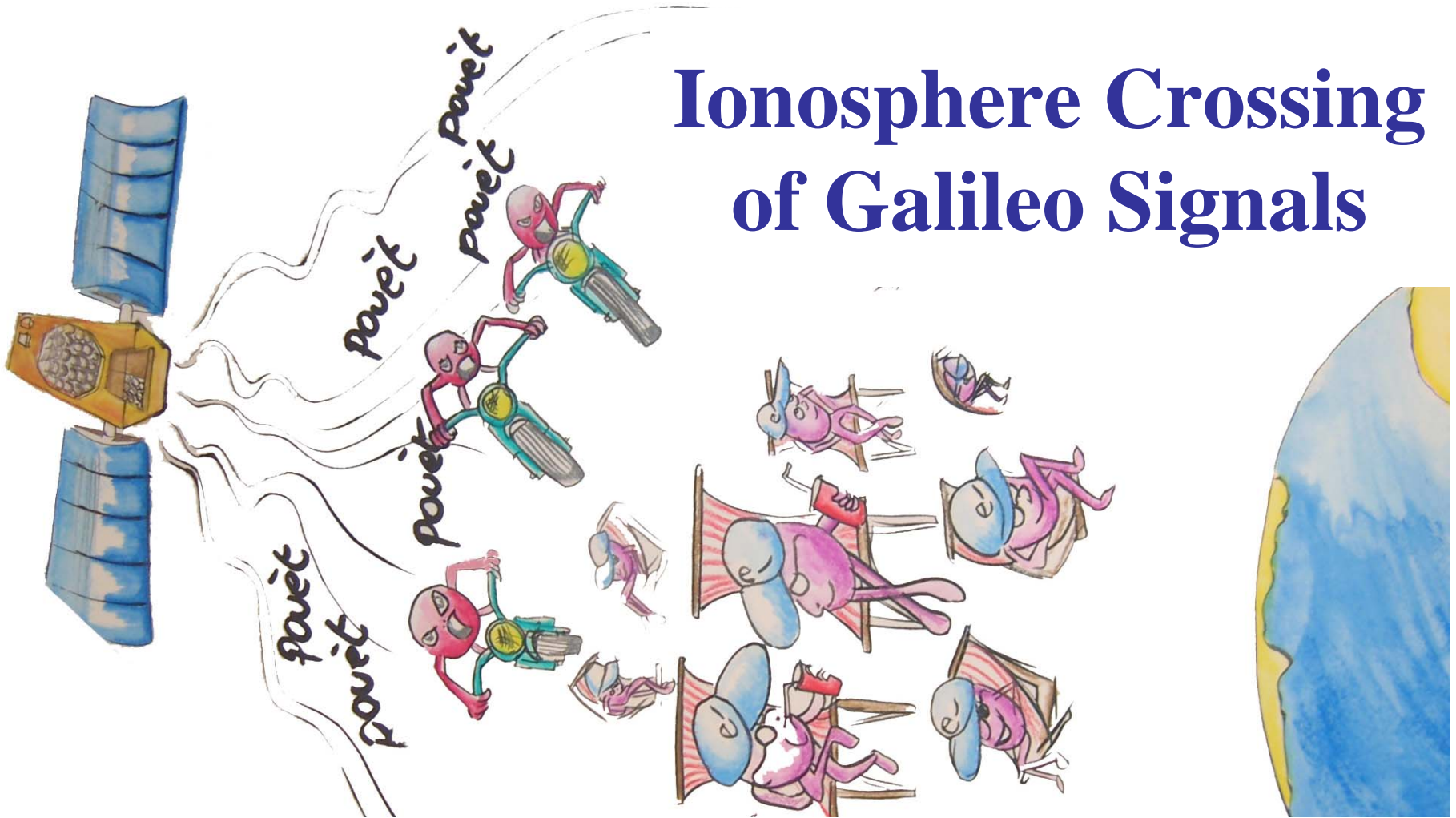
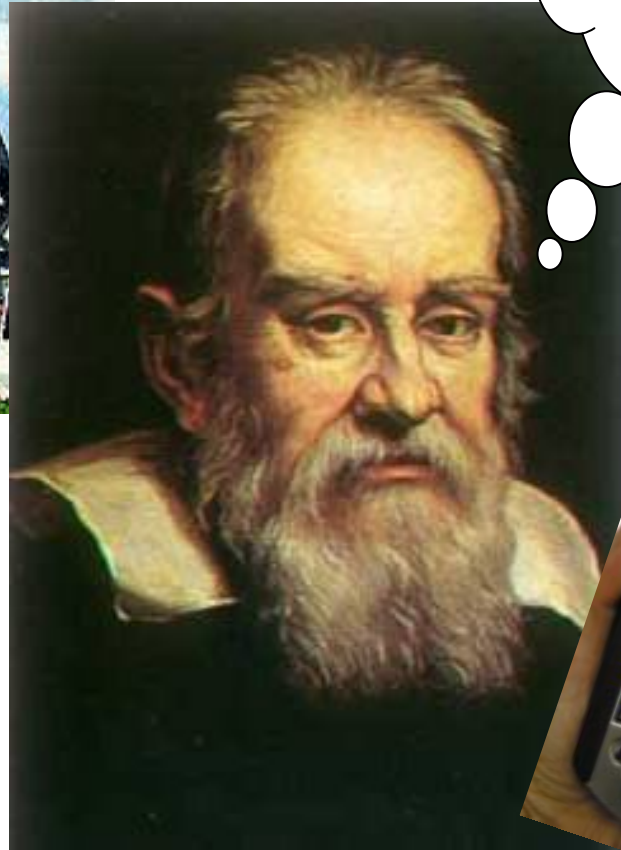
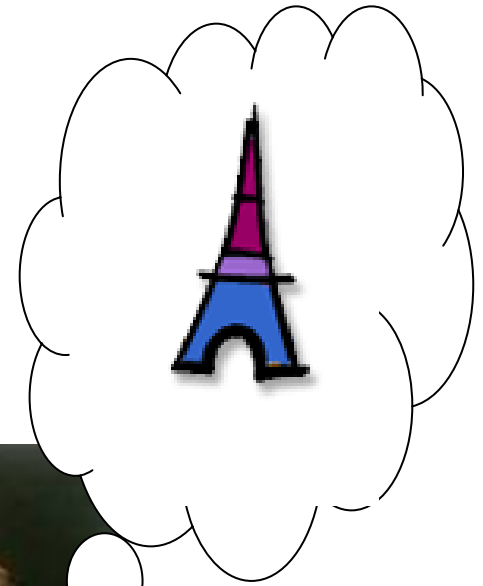
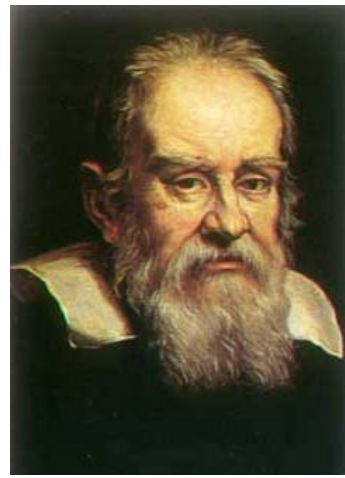


# Ionosphere Crossing of Galileo Signals



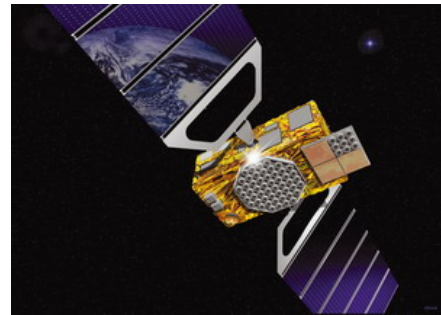




- “Please minimize the positioning error!”



