ARTIST-5 automatic scaling of quick-run DPS-4D ionograms

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3rd URSI AT-AP-RASC, Gran Canaria, 2022–06–02

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Outline

Introduction

Previously, at URSI-GASS 2021...

- We presented a statistical analysis of the performance of ARTIST-5 autoscaler for processing ionograms from the Dourbes observatory, deducing 95% error bounds.
- This analysis was based on the "standard" ionograms, which are produced during routine operations.
- Results were generally excellent, but...

The performance under high-candence operating conditions during the 2015 solar eclipse looked not so great. That campaign only comprised a few hundred quick ionograms. Here, we will show the analyses of a larger data set.

“Quick-run” ionograms

Typical “standard” and “quick-run” ionogram settings used for the DPS-4D sounder at the Dourbes observatory.

Parameter	Standard	Quick-run
Frequency range	1–16 Mhz	1–10 MHz
Height range	80–1357.5 km	80–717.5 km
Coarse frequency step	50 kHz	50 kHz
Fine steps	2 steps, 5 kHz, multiplexed	2 steps, 5 kHz, multiplexed
Integrated repeats	8	4
Wave form	16-chip pulse encoded	66.667 μs short pulse
Polarization	O & X	only O
Total runtime	$3'12.67''$	$14.510''$

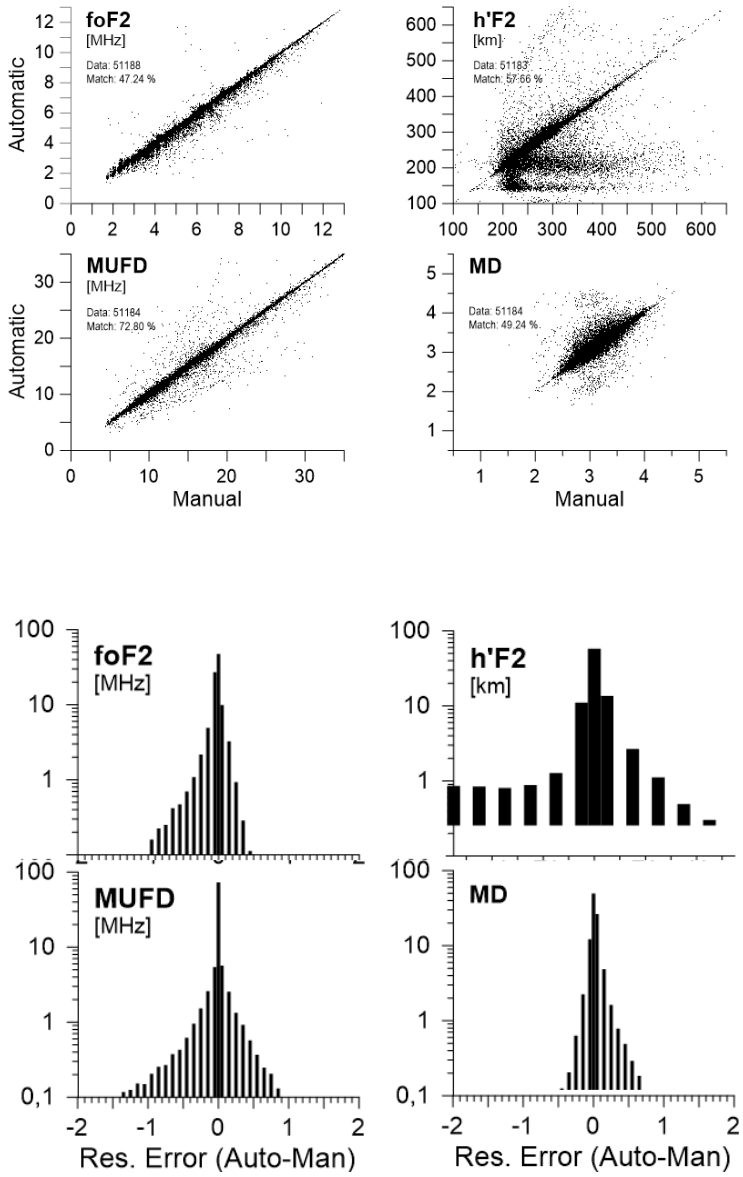
Not all quick-run ionograms are created equal!

In this study we combine results obtained with different configurations, but the precise settings can matter (a lot).

