ESGIT - IAV H2

CRASTE-LF

Local Ionosphere Modeling Using GNSS Reference Stations Network in Morocco

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Outline

- Introduction
- Motivations
- Modeling Approach
- Assessment
- Activities related to space weather

Introduction

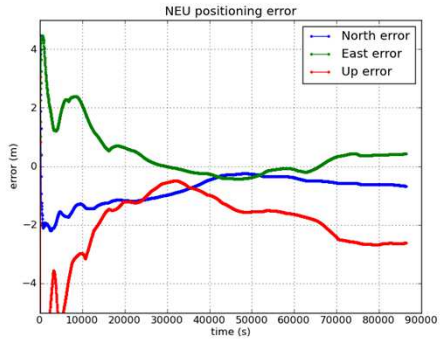
- GNSS contributed to advancing the understanding of the ionosphere in the last decades.
- At the same time GNSS techniques have benefited from improved knowledge of the electron content distribution in time and space.
- The increase knowledge has been made possible due to the use of GNSS with its unprecedented high temporal and spatial sampling rates.
- Implementation of new GNSS Infrastructure.
- Development of local products to support the use of GNSS PPP positioning .

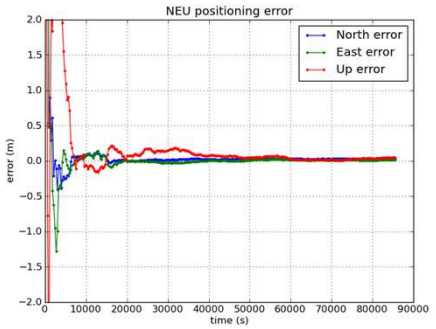
Motivations

1. Scientific :

Accurate knowledge of ionosphere conditions can in turn be used to improve geodetic techniques :

- ✓ Evaluation and application of higher-order ionosphere corrections.
- ✓ High-precision GNSS real-time positioning.





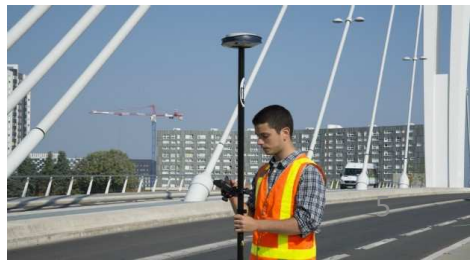
Motivations

2. Operational :

Ionosphere modeling is critical for mass-market single frequency users and for many national priority applications :

- ✓ Surveying, mapping, construction
- ✓ Precision agriculture, land administration
- ✓ Weather forecasting models
- ✓ Automatic vehicle location and in- vehicle navigation systems