- “We think we could help you for ionospheric delay!”



# 1. Navigation

*Where does positioning error come from?*

# 2. Ionosphere?

# 3. Modelling

# 4. Analysis

# 5. Tests

# 1. Navigation

*Where does positioning error come from?*

# 2. Ionosphere?

*What does ionosphere look like?*

# 3. Modelling

# 4. Analysis

# 5. Tests

# 1. Navigation

*Where does positioning error come from?*

# 2. Ionosphere?

*What does ionosphere look like?*

# 3. Modelling

*How is it modelled?*

# 4. Analysis

# 5. Tests

# 1. Navigation

*Where does positioning error come from?*

# 2. Ionosphere?

*What does ionosphere look like?*

# 3. Modelling

*How is it modelled?*

# 4. Analysis

*Let's assess NeQuick!*

# 5. Tests

# 1. Navigation

*Where does positioning error come from?*

# 2. Ionosphere?

*What does ionosphere look like?*

# 3. Modelling

*How is it modelled?*

# 4. Analysis

*Let's assess NeQuick!*

# 5. Tests

*A little drawing is better than a long speech...*



1. Navigation

2. Ionosphere?

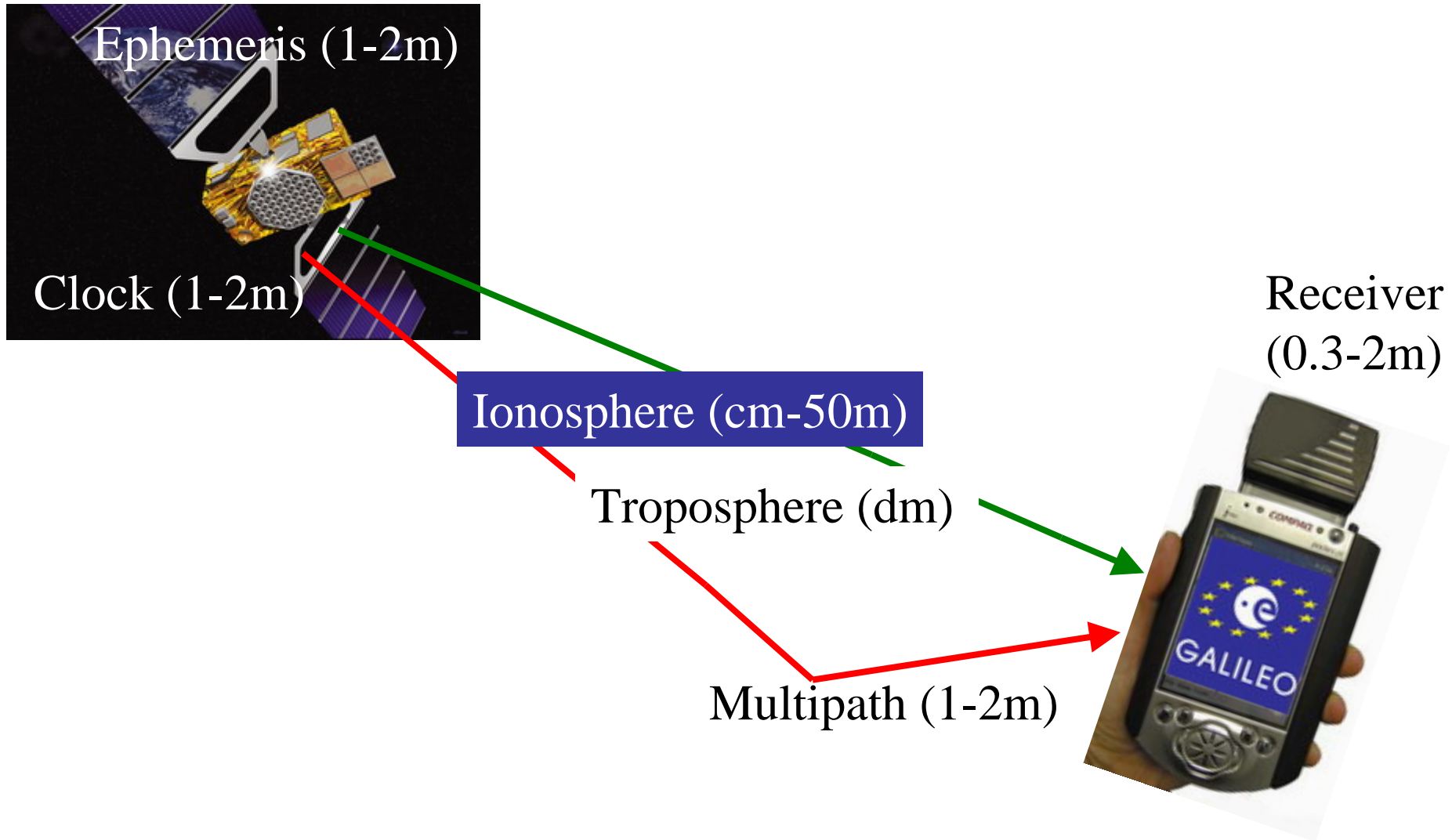
3. Modelling

4. Analysis

5. Tests

# 1. Navigation

Positioning error comes from systems and atmospheric issues...



## 1. Navigation

...and is calculated on the basis of range errors.

- Position accuracy = DOP \* UERE
- Iono delay =  $40.3 * \text{TEC} / f^2$

TEC  $\rightarrow$  1 TECu =  $10^{16}$  el. m<sup>-2</sup>  $\sim$  0.16 m (L1)

f  $\rightarrow$  need of model only for single frequency users

1. Navigation

2. Ionosphere?

3. Modelling

4. Analysis

5. Tests

## 2. Ionosphere?

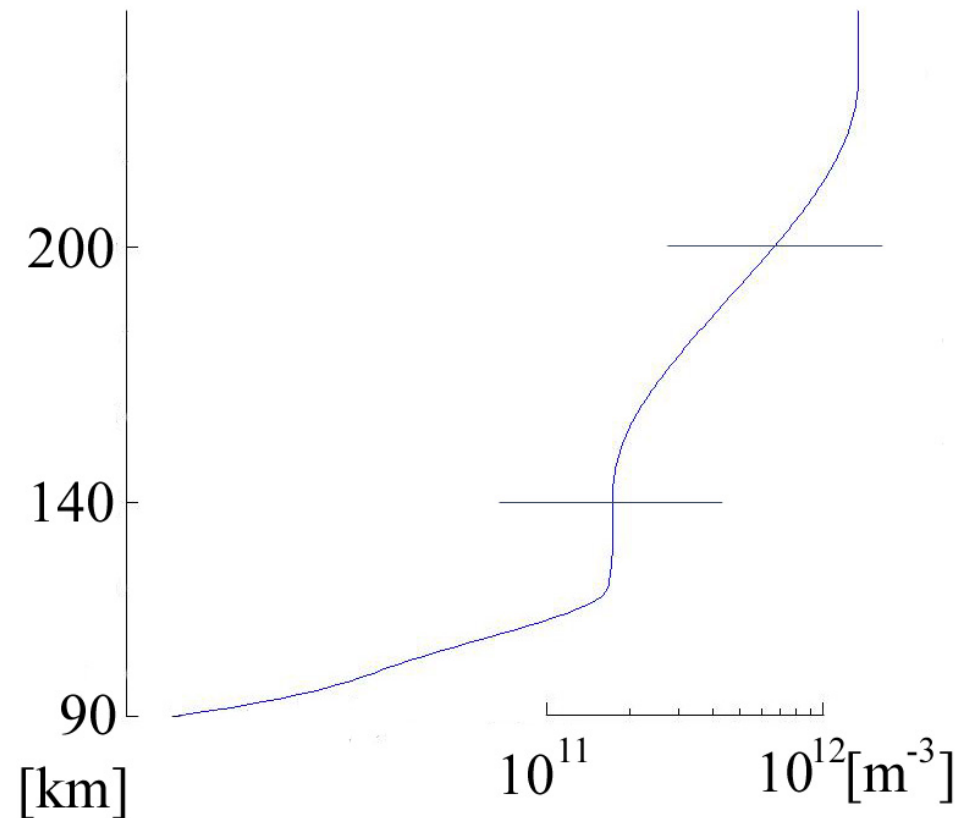
# Atmosphere is ionized by sun radiations...

