



NeQuick-N performance in NVS-01

A background graphic showing a globe with several satellite icons and lines representing a navigation satellite system constellation.

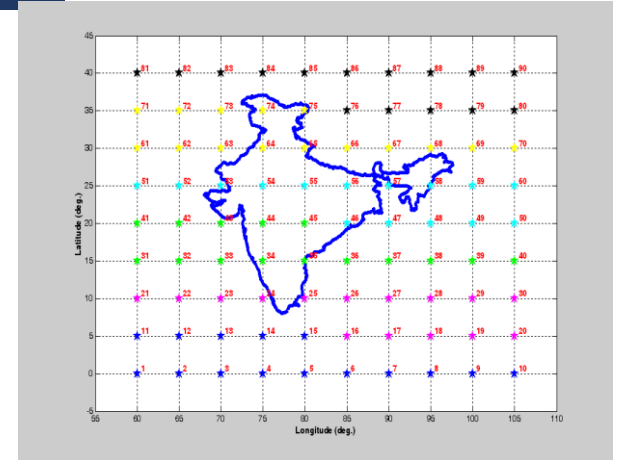
Megha Maheshwari & Gurpreet Singh
INDIAN SPACE RESEARCH ORGANIZATION (ISRO)

- **Ionosphere correction models for NavIC**
- **Inclusion of NeQuick-N model from NVS-01 onwards**
- **Description of NeQuick-N broadcast parameters**
- **Performance of NeQuick-N with NVS-01 measurements**
- **Conclusion**

- **Ionospheric Corrections for Single Frequency Users (1st generation: 1A - 1I)**
 - Grid Based (Indian region and around)
 - Klobuchar-like Co-efficients
- **Additional Ionospheric Corrections for Single Frequency (L1) Users (NVS-01 onwards)**
 - **NeQuick-N:** Three coefficients to compute Effective Ionization level (A_z)
 - Based on NeQuick model

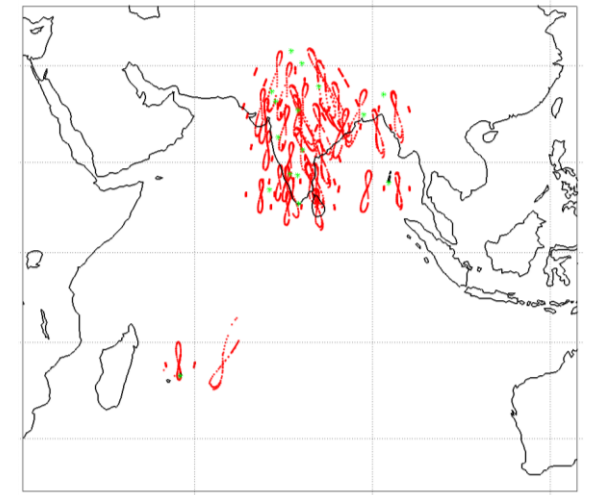
Grid Based Ionospheric Corrections (IIM- Indian Ionospheric Model)

- NavIC single frequency users can operate either on L5 or S frequencies
- Grid Based Corrections to provide comparable accuracy for single frequency L5 users
- Currently, servicing 90 grids points over Indian region (segmented into 6 regions with 15 points in each) and broadcasted every 5 min.



Co-efficient (Klobuchar like) Based Ionosphere Corrections

- 8 coefficients ($\alpha_n, \beta_n; n = 0$ to 3), are provided in sub-frame 4 of the Navigation data.
- α_n are the coefficients of a cubic equation representing the amplitude of the vertical delay
- β_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)



- Semi-empirical model
- Requires less bits to transmit the message
- Incorporates latest change in earth magnetic field
- Uses climatological/average ionosphere data to define ionosphere.
- Used data ingestion over Indian land mass to estimate coefficients.
- Used interpolation technique to generate coefficients for secondary service area.
- **GNSS receiver compatibility :**
 - **The user (receiver) algorithm for NavIC NeQuick (NeQuick-N) Model and NeQuick-G (GALILEO) are the same to maintain compatibility for the user Receiver**

Hence ionospheric message named NeQuick-N (NeQuick Model for NavIC) is included from NVS-01 onwards

