M-Ingestion: Simultaneous Ingestion of Ionosonde and GNSS Data into the NeQuick Ionospheric Model

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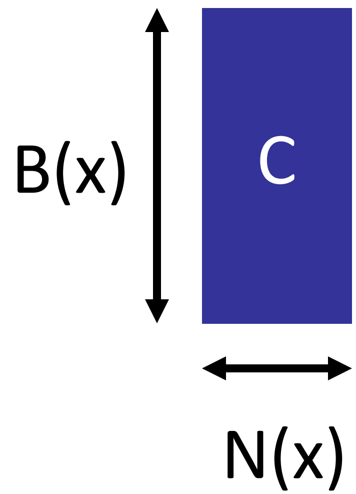
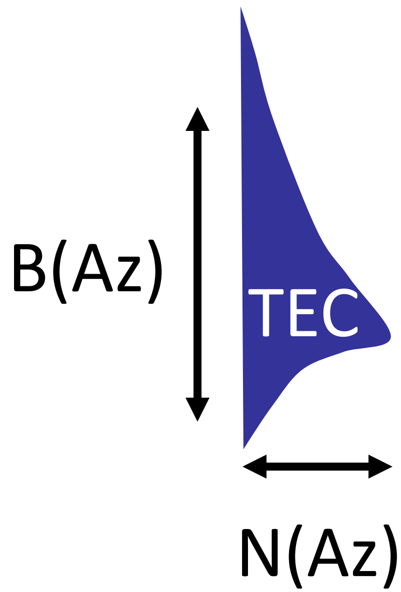
Ionospheric modelling exam June 2010



x ? so that $B(x) * N(x) = C$

Additional constrain: $N(x) = N_0$

M-Ingestion combines reliable F2-peak and vTEC.



Az ? so that

$$\begin{cases} TEC(B(Az),N(Az)) = TEC_0 \\ N(Az) = N_0 \end{cases}$$

- Standard ingestion: one or the other but not both conditions

→ Slab thickness representation?

- Define multiple effective parameters

M-Ingestion combines reliable F2-peak and vTEC.

1. Technique

   NeQuick and (m-)ingestion

2. Experiment

   Mid-latitudes and high solar activity

3. Validation

   foF2 and vTEC at distant stations

1. Technique

2. Experiment

3. Validation

1. Technique

NeQuick is an empirical « profiler ».