Results for standard ionograms

The ARTIST-5 autoscaler was found to be quite reliable.

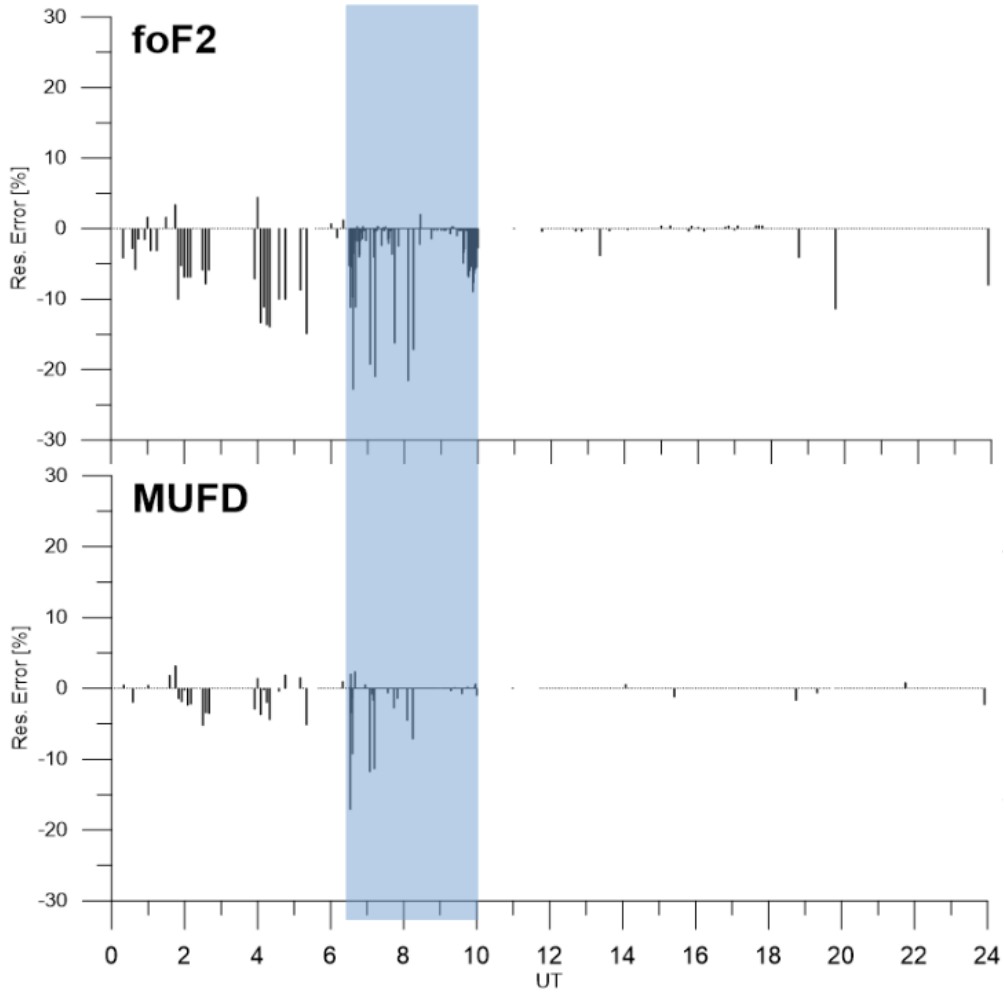
Characteristic	95% interval
f_oF_2 [MHz]	(-0.35,+0.25)
$h'F_2$ [km]	(-115,+45)
f_oF_1 [MHz]	(-0.60,+0.40)
$h'F$ [km]	(-95,+35)
f_oE [MHz]	(-0.30,+0.30)
$h'E$ [km]	(-6,+6)
$foEs$ [MHz]	(-0.80,+0.35)
$h'Es$ [km]	(-18,+16)
$MUF(3000)$ [MHz]	(-0.55,+0.50)
$M(3000)$	(-0.20,+0.25)



95% confidence intervals are generally small. Most errors are of a few distinct types, can be filtered out by simple heuristics.

Data from 2015 solar eclipse

A few hours of high-cadence soundings ran in Dourbes on March 20, 2015 during a solar eclipse.



The performance of ARTIST looks a little worse during the campaign.

The question:

Is this really the case?

With little data (and during an eclipse) it is difficult to be sure.