- Coefficients are transmitted at L5 frequency (maintain legacy)
- Provision of three sets of broadcast coefficients for different regions
- The structure is define to accommodate the future expansion of NavIC constellation
- Provision of broadcasting different sets of the coefficients in a day
- Provision to protect users from any anomaly in broadcast data using Flag
- User algorithm is same as Galileo ionosphere model to maintain the receiver compatibility

S. No.	Parameter
1	Maximum MODIP coverage
2	Minimum MODIP coverage
3	Maximum Longitude coverage
4	Minimum Longitude coverage
5	Effective Ionization level 1 st order
6	Effective Ionization level 2 nd order
7	Effective Ionization level 3 rd order
8	Ionosphere Disturbance Flag
9	The Issue of Data NeQuick-N

Typical message content of NeQuick-N
(From NavIC SIS ICD for L1 signal)

- **NeQuick-N with NavIC measurements**
 - Line of sight slant delay for each NavIC reference receiver
 - GEO and GSO satellites
 - Overall error assessment

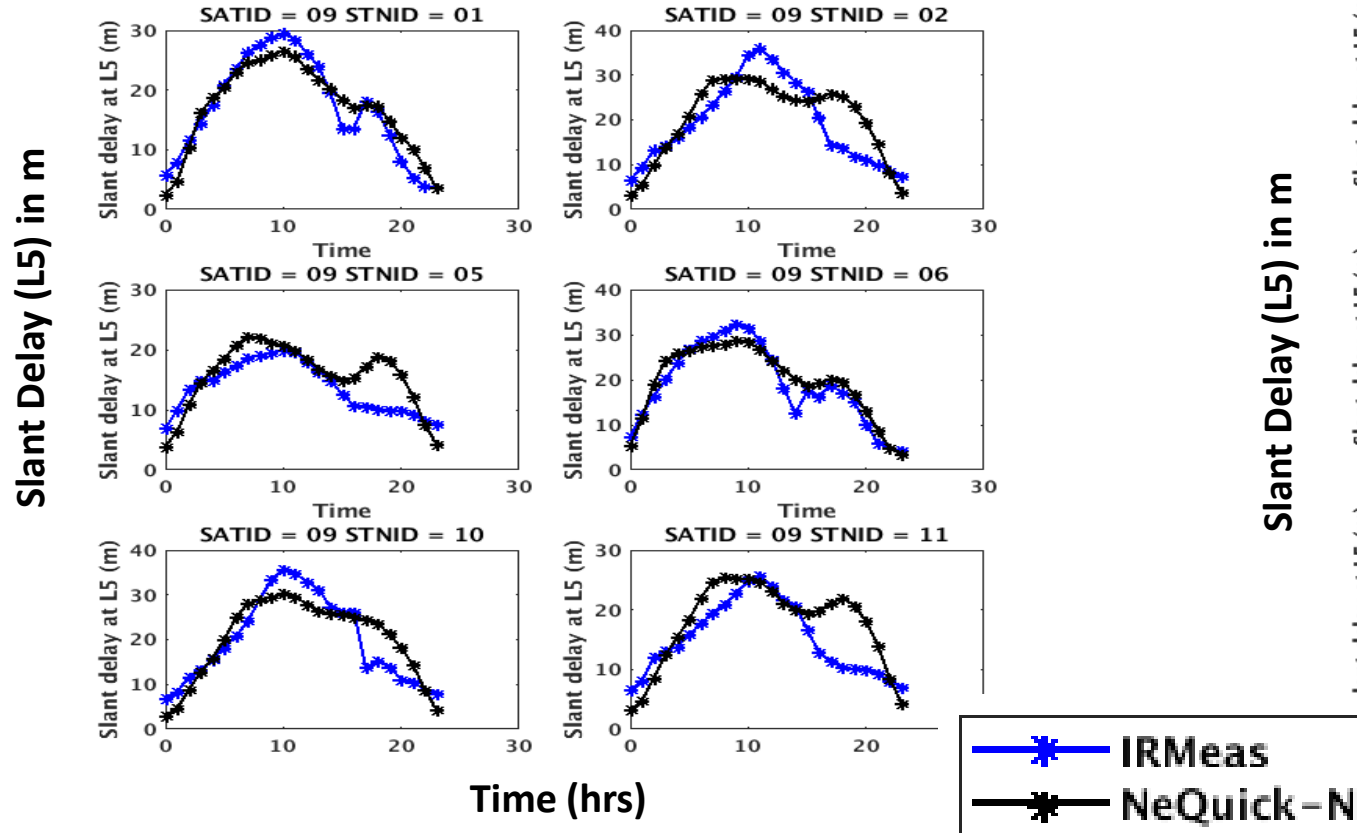
- **NeQuick-N with GIM**
 - Vertical delay computation at GIM grid points
 - Grid map generation over NavIC service area