- Electrically **charged** part / dispersive

- F2

- F1

- E

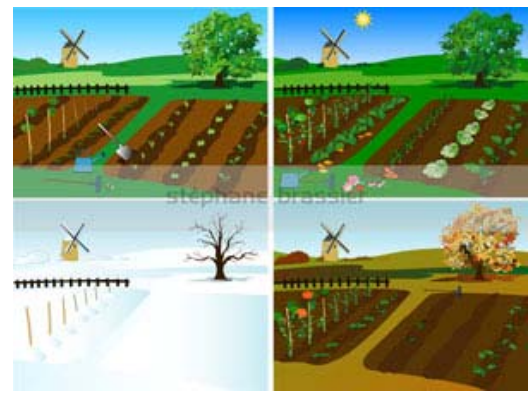


## 2. Ionosphere?

...which influence varies according to different parameters.



→ lat, long



→ mth



→ F10.7/R



→ UT

1. Navigation

2. Ionosphere?

3. Modelling

4. Analysis

5. Tests

# The model chosen for Galileo is called NeQuick...

- « Profiler » → E, F1 and F2 peaks = anchor points
- Input = ionospheric variables
- Output = electron density



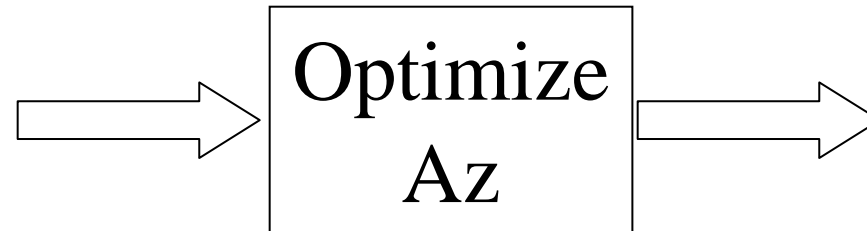
### 3. Modelling

...and is due to be used in a daily effective way.

- Monthly flux replaced by **daily** parameter ( $Az$ )



Measure  
sTEC



Run  
NeQuick

1. Navigation

2. Ionosphere?

3. Modelling

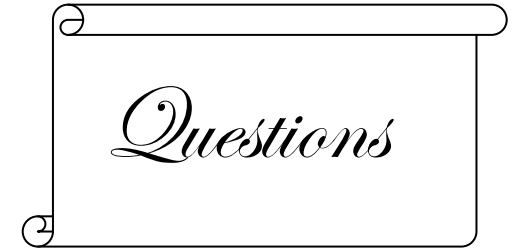
4. Analysis

5. Tests

## 4. Analysis

# How to use NeQuick for Galileo single-frequency receivers?

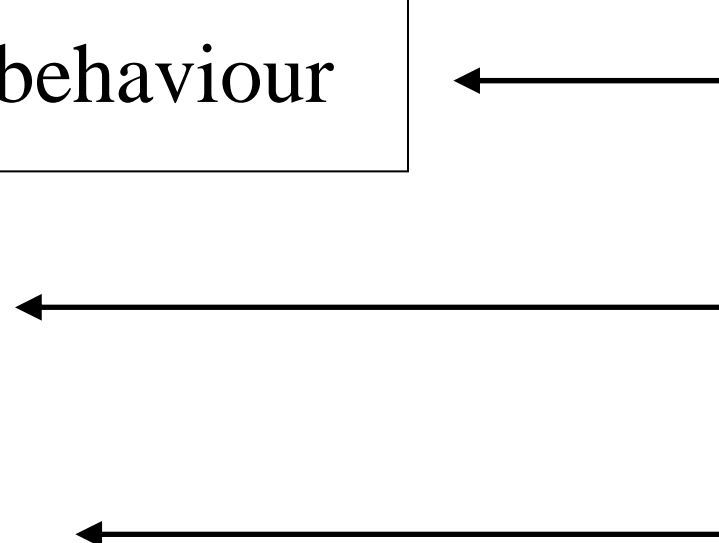
- Understand NeQuick →



- Improve physical behaviour

- Effective use

- Implementation



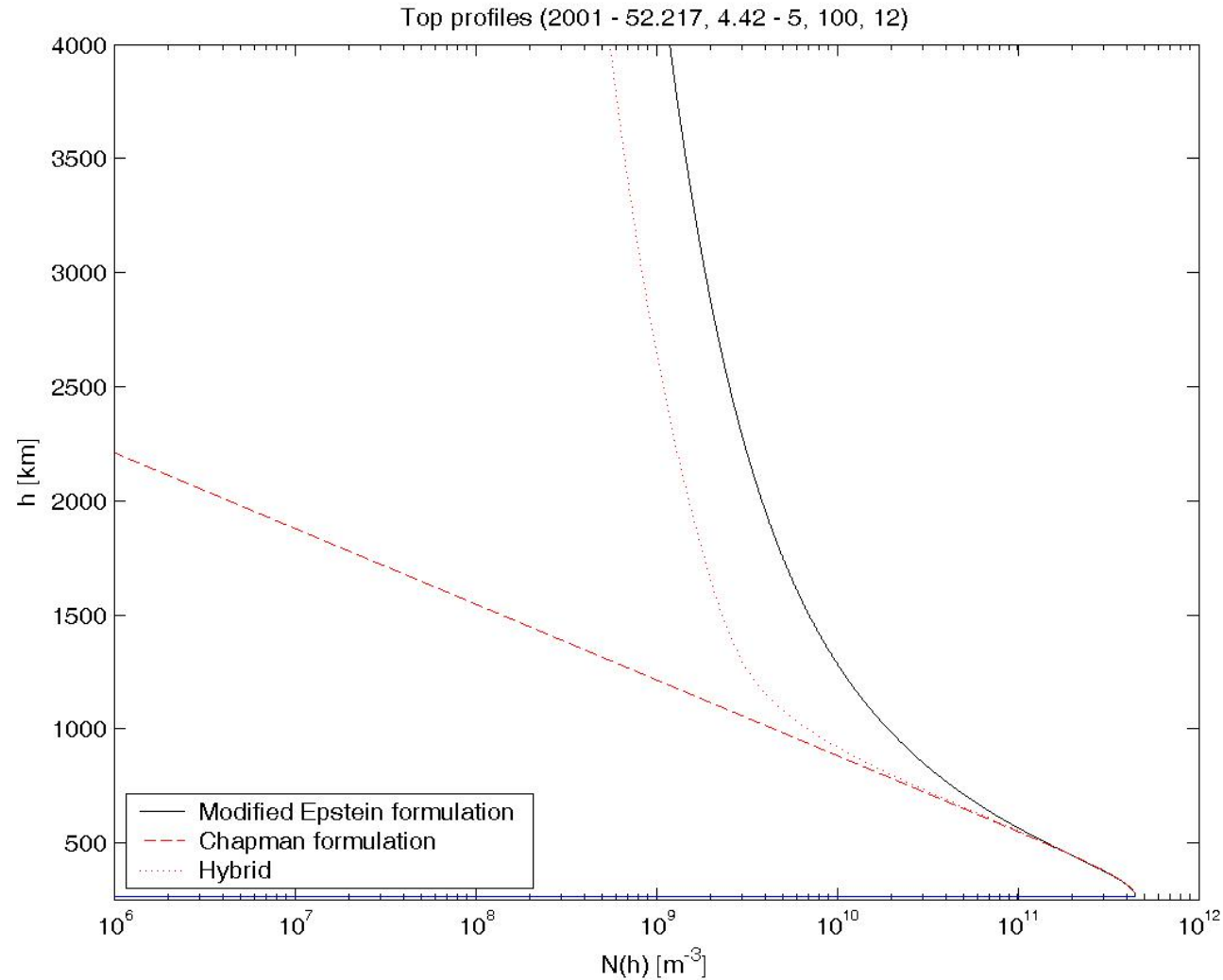
## 4. Analysis

Physical related issues change between different versions...