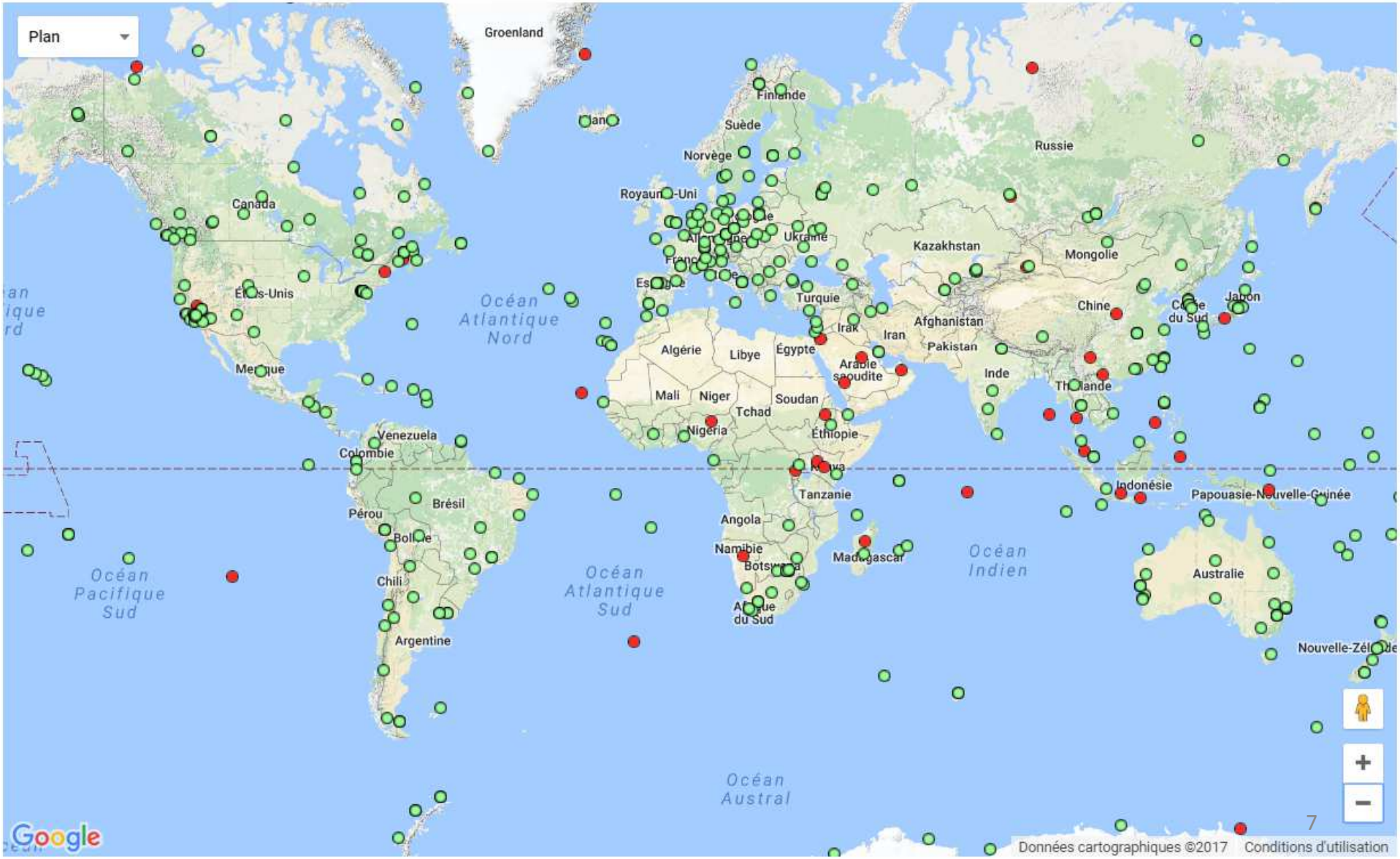
Motivations

3. Outreach :

Raise awareness of the usefulness of space weather science for the following reasons:

- ✓ Obtain the involvement of national organizations in research activities by showing the benefit through products that meet their needs.
- ✓ Create a service that has a societal impact.
- ✓ Have access to data and instruments of national administrations concerned.
- ✓ Collect national funds and logistical support for science and education activities related to Space Weather.

Network


Plan
Groenland
Finlande
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Turquie
Afghanistan
Pakistan
Inde
Algérie
Libye
Égypte
Arabie saoudite
Mali
Niger
Tchad
Soudan
Nigeria
Éthiopie
Kenya
Tanzanie
Angola
Namibie
Madagascar
Afrique du Sud
Indonésie
Papouasie-Nouvelle-Guinée
Australie
Nouvelle-Zélande
Venezuela
Colombie
Brésil
Pérou
Chili
Argentine
Océan Atlantique Nord
Océan Pacifique Sud
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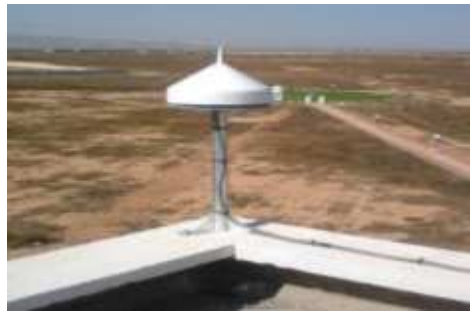
Océan Indien
Océan Austral
Google
Données cartographiques ©2017
Conditions d'utilisation

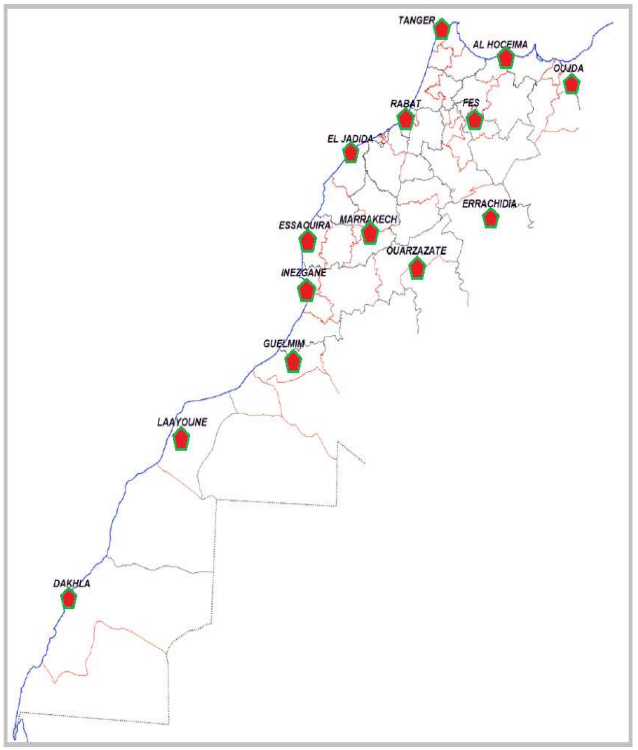
GNSS Data in Morocco



- Many agencies are deploying GNSS permanent stations
  - ANCFCC, CNRST, DMN, UNAVCOO, Universities.

- Currently only 01 IGS station located in Morocco

- More than 30 National GNSS Stations



Modeling Approach

1. Calculation of the ionosphere delay by linear combination : Geometry-free

2. Single layer model at h=350 km

3. Mapping with polynomial function

➔ High spatial and temporal resolution are required :

15 - 20 min on a 0.5° X 0.5° grid

- Integration of all National GNSS Permanent Reference Stations (NPRS);
- Near real time availability