- **NeQuick-N with NeQuick-G**
 - SD using NeQuick-G broadcast parameters
 - SD using NeQuick-N broadcast parameters
 - NeQuick model limitation for NavIC.

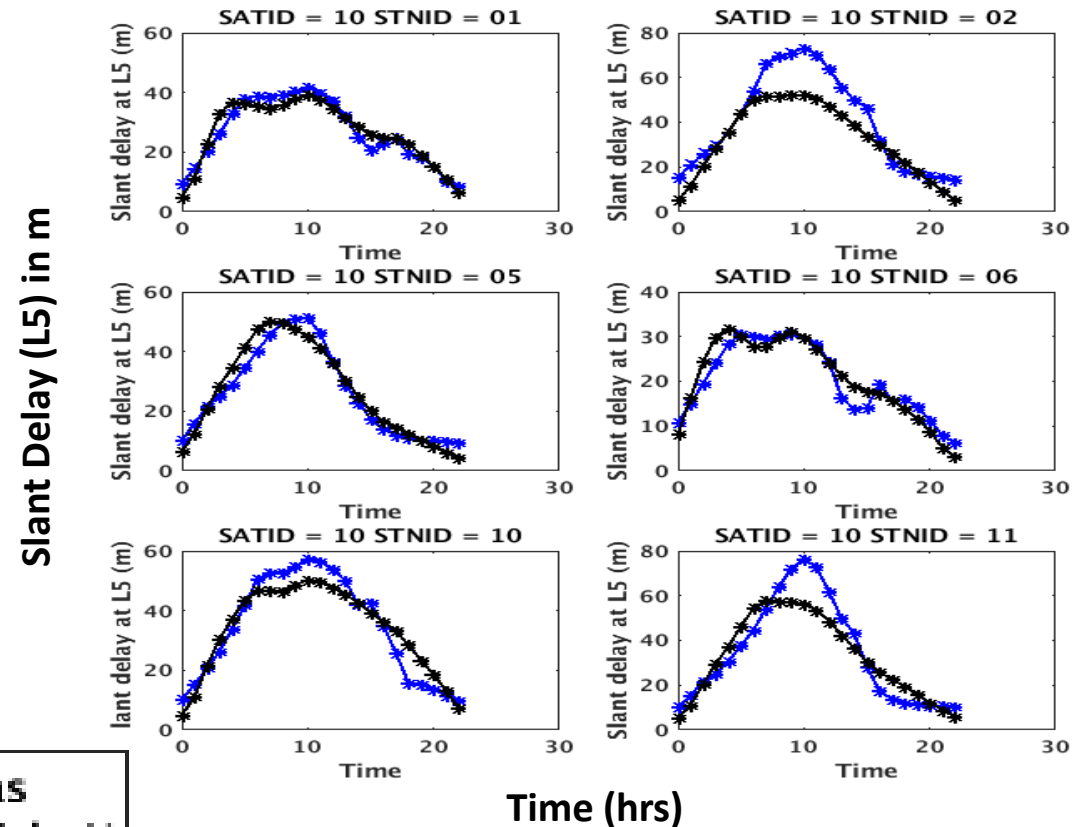
Line of sight Slant delay over a day at NavIC reference receiver location

Comparison for NVS-01 (GEO) and 1I (GSO)

IRNSS-1I (first Generation, GSO)