- 2001: ITU-R baseline (v1)
- 2002: basic and intermediate parameters
- 2005a: topside (k parameter)
- 2005b: new files (v2)

## 4. Analysis

...and are currently studied.



- ↗
- ↗
- ↗
- ]



1. Navigation

2. Ionosphere?

3. Modelling

4. Analysis

5. Tests

## 5. Tests

# How could we investigate...



- FORTRAN drivers using NeQuick
- Matlab GUI

# 5. Tests

# ...profiles?

The screenshot shows the NeQuick software interface. The main window is titled "NeQuick" and has a menu bar with "NeQuick model", "Tools", "Electron densities", "Profiles", "vTEC analysis", "sTEC analysis", "Flux", and "Quit". A secondary window titled "NeQuick\_profiles" is open, showing the "Electron density profiles" interface. This window has a menu bar with "Manage", "Instructions", "Close figures", and "Quit".

The "Electron density profiles" window is divided into several sections:

- Comparisons between versions:** Includes an "Input" section with fields for Latitude (52.217), Longitude (4.42), Month (May), Flux (100), and UT (12). Below this are three sections: "One version" (Version: 2001), "Two versions" (Version 1: 2001, Version 2: 2006), and "More versions" (Versions: All). Each section has a "Plot" button.
- Bottom layers:** A section with a "Version" dropdown set to 2001 and a "Plot" button.
- Topside profiles:** A section with a "Version" dropdown set to 2001 and a "Plot" button.
- Height:** A section with "Minimum" (60), "Maximum" (1000), and "Step" (1) fields.
- Comparison for one version:** A section with a "Version" dropdown set to 2001 and a "Number of situations" dropdown set to 5. Below this is a table of five situations:

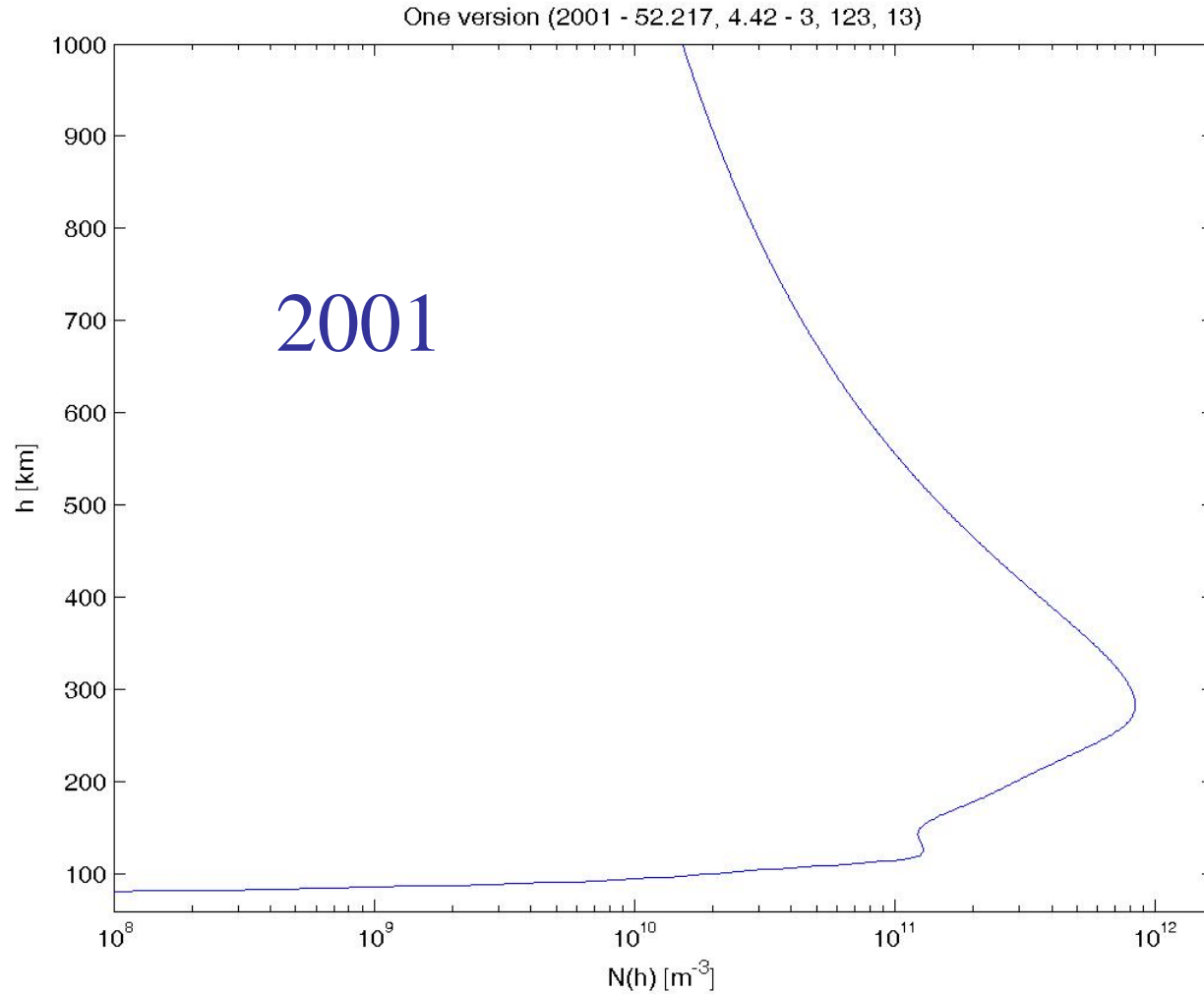
	Latitude	Longitude	Month	Flux	UT
Situation 1	-60	0	May	100	12
Situation 2	-30	0	May	100	12
Situation 3	0	0	May	100	12
Situation 4	30	0	May	100	12
Situation 5	60	0	May	100	12

At the bottom of the "Comparison for one version" section is a "Plot" button.



