation using IRNSS

Re-construction of Solar Flux using GNSS data

Variation of PSF (black) and computed SF (red) using GIM data from January 2012 to December 2016

Difference (in sfu) between PSF and computed SF using GIM (black) and GAGAN (green) data for year 2016

Presently, error in the estimation is more for very high range of SF value (generally >130 SFU) as compared to the moderate SF.
Thank You