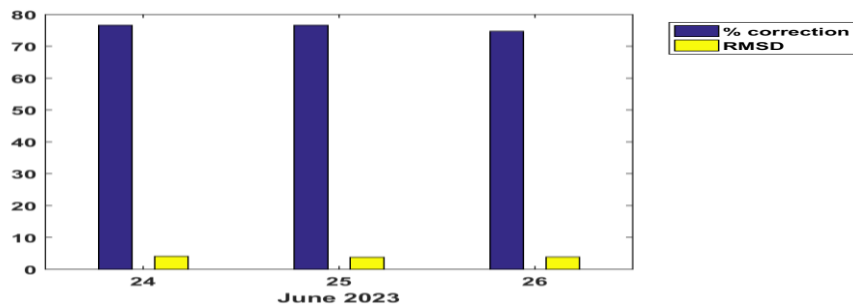
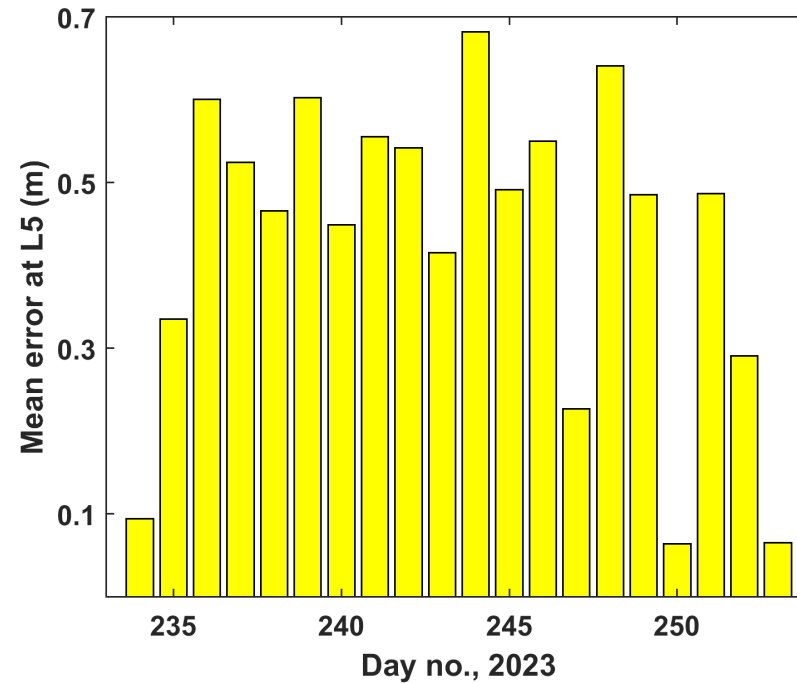
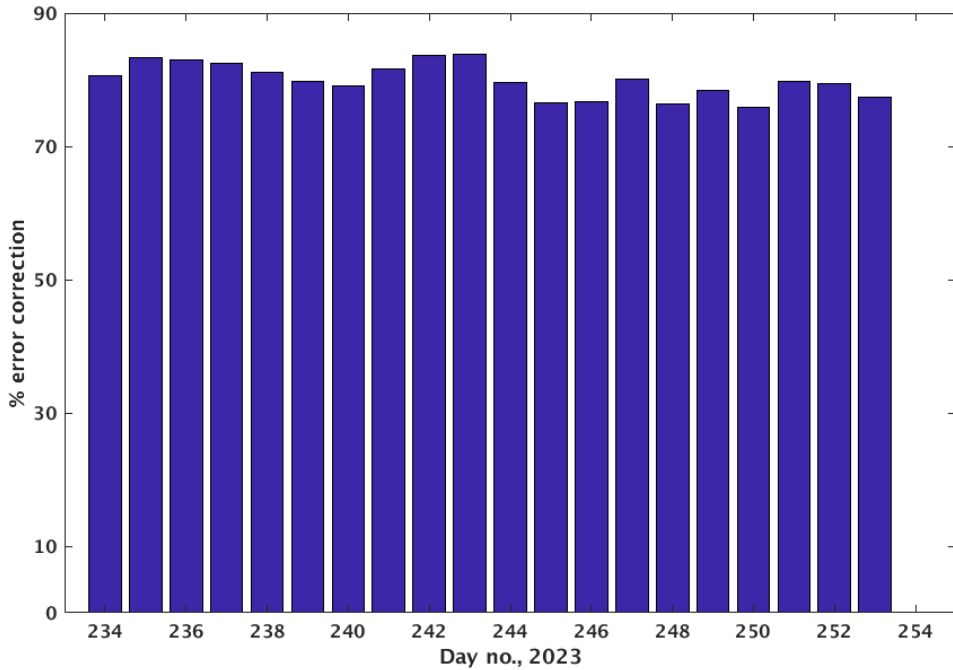