TEC determination

$$\frac{\alpha}{f^2}TEC$$

$$P^s_{r,f_i} = \rho^s_r + c * \mathrm{dt_{rec}} - c * dt^{sat} - \mathrm{c} * \Delta\mathrm{t^{sat}} + \mathrm{d}^{\mathrm{s}}_{f_i} + \mathrm{d}_{r,f_i} + T^s_{r,f_i} + I^s_{r,f_i} + \Delta R^s_r + m^s_r + e^s_{P,r}$$

$$L^s_{r,f_i} = \rho^s_r - \lambda * N^s_r + c * \mathrm{dt_{rec}} + b_{r,f_i} - \lambda * \phi_r(t_0) - c * dt^{sat} - c * \Delta t^{sat} + b^s_{fi} + \lambda * \phi^s(t_0) + T^s_{r,f_i} - I^s_{r,f_i} + \Delta R^s_r + \mu^s_r + dp^s_u + \varepsilon^s_{P,r}$$

$$P^s_{r,f_1} - P^s_{r,f_2} = I^s_{r,f_1} - I^s_{r,f_2} + (d^s_{f_1} - d^s_{f_2}) + (d_{r,f_1} - d_{r,f_2})$$

$$P1 - P2 = 40.3\left(\frac{1}{{f_1}^2} - \frac{1}{{f_2}^2}\right) * STEC + c * (DCB^s + DCB_r)$$

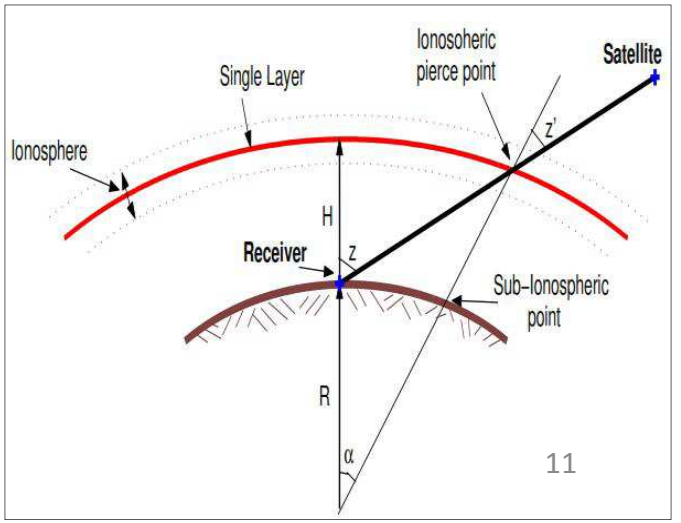
Polynomial model

$$STEC = \frac{1}{CI}[\mathrm{P4} + c * (DCB^s + DCB_r)] \qquad CI = \frac{{f_2}^2 - {f_1}^2}{40.3 * {f_1}^2 {f_2}^2}$$

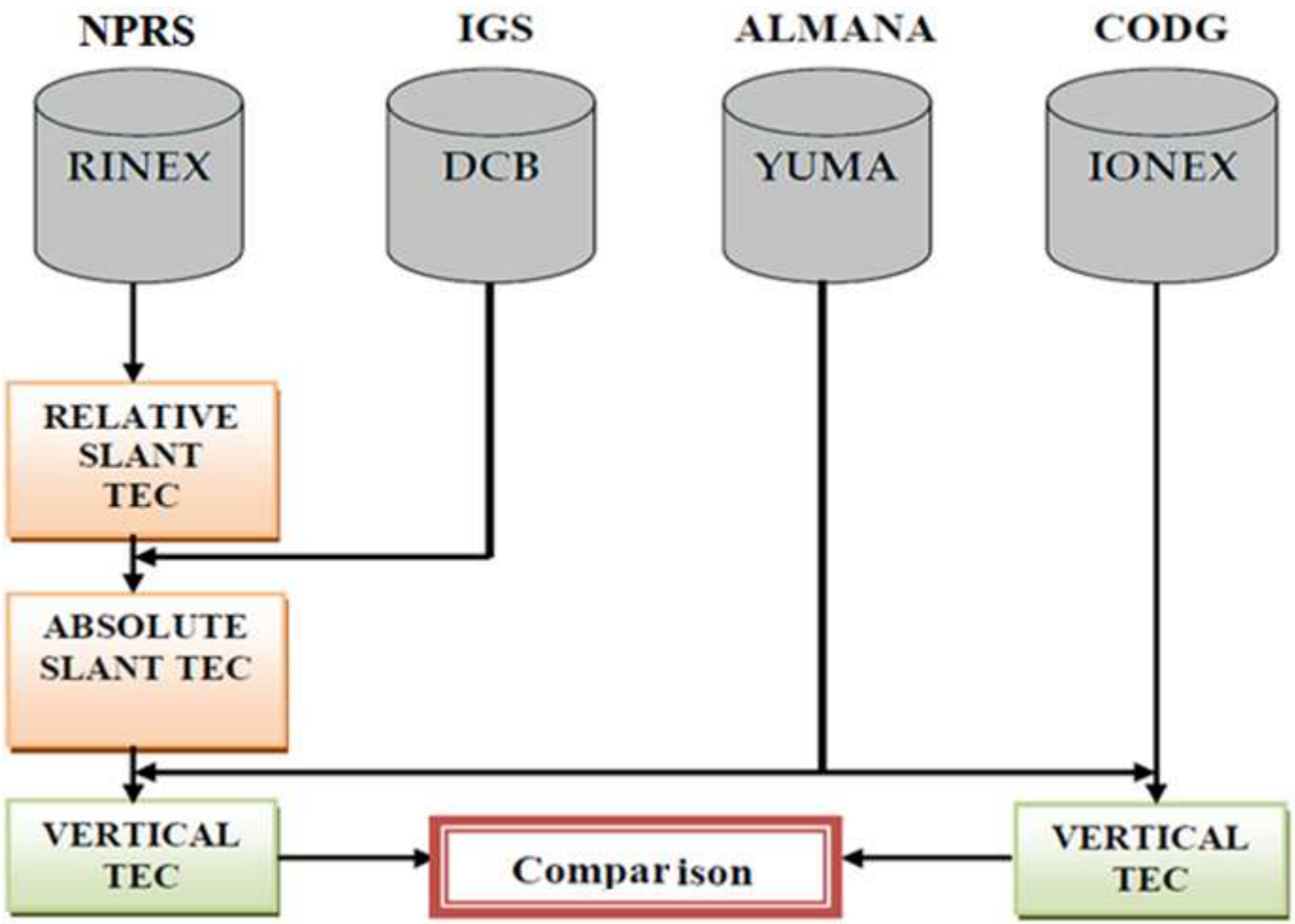
$$VTEC = STEC * \sqrt{1 - \left(\frac{R}{R+H} cos\beta\right)^2}$$