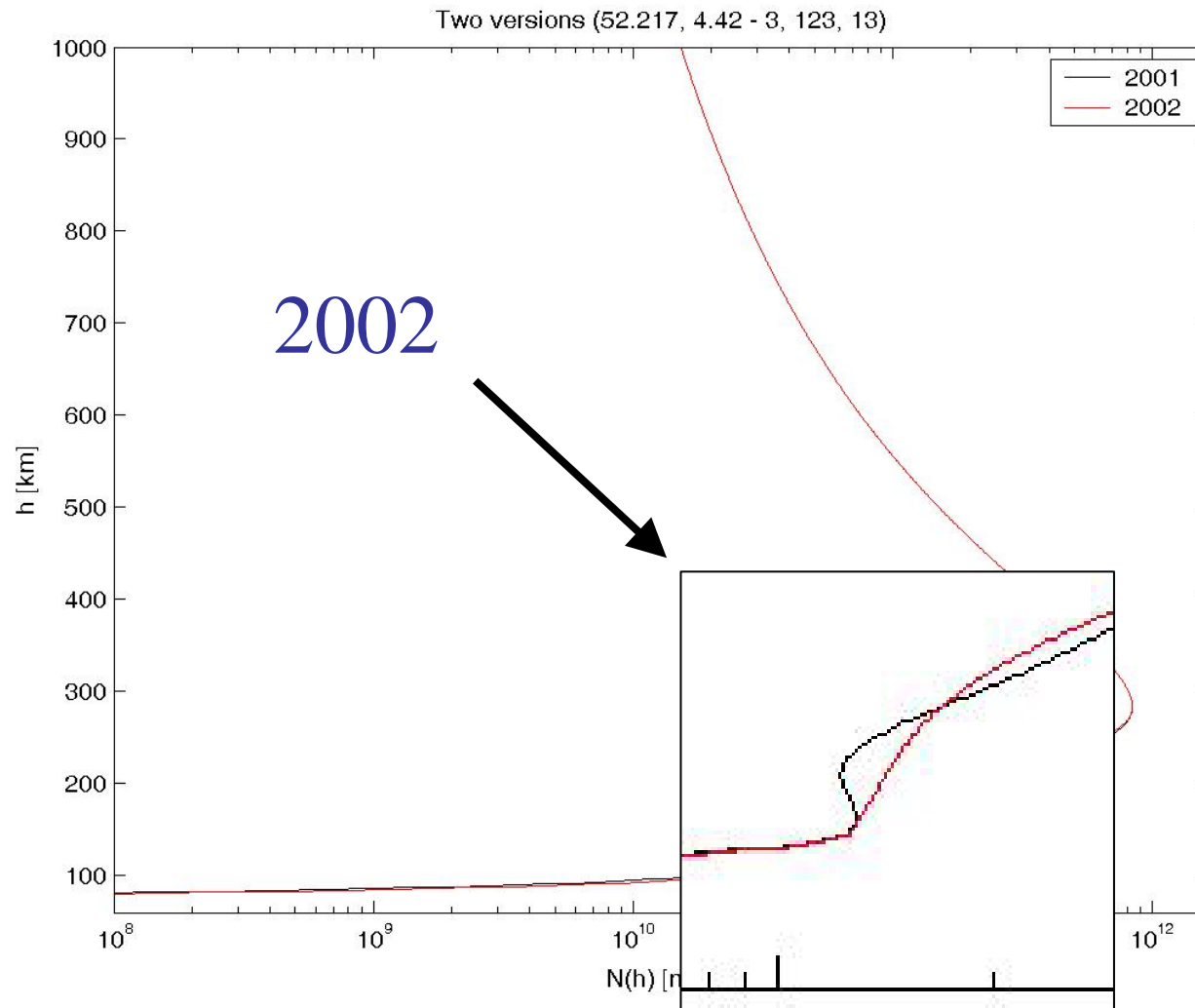
# 5. Tests

# ...profiles?



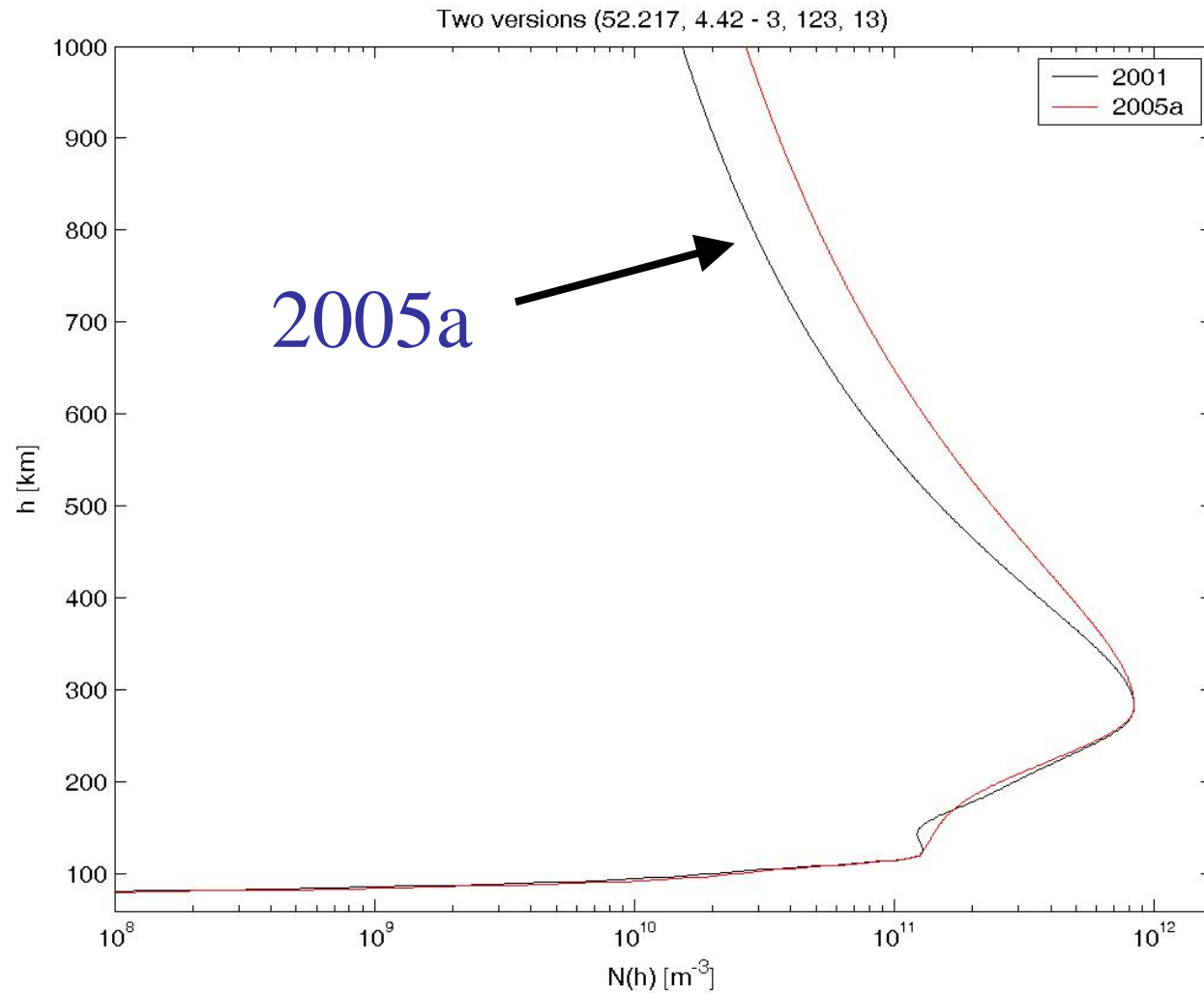
# 5. Tests

# ...profiles?



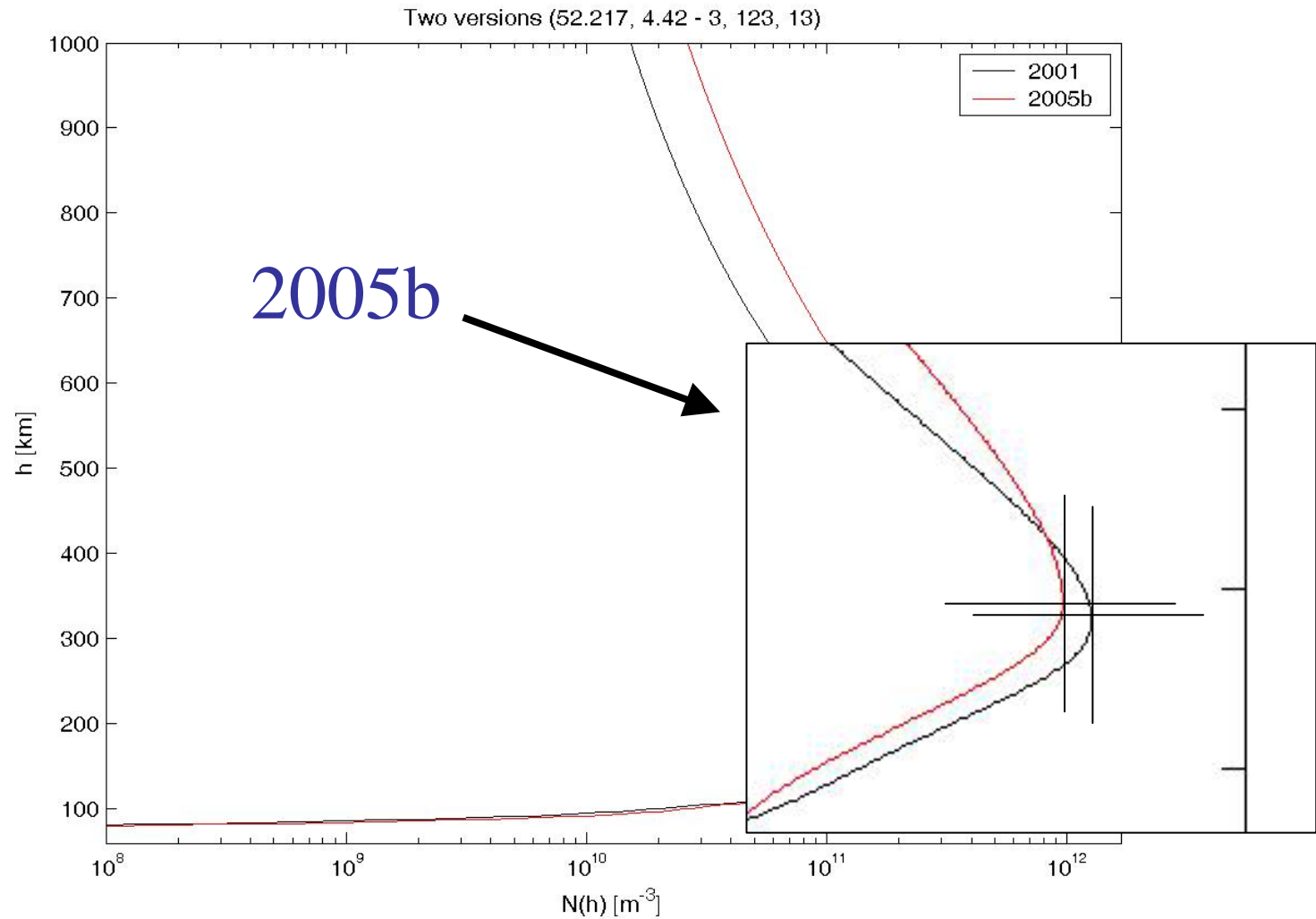
# 5. Tests

# ...profiles?



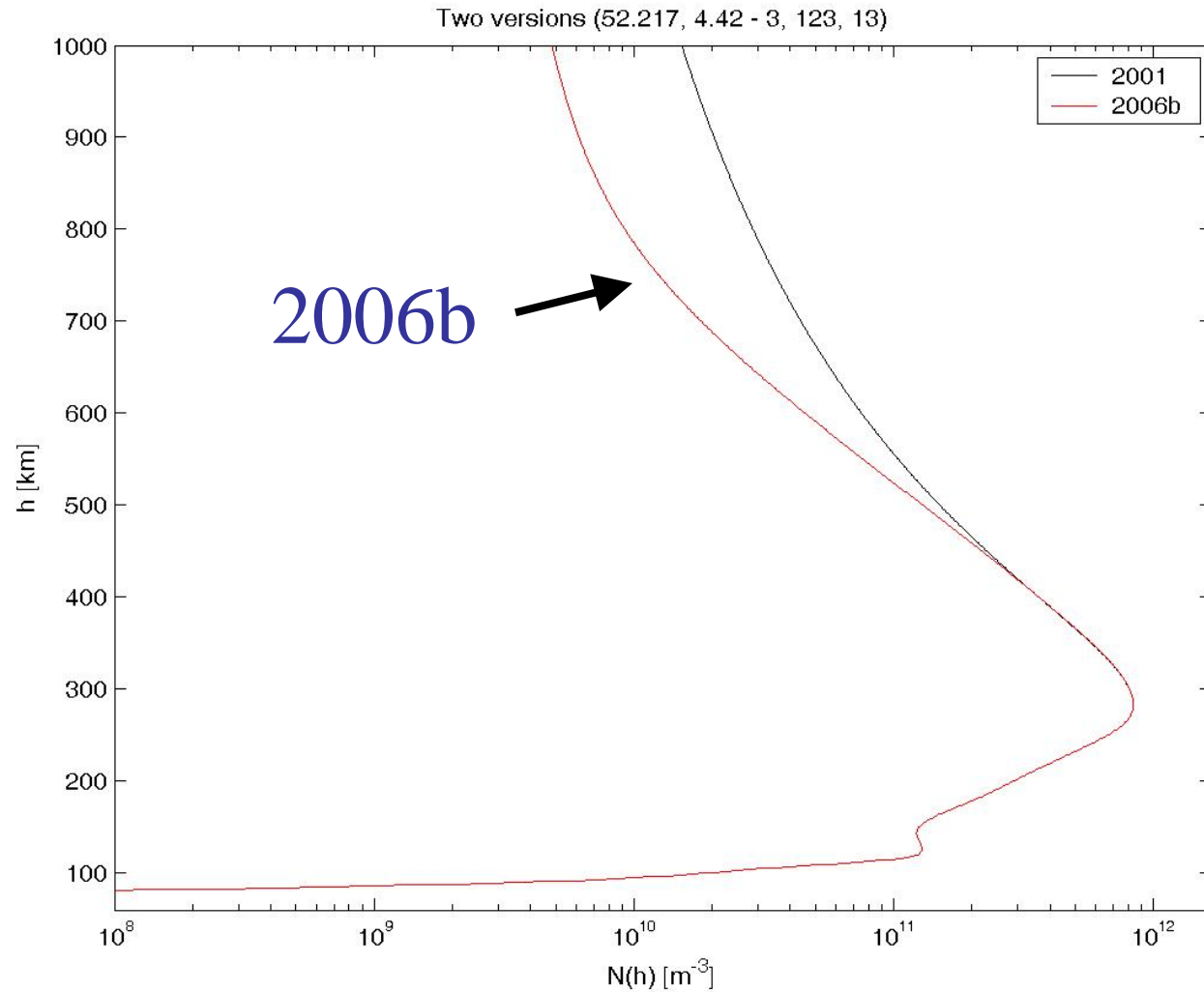
# 5. Tests

# ...profiles?



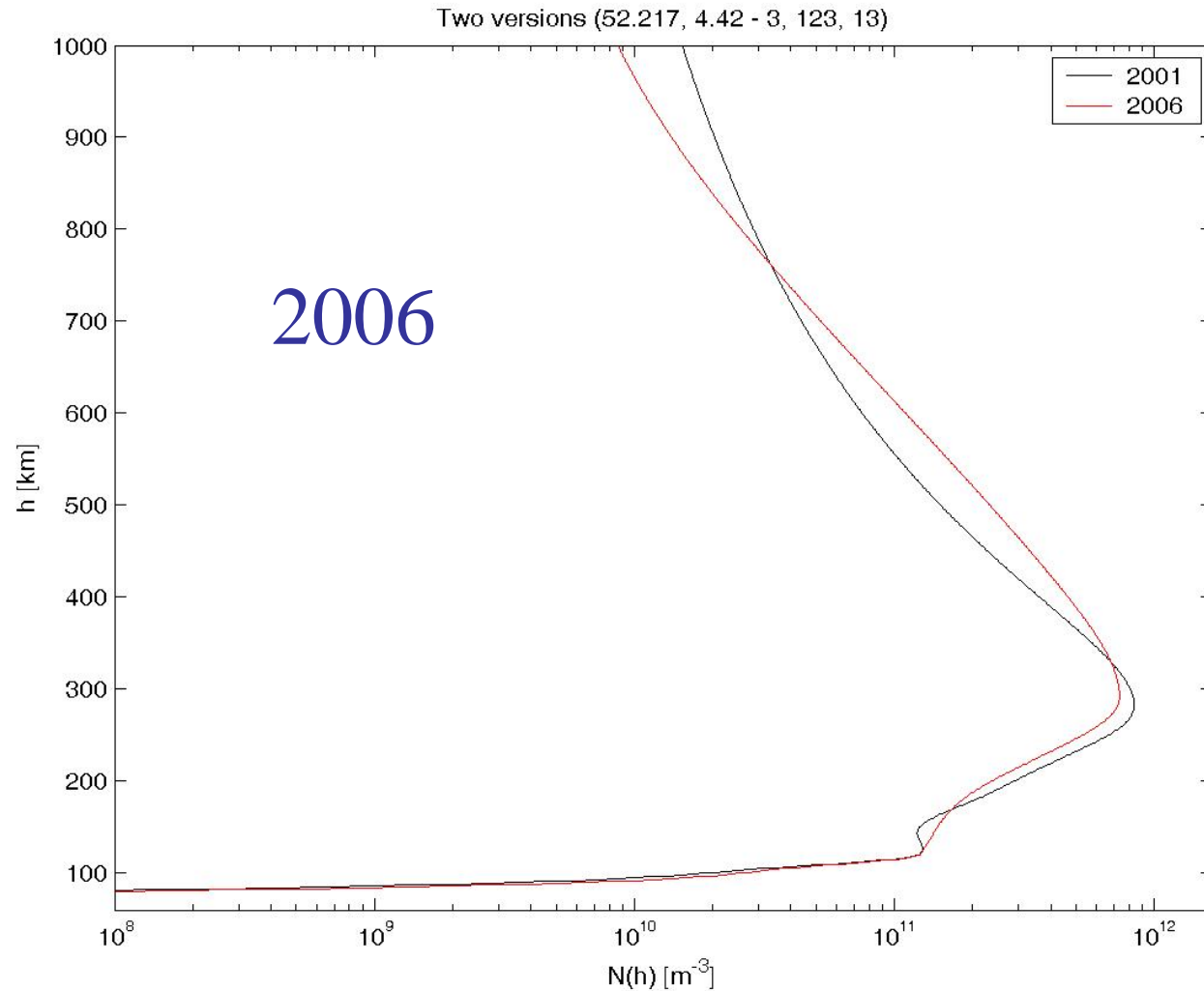
# 5. Tests

# ...profiles?



# 5. Tests

# ...profiles?



# 5. Tests

# ...vTEC maps?