NVS-01 (Second Generation, GEO)



- IRMeas: SD from NavIC receivers' measurements
- NeQuick-N: SD from NeQuick-N coefficients

▪ No GEO/GSO orbit influence on the ionosphere delay pattern

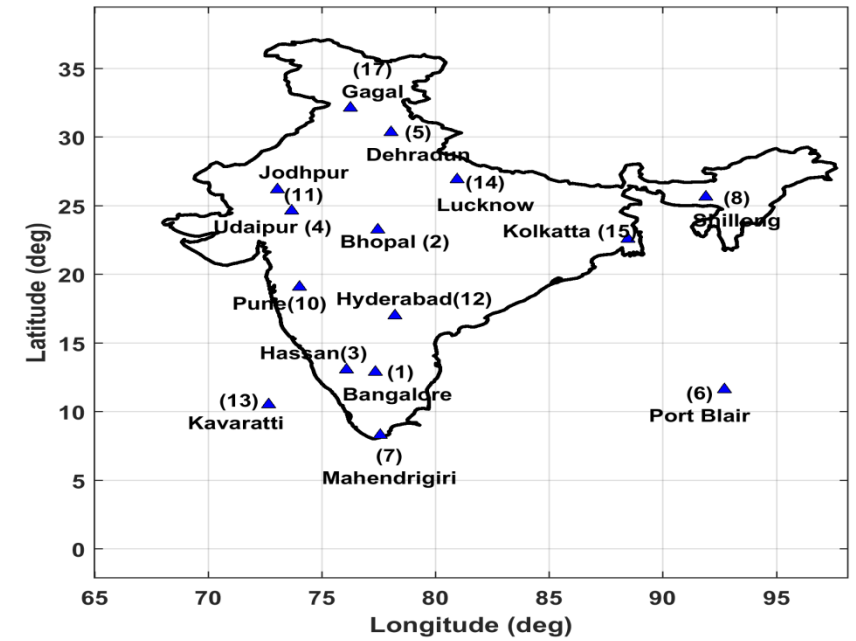
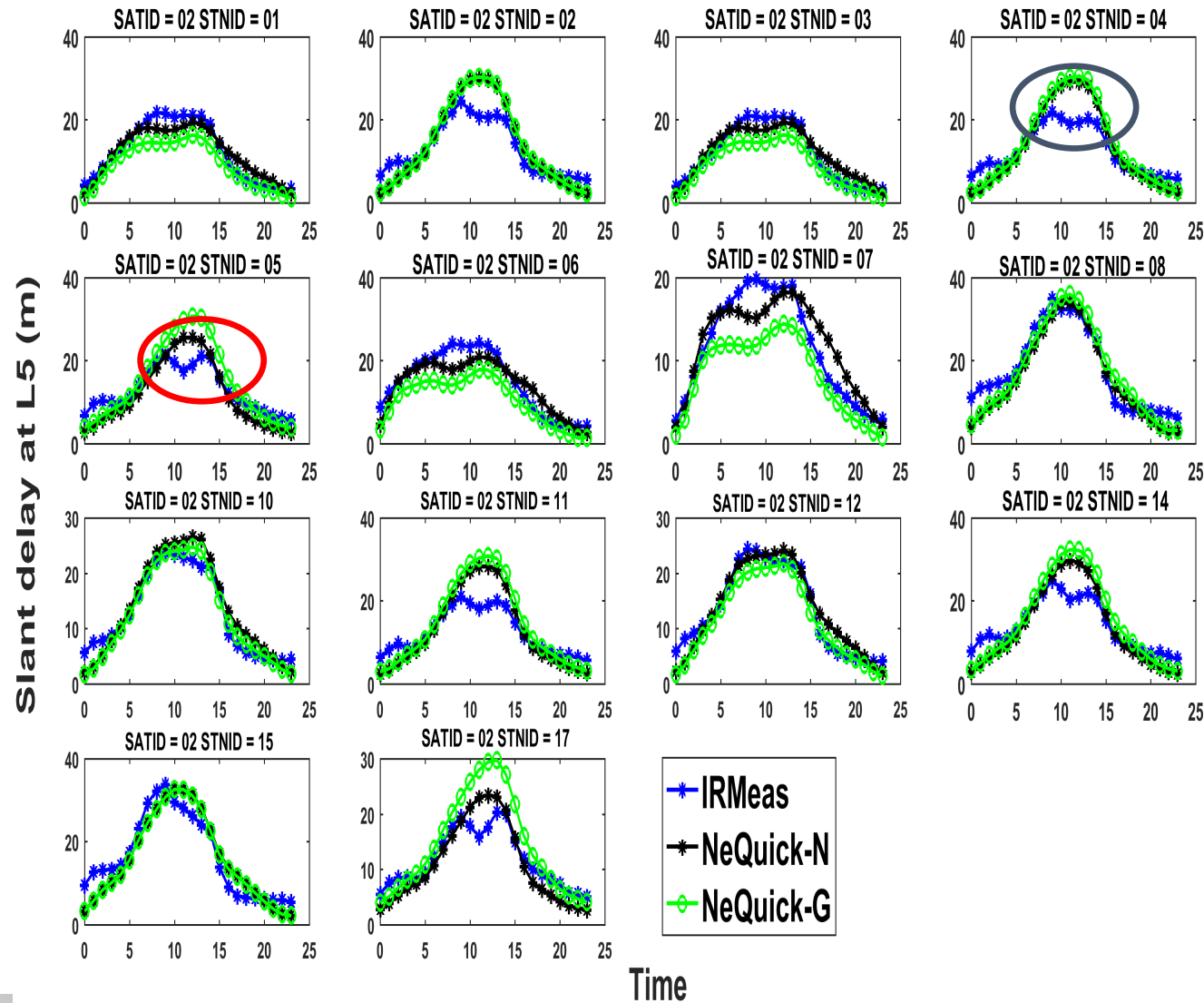