ICTP / U Graz / COST 296 and before

- Output = *Ne*

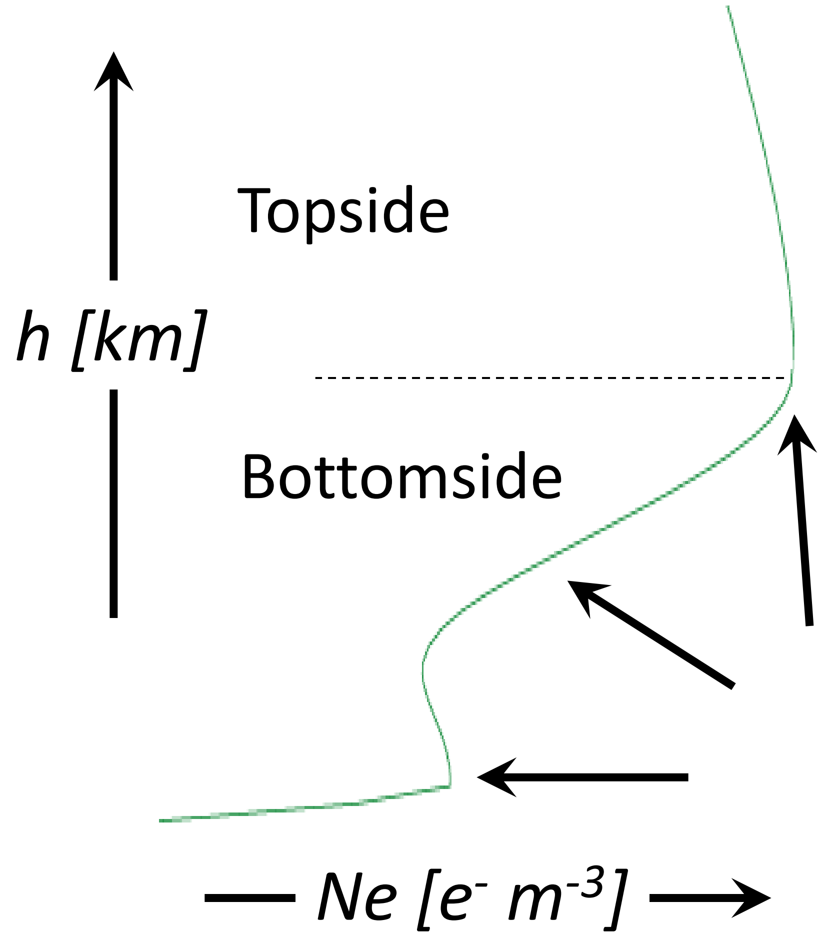
  → *TEC* with integration

- Layer peaks = anchor points

  → monthly median maps

- NeQuick 2 (Nava et al., 2008)

  → topside modification



1. Technique

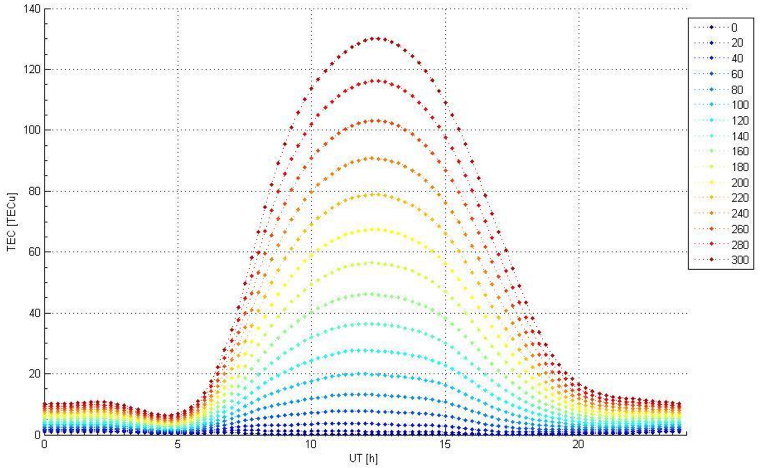
Ingestion is based on effective parameters.

- Solar activity indices = standard input of ionospheric models

→ use of "effective" indices to drive a model towards measured values

- Linear dependence of TEC on solar flux

→ compute Az leading to minimum Root Mean Square slant TEC difference



vTEC (Dourbes – November)

1. Technique

M-Ingestion combines several effective parameters.

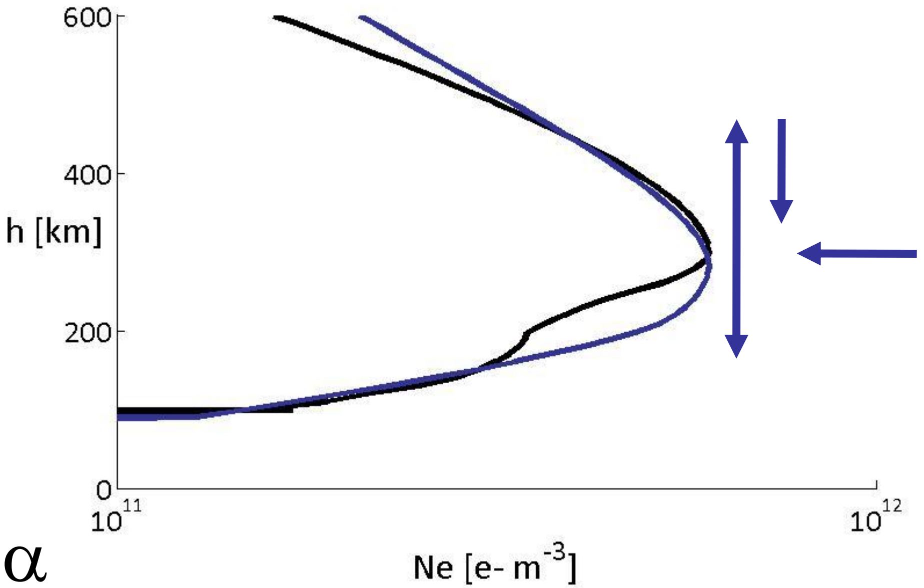
Standard ingestion: good TEC but wrong F2-peak

→ Constrain peak using

1 Az for foF2

and 1 Az for M(3000)F2

→ Modify thickness using a modulating factor α to adapt to sTEC



1. Technique

2. Experiment

3. Validation

2. Experiment

We apply m-ingestion at mid-latitudes and high solar activity.