$$\boldsymbol{VTEC = \frac{1}{CI}[(P1 - P2) + c * (DCB^s + DCB_r)] * \sqrt{1 - \left(\frac{R}{R+H} cos\beta\right)^2}}$$

$$\boldsymbol{VTEC(\beta, s) = \sum_{n=0}^{n_{max}} \sum_{m=0}^{m_{max}} E_{nm}(\beta - \beta_0)^n (s - s_0)^m}$$

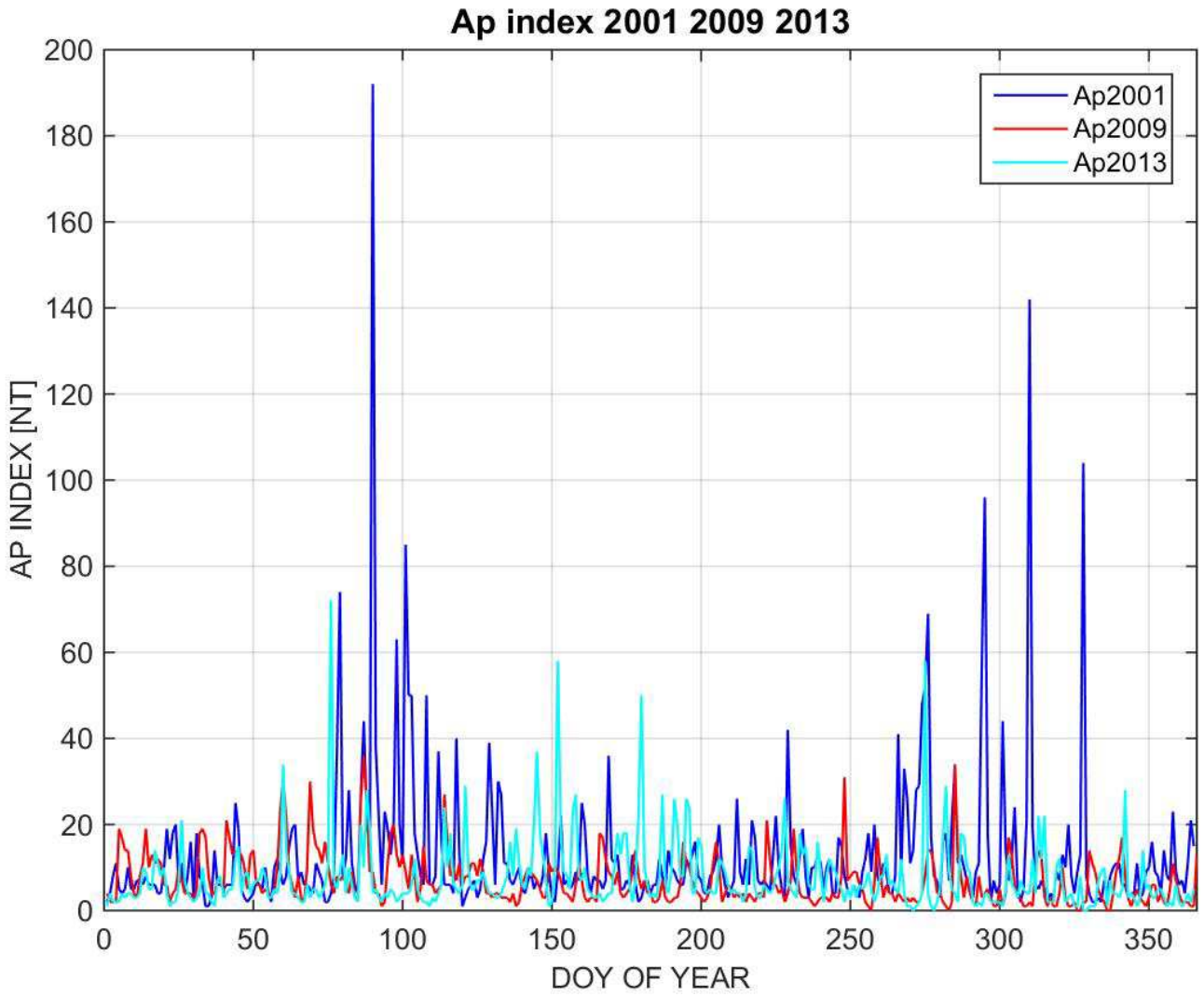


LIM & GIM Comparison



Program Rinex-TEC (Rolland Fleury)