Solar activity index

DOY, 2023	F10.7 (SFU)*
24-June	166.5
25-June	160.3
26-June	163.4

* High Solar Activity

- Moderate Geo-magnetic activity (Dst:-30nTs)
- All the corrections (Grid, Klobuchar-like & NeQuick-N are broadcasted on L5; User to apply appropriate scale factor for his Line of Sight (LOS)

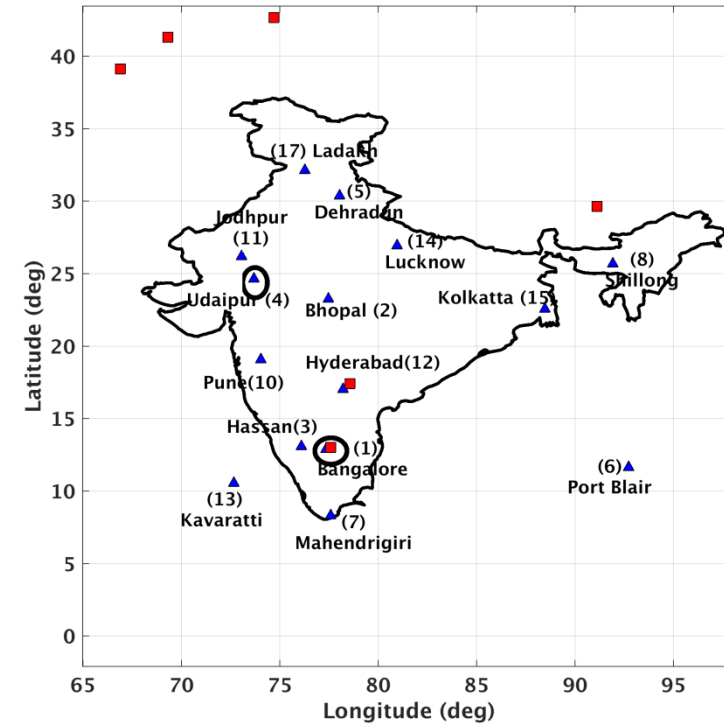
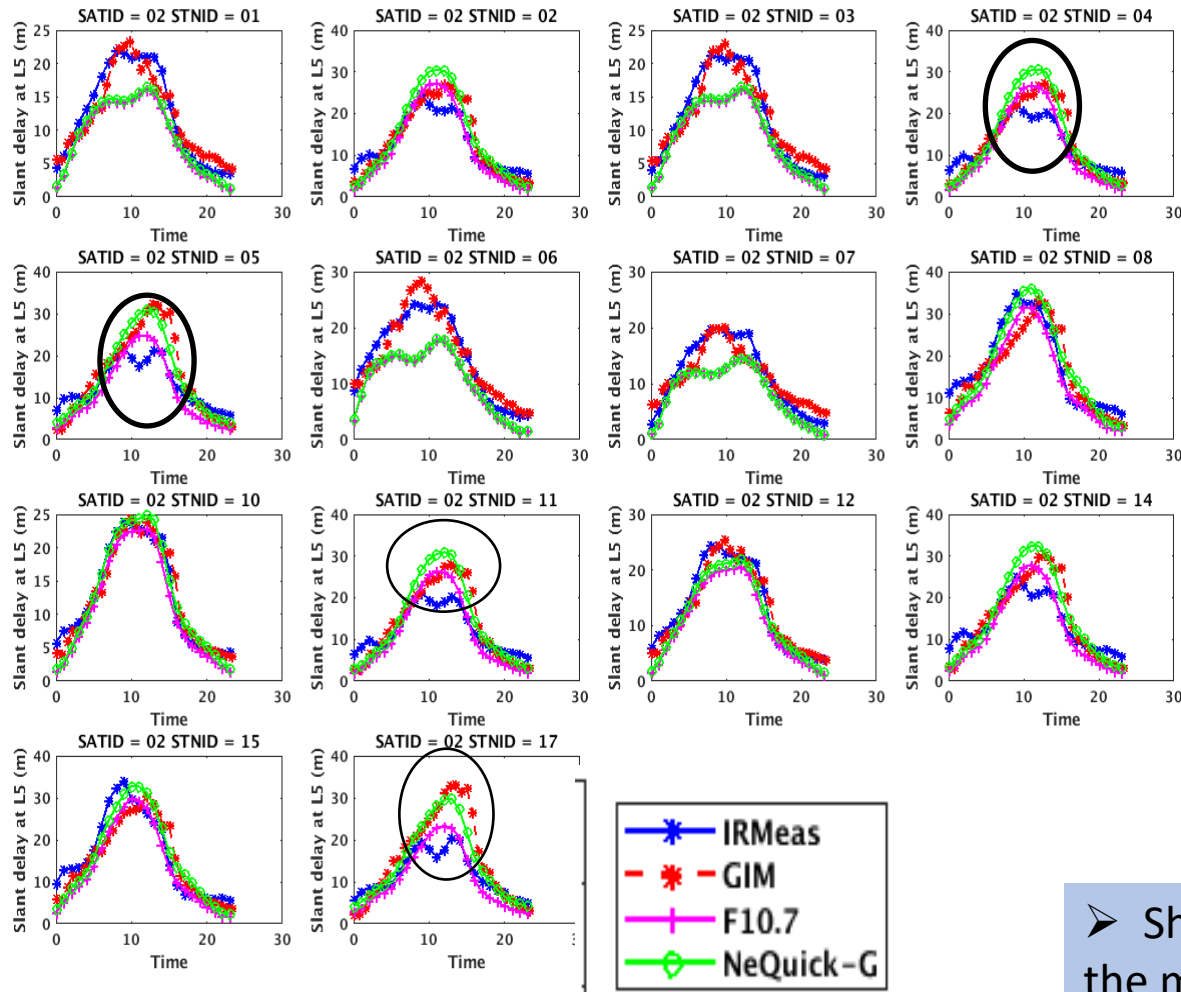


Statistics wrt NavIC Measurements

DOY 148, 2023	% Error correction	Mean Error (m)
NeQuick-N	75.37	0.695
NeQuick-G	74.4	1.062
NeQuick-F10.7	70.2	2.820