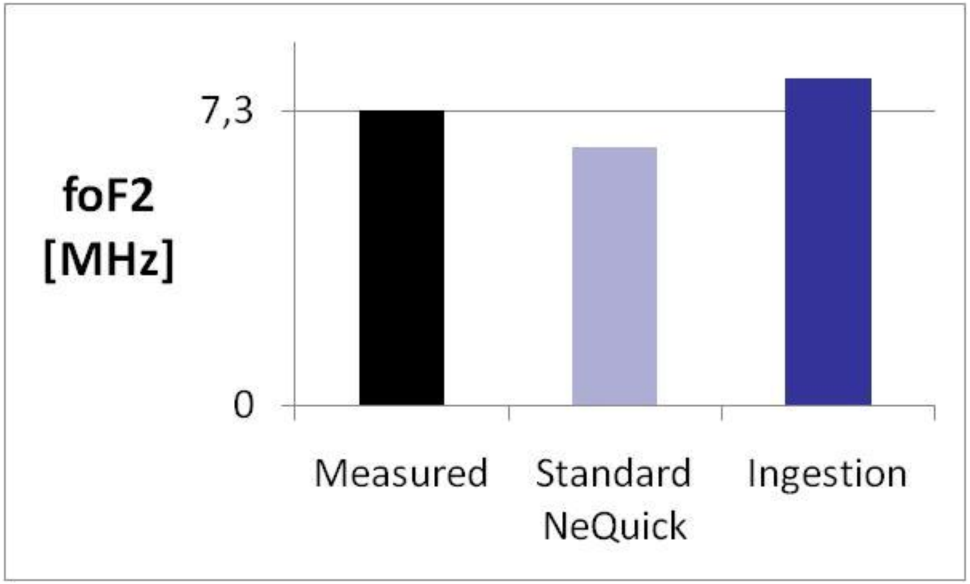
- Compute hourly effective parameters
- Co-located digisonde and EUREF station at Dourbes (B)
- Year 2002
- Two basis data types
  - Manually validated ionosonde data
  - Slant TEC from GIM levelling (Orus et al., 2007)

→ Difference between measured and modelled values for different techniques?

2. Experiment

Ingestion leads to foF2 overestimation.

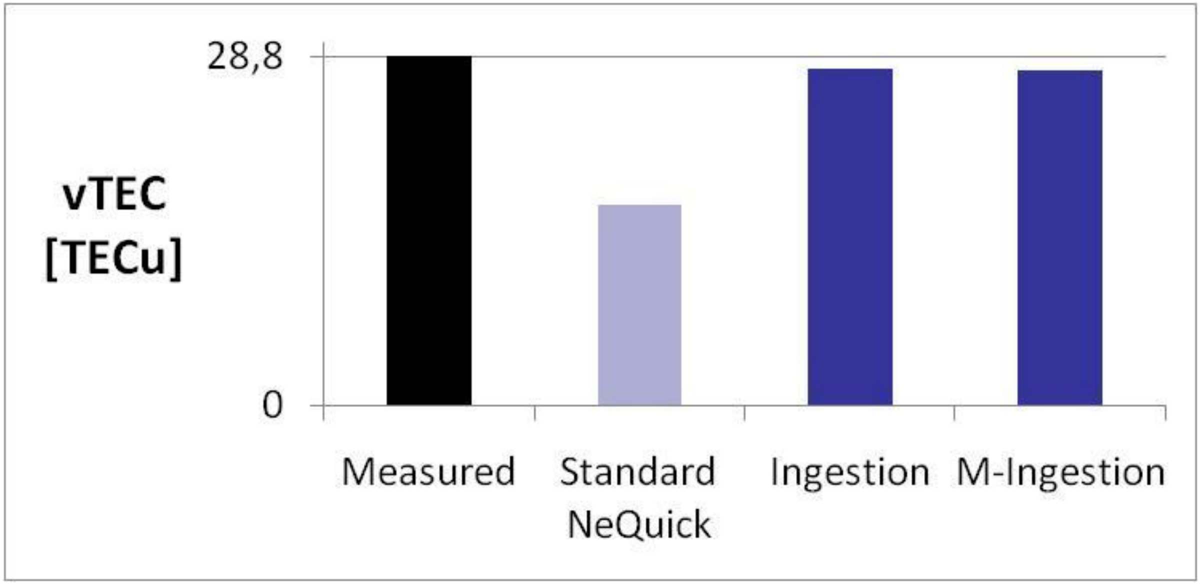
Yearly foF2 mean



- 13% underestimation for standard use
- TEC adaptation → 10% overestimation for ingestion

vTEC remains slightly underestimated with (m-)ingestion.