Assessment


Ap index 2001 2009 2013
Ap2001
Ap2009
Ap2013
AP INDEX [NT]
DOY OF YEAR
0
20
40
60
80
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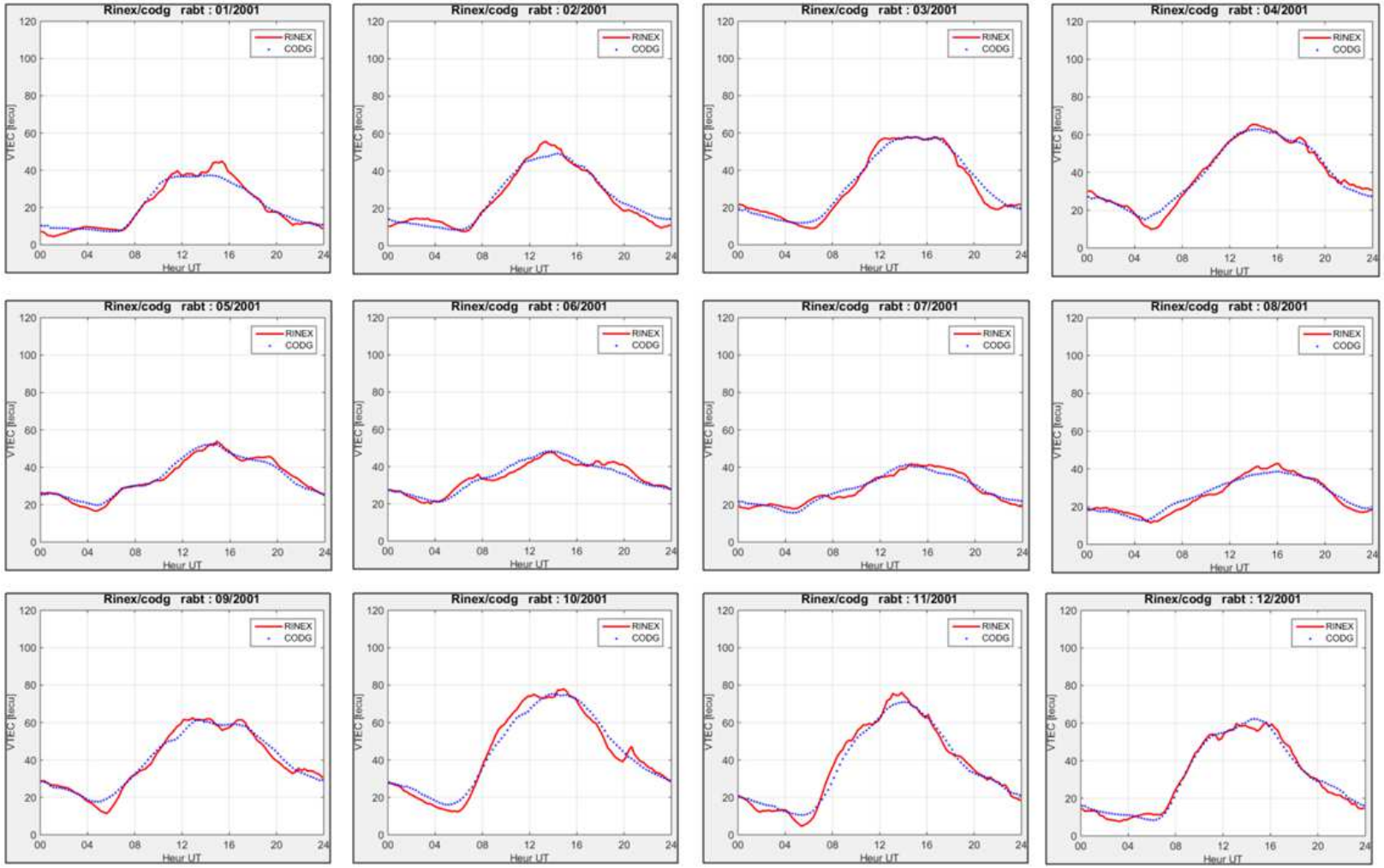
350