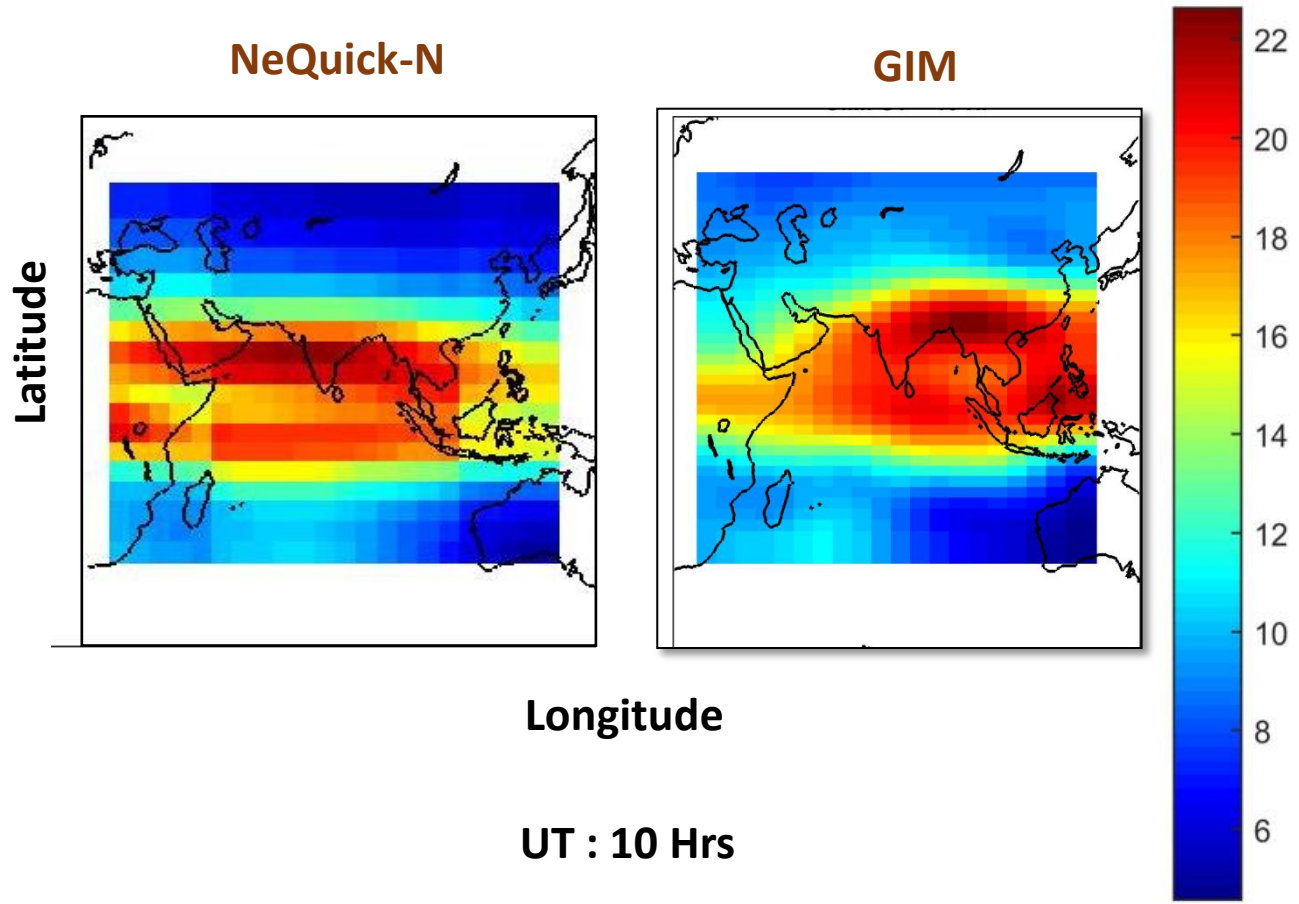
NeQuick model for low latitude region

Blue triangle : NavIC Stations
Red square : IGS stations



➤ Shape of NeQuick model at peak iono time does not match with the measurements above 20 deg Latitude

NeQuick-N with GIM over NavIC service area



- JPL derived GIM data is used for comparison.
 - VD is computed using broadcast NeQuick-N coefficients.
 - Different sets of coefficients are used based on the MODIP and Longitude coverage area.
- Matching well with GIM over primary service area
 - The difference is more at the edges of secondary service area.

- NeQuick-N coefficients are broadcasted from NVS-01 onwards.
- The coefficients are broadcasted for three different regions.
- Different techniques are used to generate coefficients at three different regions.
- Message structure is flexible to accommodate future navIC constellation expansion
- There is a provision to broadcast ionosphere disturbance Flag value and multiple sets of coefficients over a day.
- NeQuick-N performance is satisfactory with NavIC measurements as well as with GIM measurements

Thank You