Yearly vertical TEC mean

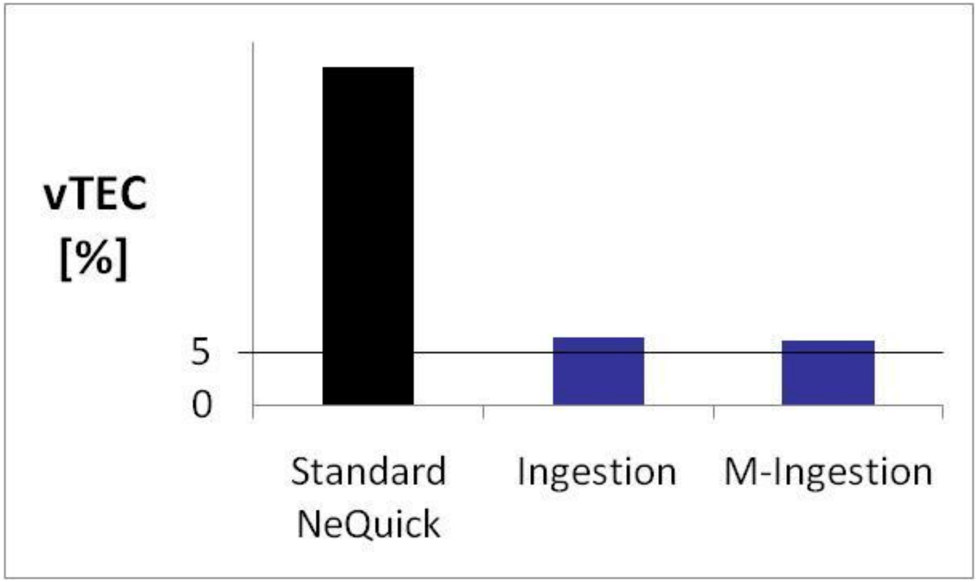


- 43% underestimation for standard use
  → origin of foF2 overestimation for ingestion
- 4% underestimation for (m-)ingestion → self-consistency

2. Experiment

(M-)Ingestion is self-consistent.

Yearly relative vertical TEC standard deviation



- 33% dispersion for standard use
- 6% dispersion for (m-)ingestion

1. Technique

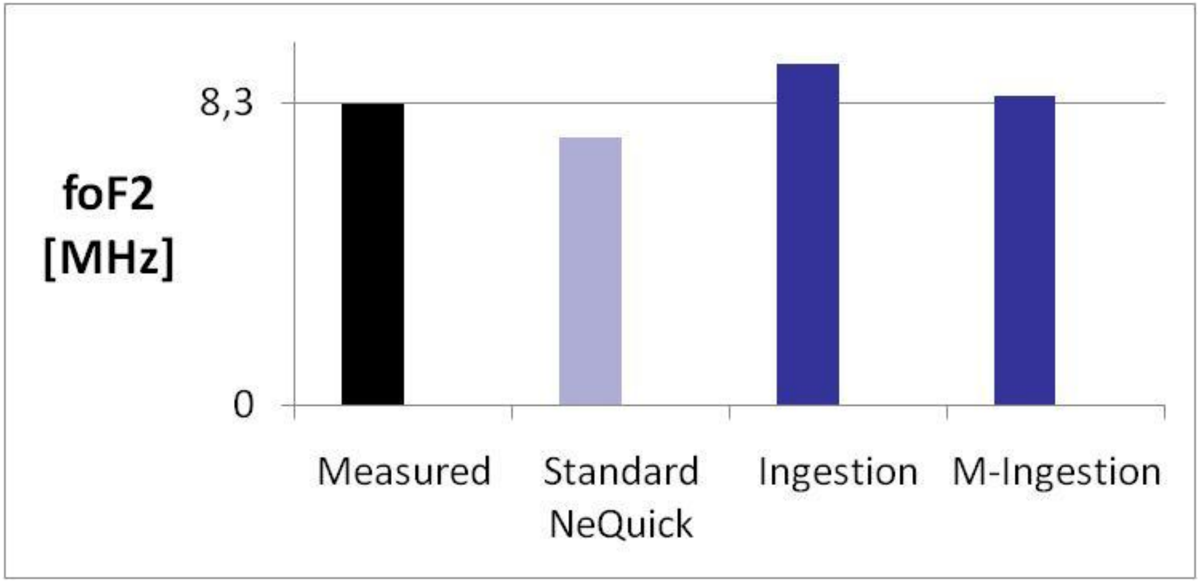
2. Experiment

3. Validation

3. Validation

Using the effective parameters at a distant station: Roquetes leads to foF2 overestimation.