The screenshot shows the NeQuick software interface with the 'vTEC analysis' menu item selected. A secondary window titled 'NeQuick\_vTEC' is open, displaying the 'Vertical total electron contents' settings. The interface is divided into several sections:

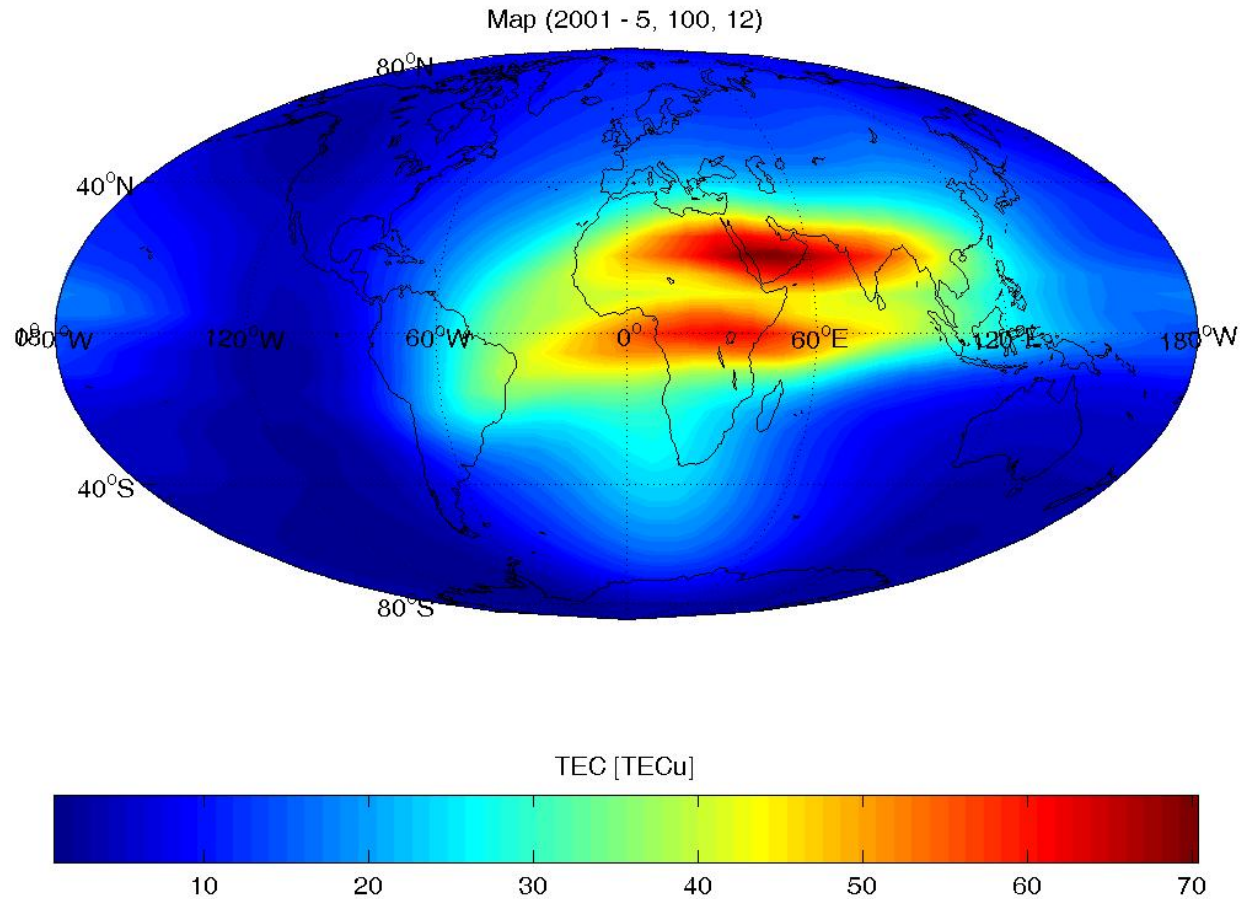
- Maps:** Includes 'Input' (Month: May, Flux: 100, UT LT: 12), 'One version' (Version: 2001, Plot button), and 'Differences' (Version 1: 2001, Version 2: 2006, Plot button).
- Space:** A table defining the spatial grid for the analysis.
- Analysis:** Includes 'Input' (Version 1: 2001, Version 2: 2006, Month: May, Flux: 100, Minimum: 0, Maximum: 23, Step: 1, UT LT), 'Global' (Calculate button, TEC (version 1), Mean, Maximum, Bias, Maximum, RMS, units [TECu]), and 'Differences' (Absolute, Relative, units [TECu], [%]).
- Dependences:** Options for 'Latitude dependence', 'MODIP dependence', and 'UT dependence', each with Bias, Max, and RMS buttons.