Comparison LIM & GIM

Rbat - *2001*

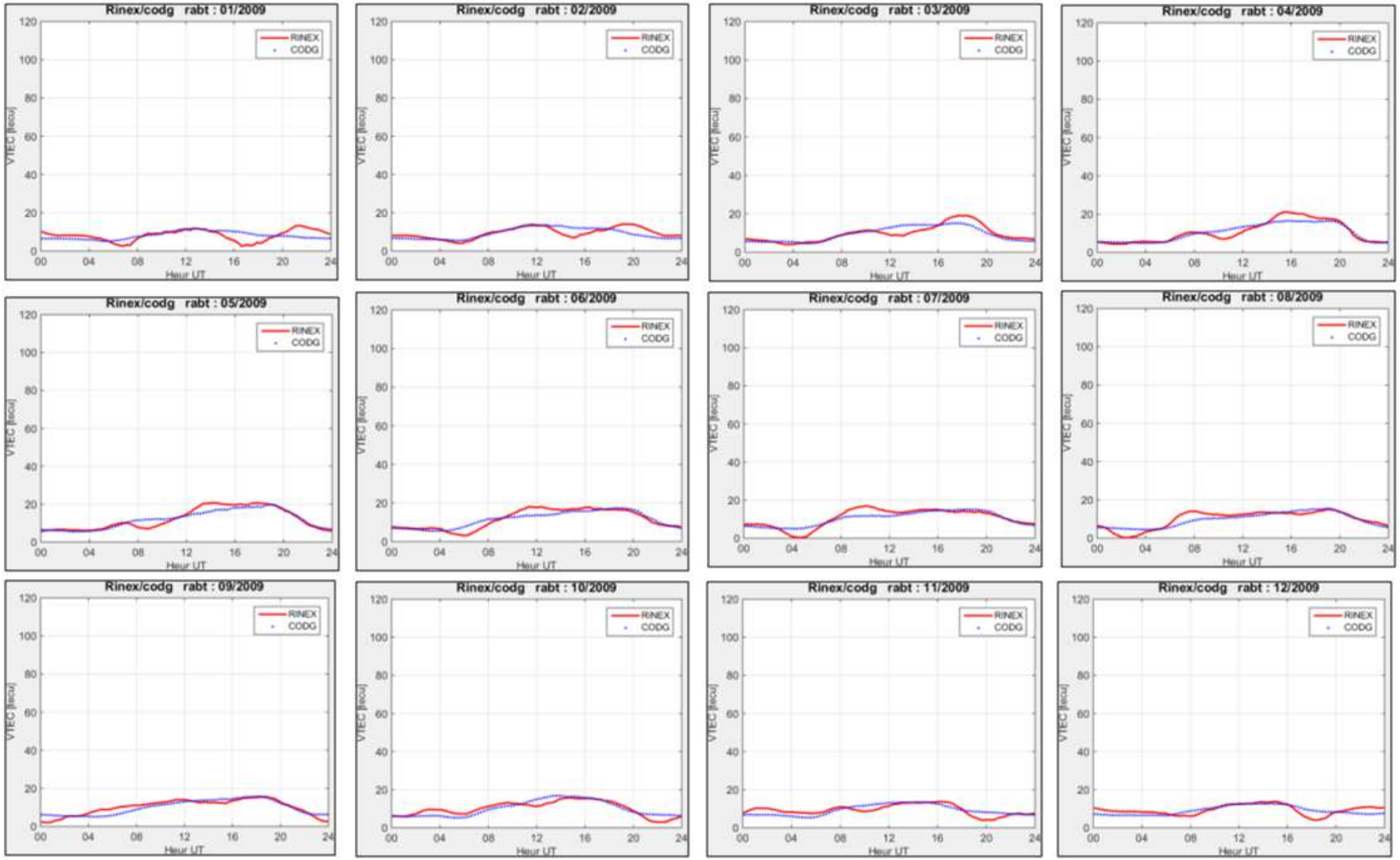


RMSE_GIM = 10 Tecu ; RMSE_ LIM = 4 Tecu

MAX_DIFF = 17 Tecu ; STD_DIFF = 5 Tecu

Comparison LIM & GIM

Rbat - *2009*

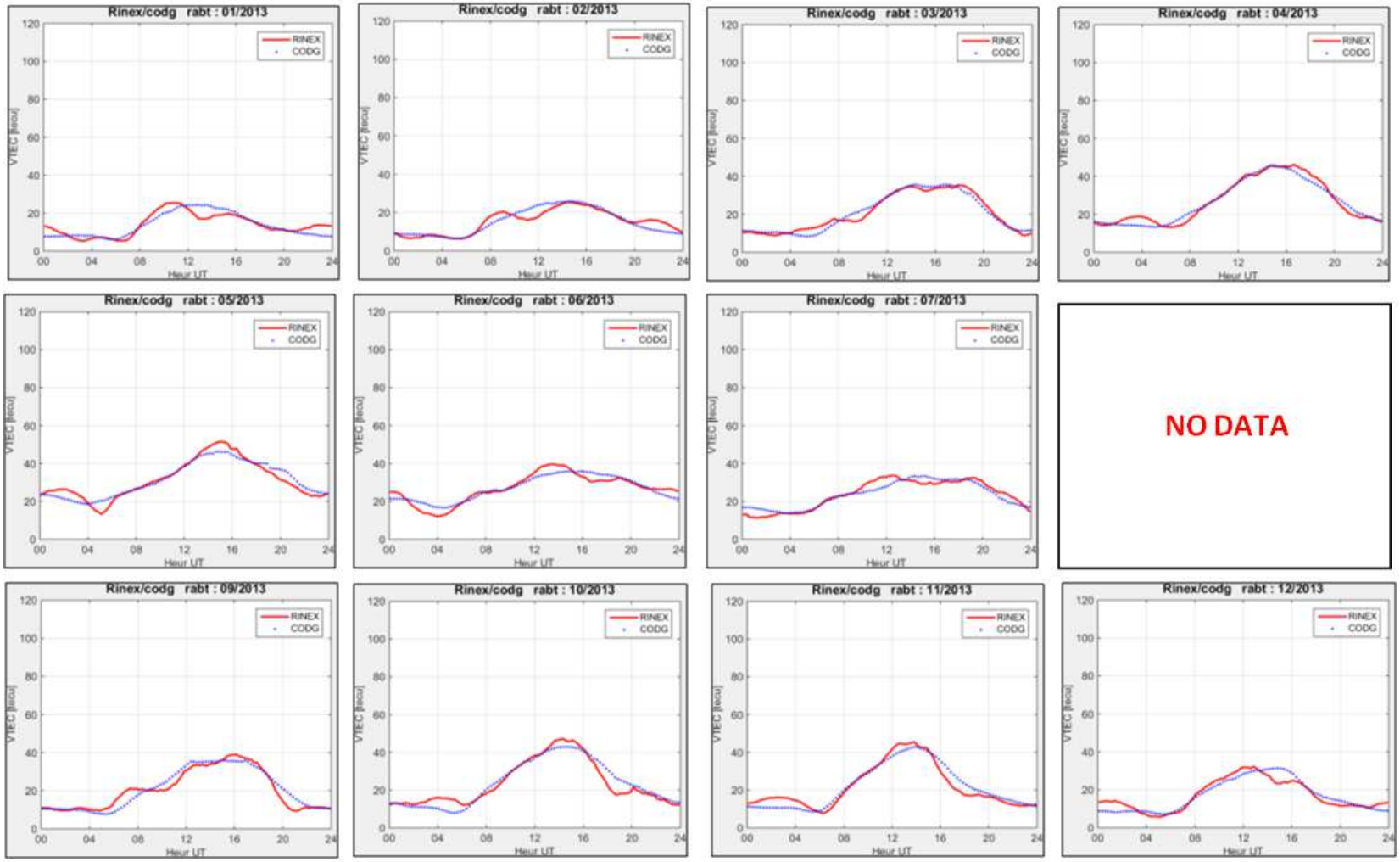


RMSE_GIM = 10 Tecu ; RMSE_ LIM = 4 Tecu

MAX_DIFF = 17 Tecu ; STD_DIFF = 5 Tecu

Comparison LIM & GIM