Yearly foF2 mean



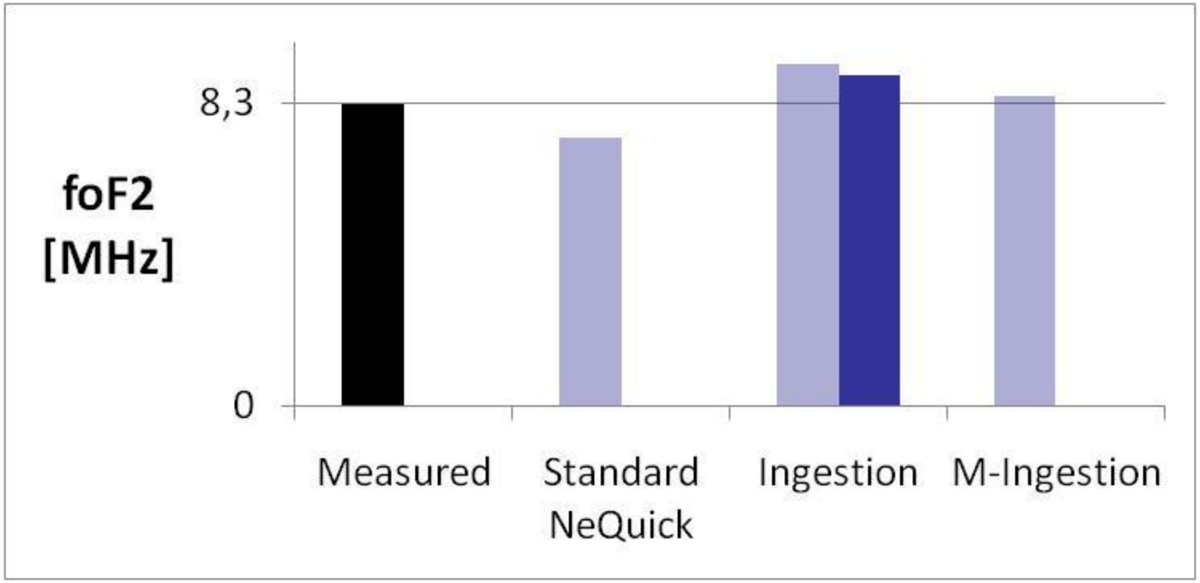
- 11% underestimation for standard use
- 13% and 2% overestimation for ingestion and m-ingestion

→ m-ingestion justified for foF2

3. Validation

Using the effective parameters southwards leads to foF2 overestimation.