Corrected quick-run ionograms

Quick-run ionograms were produced during various campaigns intended to investigate meteor induced *Es* traces.

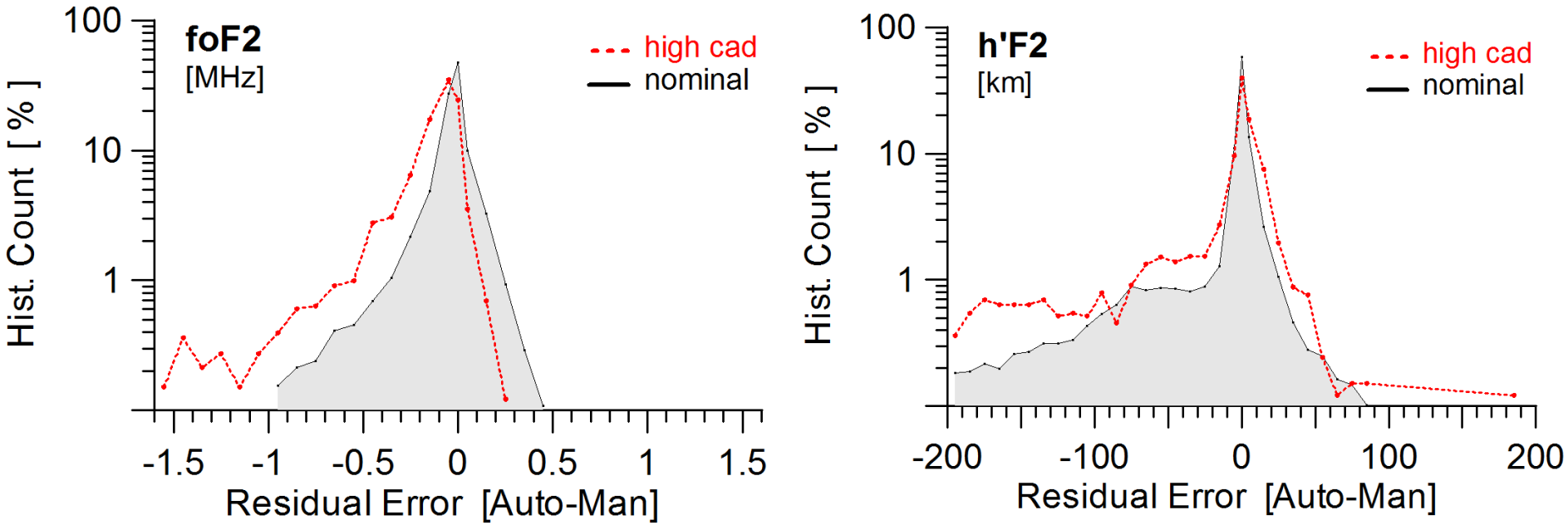
These were run on the following days: 9 August 2018, 18 November 2018, 12 August 2019.

Also included are data from the solar eclipse campaigns of 2015 (March 20 & 21) and 2017 (August 21 & 22), but these are only partial days.

In total, we have 4,163 manually scaled quick-run ionograms available (compared to about 51,000 standard ionograms).