Rbat - *2013*



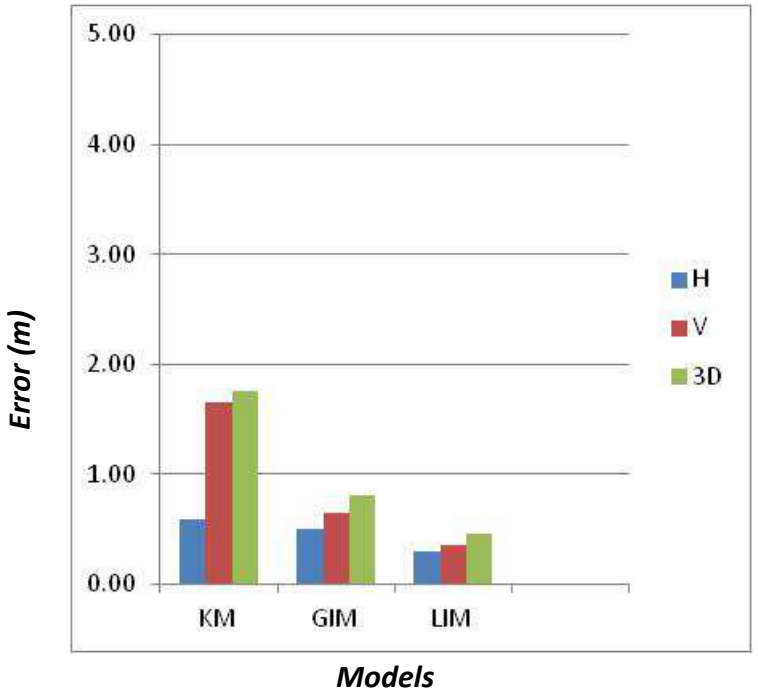
RMSE_GIM = 10 Tecu ; RMSE_ LIM = 4 Tecu

MAX_DIFF = 17 Tecu ; STD_DIFF = 5 Tecu

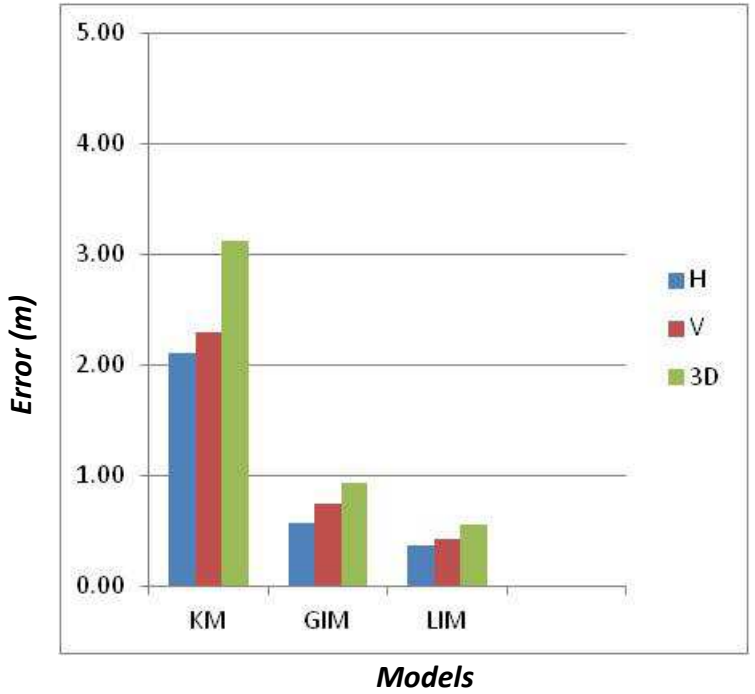
Impact on positioning

	MAR 2015										
DoY	68	69	70	71	72	73	74	75	76	77	78
Kp	8	16	15	11	11	14	19	48	39	30	28
	Source : ftp://ftp.gfz-potsdam.de/pub/home/										