Yearly foF2 mean

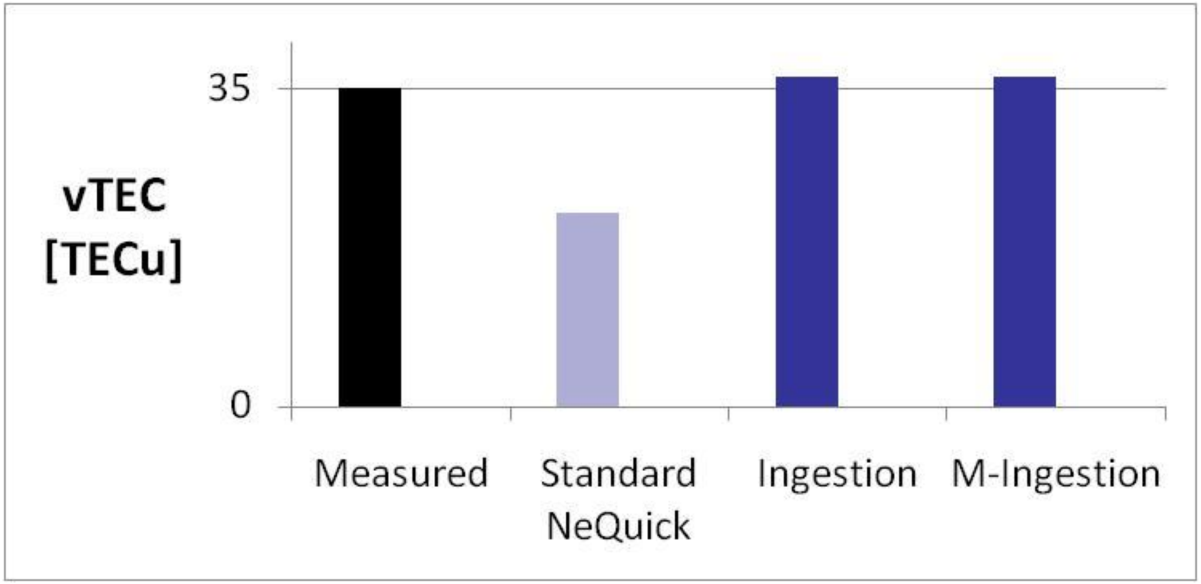


Smaller overestimation (9%) for local ingestion because smaller effective parameters towards the equator

3. Validation

Using the effective parameters southwards leads to vTEC overestimation.

Yearly vertical TEC mean



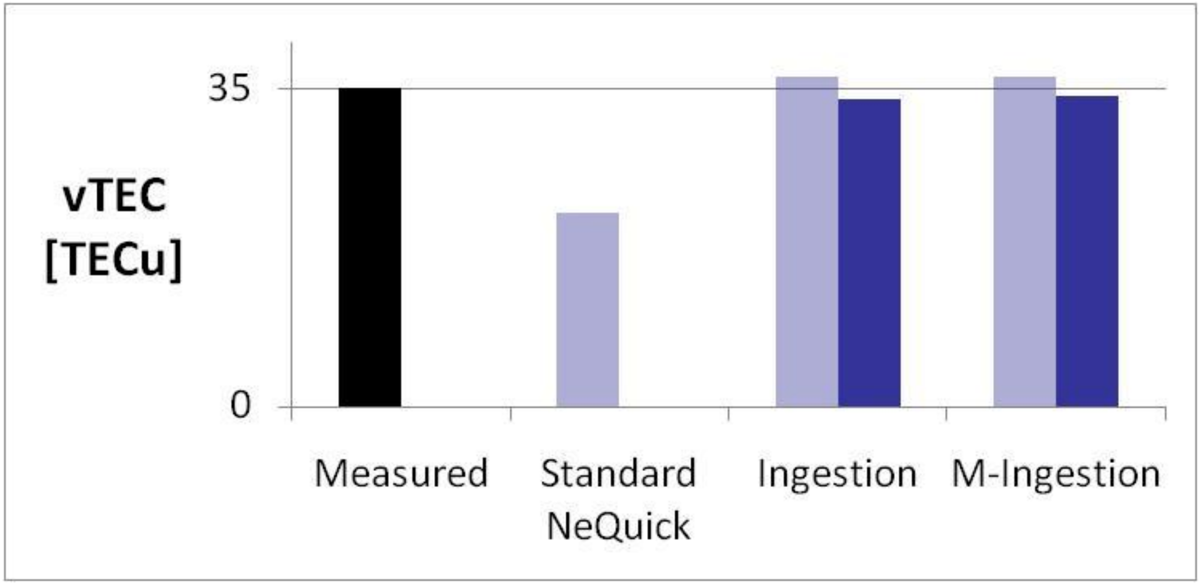
- 39% underestimation for standard use
- 3% overestimation for ingestion and m-ingestion

→ m-ingestion justified for vTEC

3. Validation

Using the effective parameters southwards leads to vTEC overestimation.

Yearly vertical TEC mean

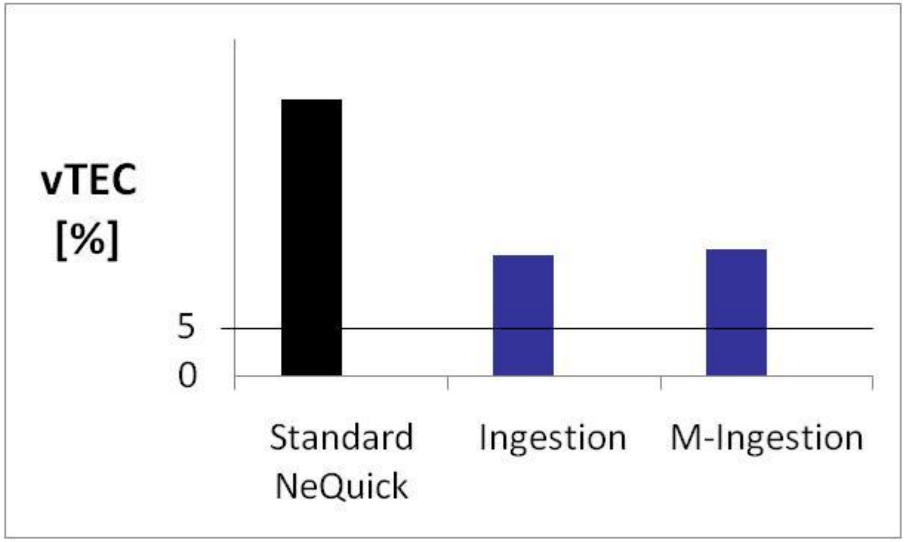


Small underestimation (3-4%) for local (m-)ingestion because smaller effective parameters towards the equator