	Height	Latitude	Longitude
Minimum	0	-90	-180
Maximum	23222	90	180
Step		5	10

# 5. Tests

# ...vTEC maps?

2001



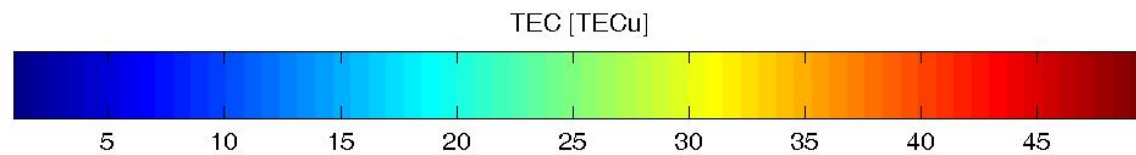
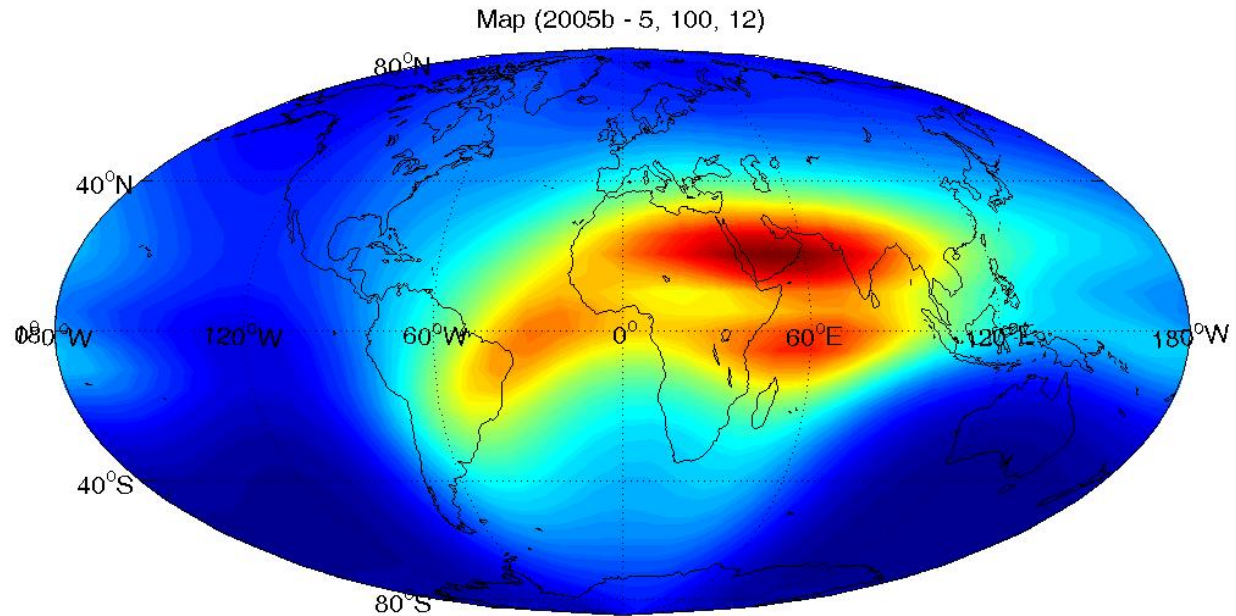
Max  
= 70



## 5. Tests

# ...vTEC maps?

2005b

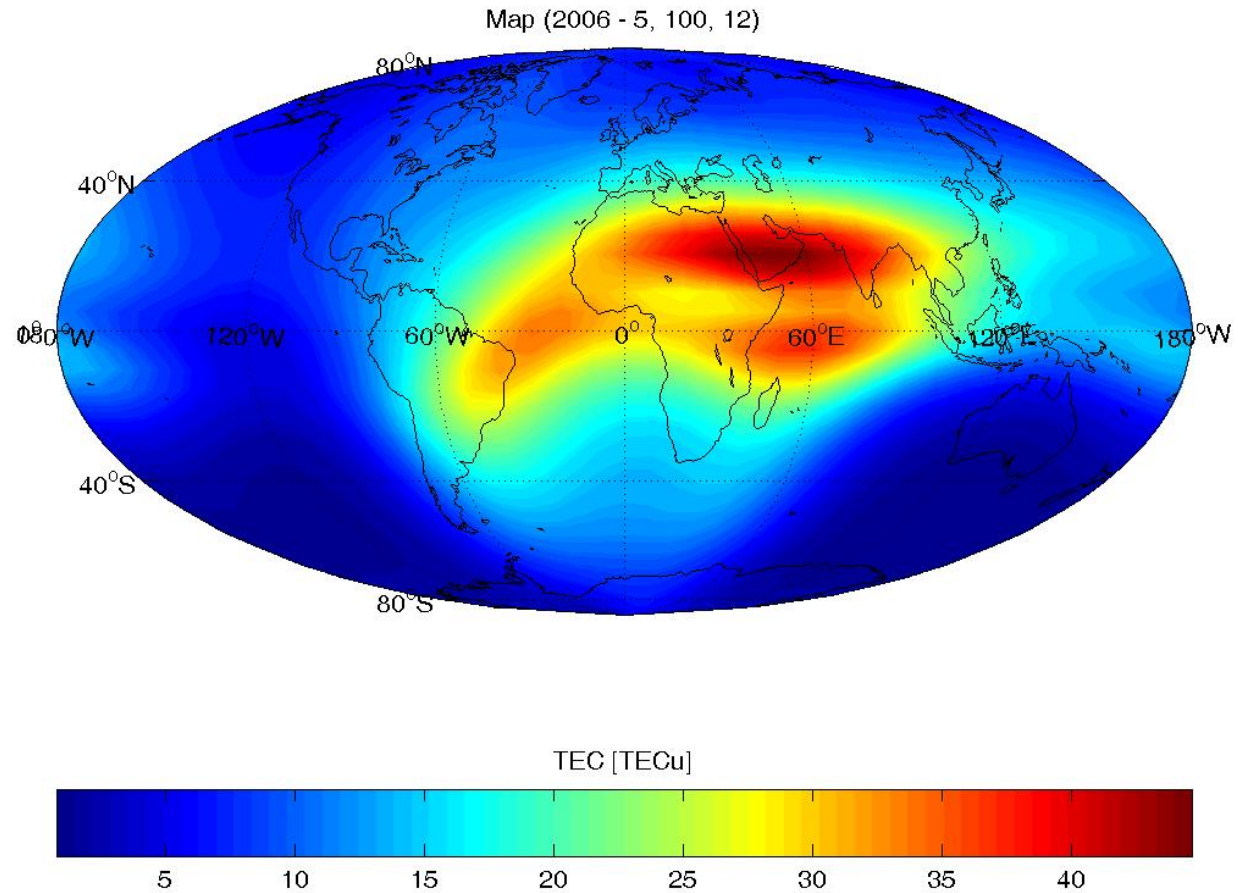


Max  
= 50

## 5. Tests

# ...vTEC maps?

2006



Max  
= 45

“We have now a complete  
basis...

- Understanding
- Check list
- Tools
- First results

... to be continued!”

- Broader **physical** behaviour analysis
  - **Topside**
- 
- **Az** calculation method
  - Intrinsic modification for **daily** use
  - **Effective** use analysis