2015_DOY : 68-72

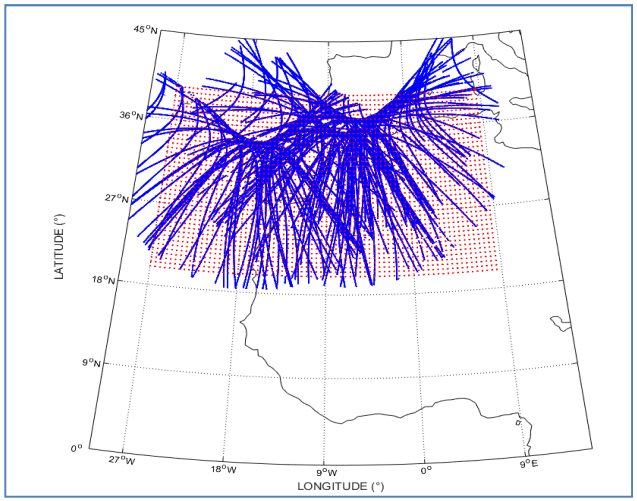


2015_DOY : 75-78

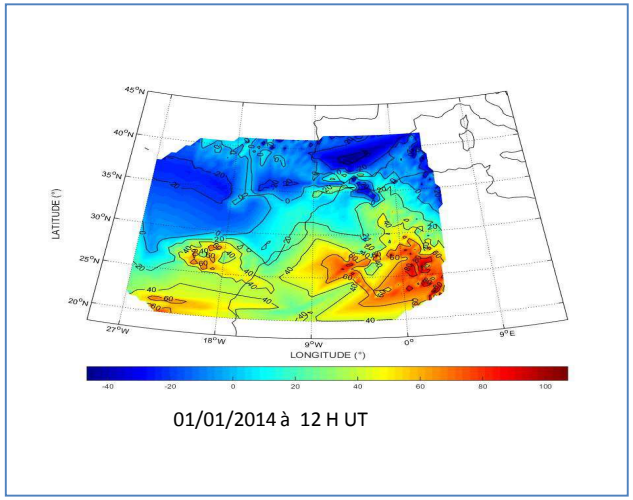


TEC Mapping

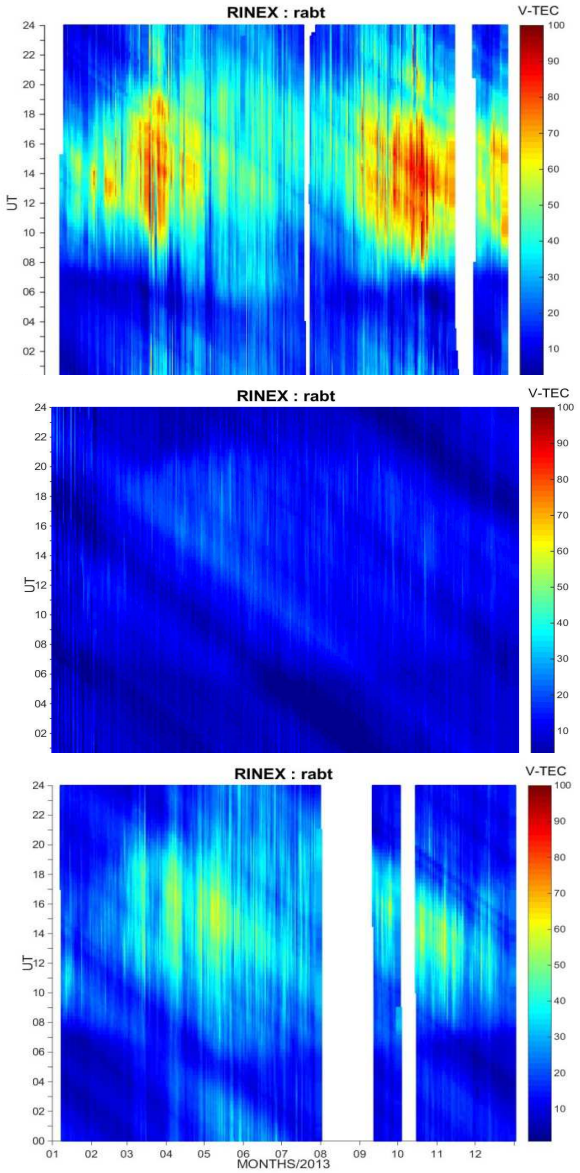
Iono-Pierce Points



VTEC-Map



01/01/2014 à 12 H UT



Conclusion

- Involvement of public administrations in research activities
- Recent Applications : Mapping, Land delimitation, Forestry, Urban Navigation
- Integration of more GNSS Stations to obtain a dense network
- More improvements needed for LIM & Inclusion of more National Permanent Reference Stations
- Experimentations assessment for the integration in Real Time are ongoing

Training on Space weather-GNSS (Craste-LF, Rabat)

- 02/2015
- 01/2017
- 05/2017



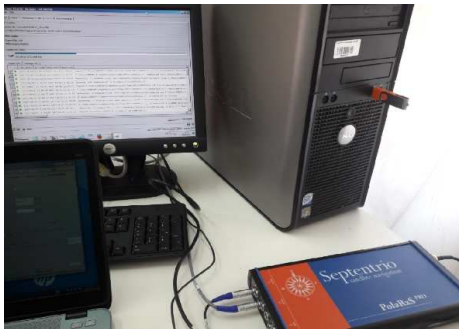



ESGIT - IAV H2

Ultra-low noise GNSS receiver for ionospheric scintillation monitoring installed in Rabat

TELECOM Bretagne

- Following a scientific collaboration agreement between scientific teams of Telecom Bretagne and the Geodesy department of IAV Hassan 2, a GNSS receiver for ionospheric scintillation monitoring was installed in Rabat, may 2017.



- The exploitation and analysis of the data will be done within the framework of a PhD. thesis which will be supervised jointly by the two partners.

Thank you