3. Validation

Using the effective parameters at a distant station provides reliable vTEC.

Yearly relative vertical TEC standard deviation



- 29% dispersion for standard use
- 13% dispersion for (m-)ingestion

→ (m-)ingestion validated

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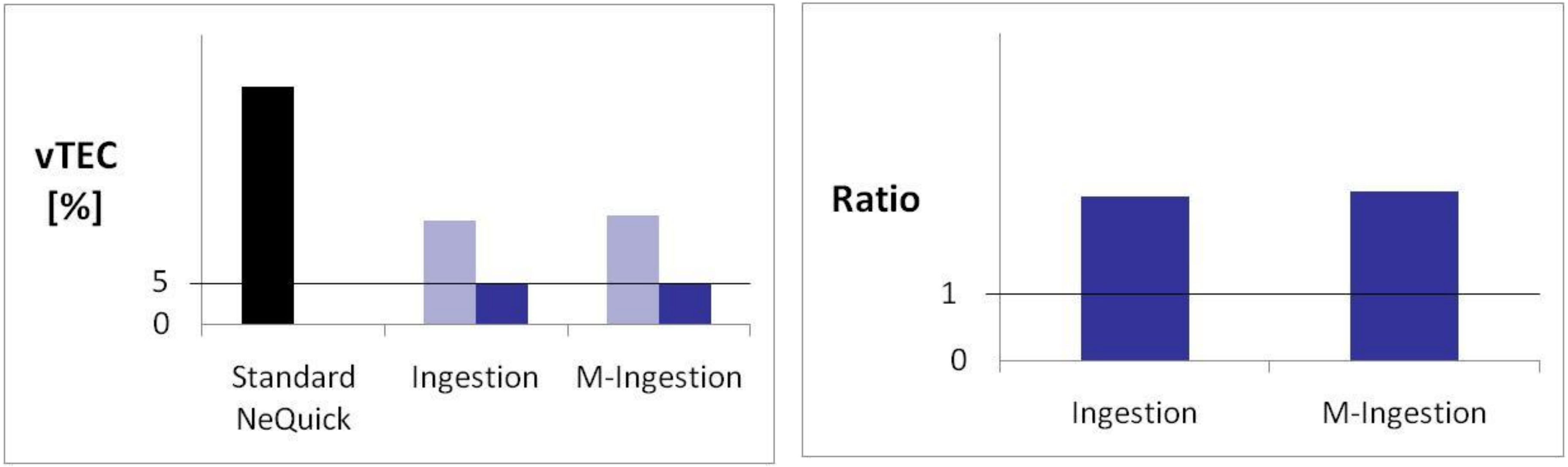
Using the effective parameters at a distant station provides reliable vTEC.