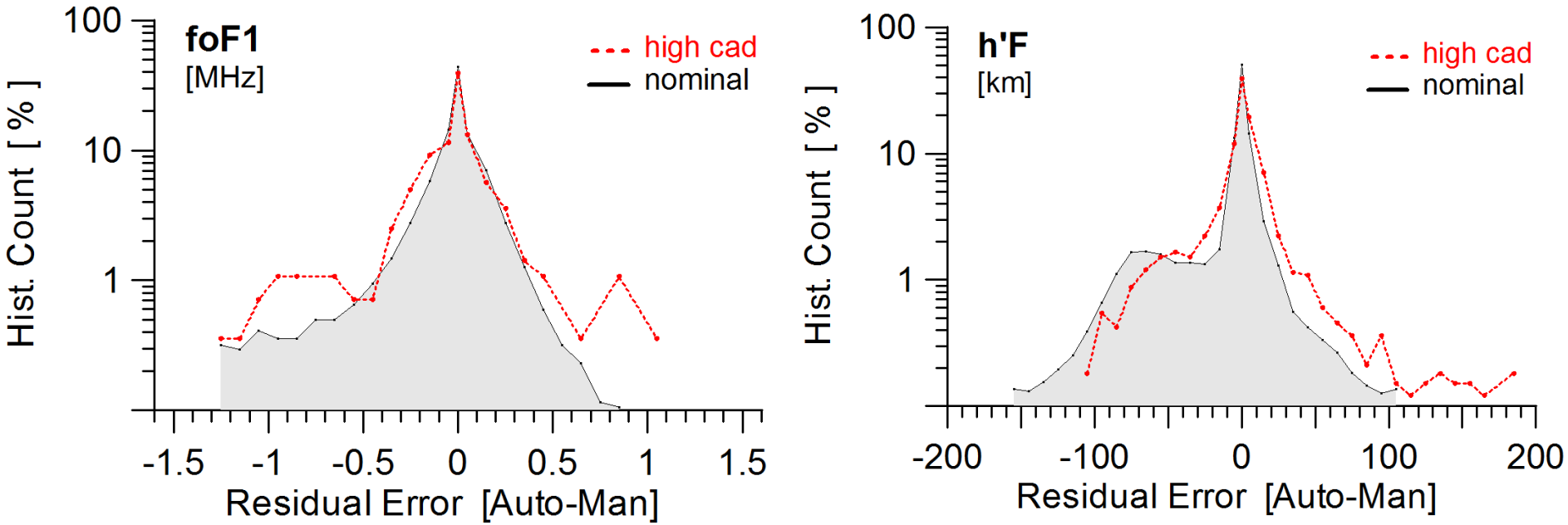
Limitations: the data is not uniformly distributed over seasons and solar cycle. Also, this analysis is done for a mid-latitude station.

F_2 layer



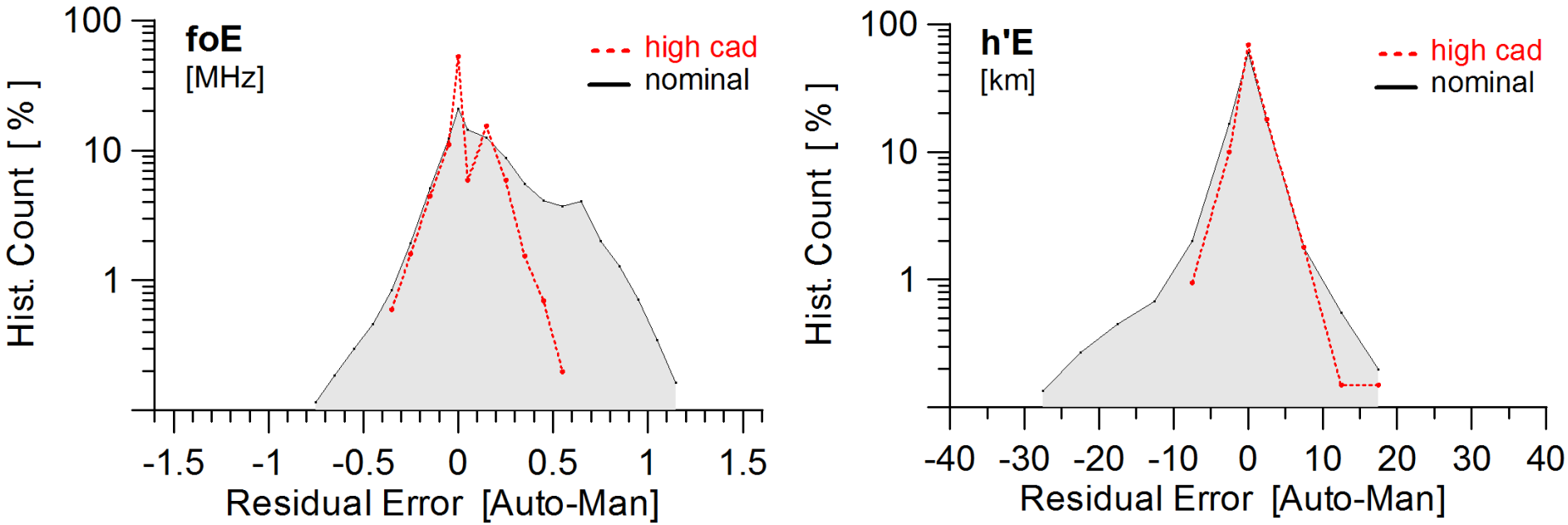
The scaling of F_2 layer is a little worse for quick-run ionograms. In particular the asymmetry is exacerbated.