Yearly relative vertical TEC standard deviation

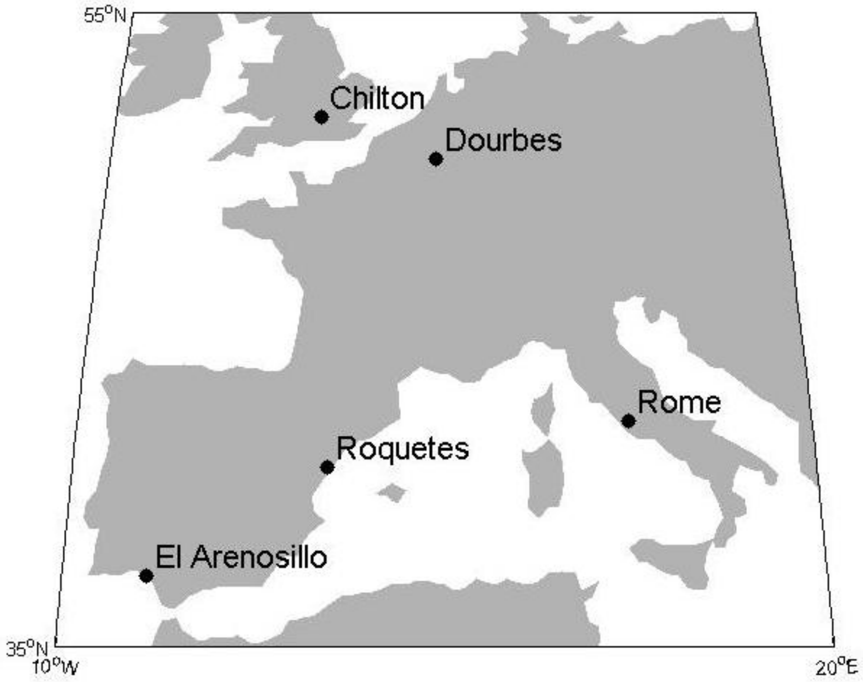


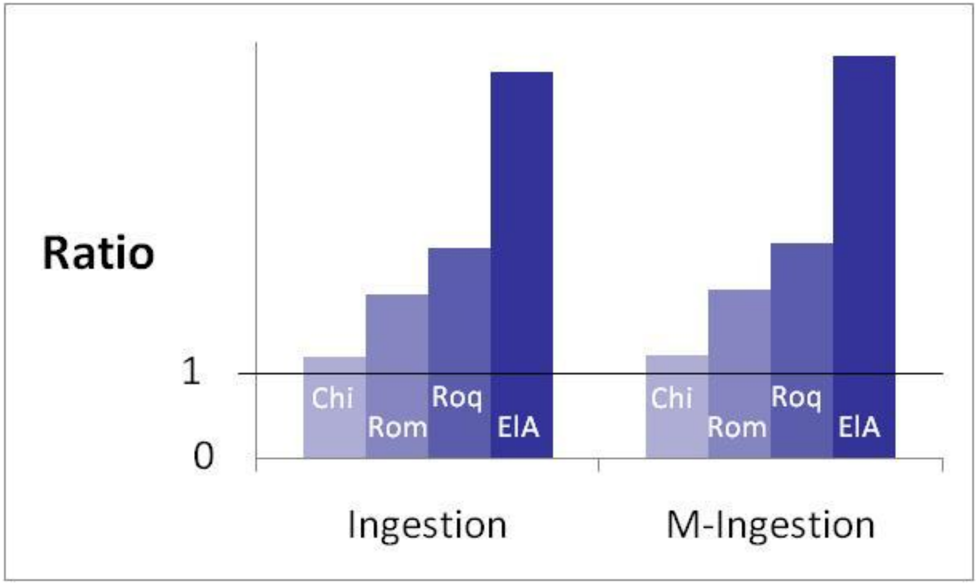
5% dispersion for local (m-)ingestion

→ optimum to which compare

→ ratio of 2.5

vTEC reliability depends on distance?





- Minimum for Chilton (400km) ~ 1
- Maximum for El Arenosillo (1700km) ~ 5

M-Ingestion combines reliable F2-peak and vTEC.

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M-Ingestion combines reliable F2-peak and vTEC.

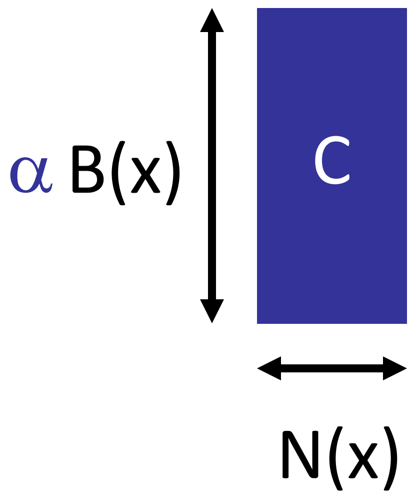
- Optimisation procedure involving NeQuick model, ionosonde and GNSS sTEC data
- Reliable representation of foF2 and vTEC around the ingestion location

  → reliable slab thickness
- Depending on distance
- Other ingestion schemes:

  ex daily instead of hourly
- Other parameters:

  ex slant TEC difference distribution

Ionospheric modelling exam June 2010



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Additional constrain: $N(x) = N_0$

→ Additional parameter α

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  - ICTP (model)
  - INTA, Observatori de l'Ebre, RMI, UMLCAR, UKSSDC (ionosonde data)
  - ESA/ESTEC (GPS TEC data)

- More on http://orbi.ulg.ac.be/handle/40738