F_1 layer



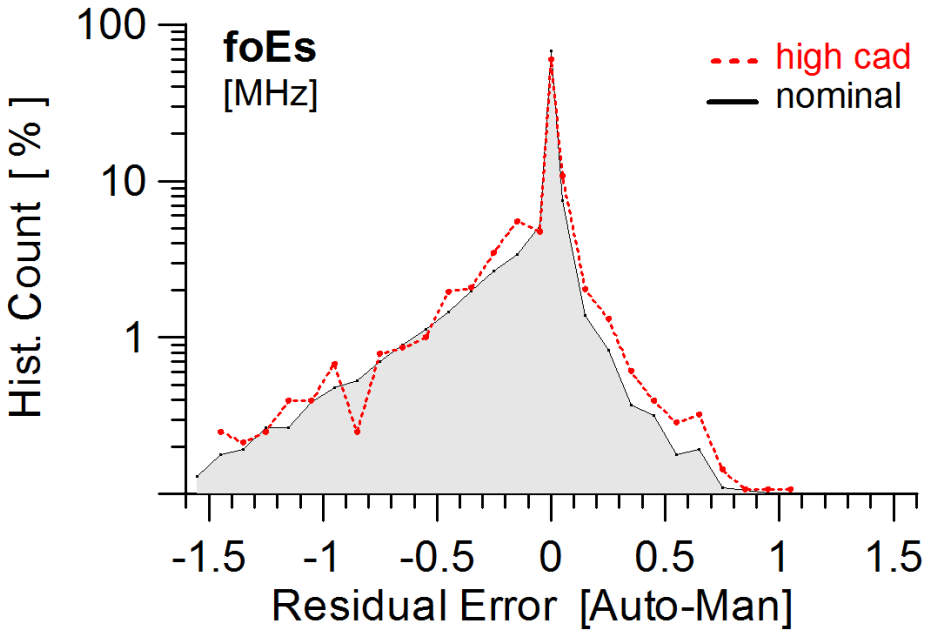
For the F_1 layer, there are somewhat more extreme residuals; but again results are mostly similar.

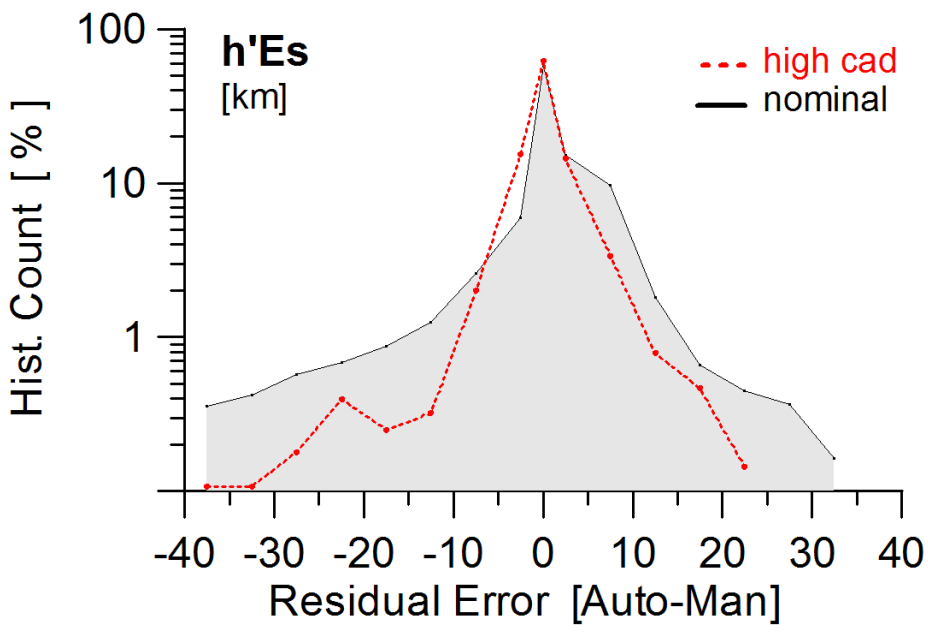
E layer



Especially for f_oE, the scaling of quick run ionograms seem to perform better, possibly due to the (lack of) sporadic layer.

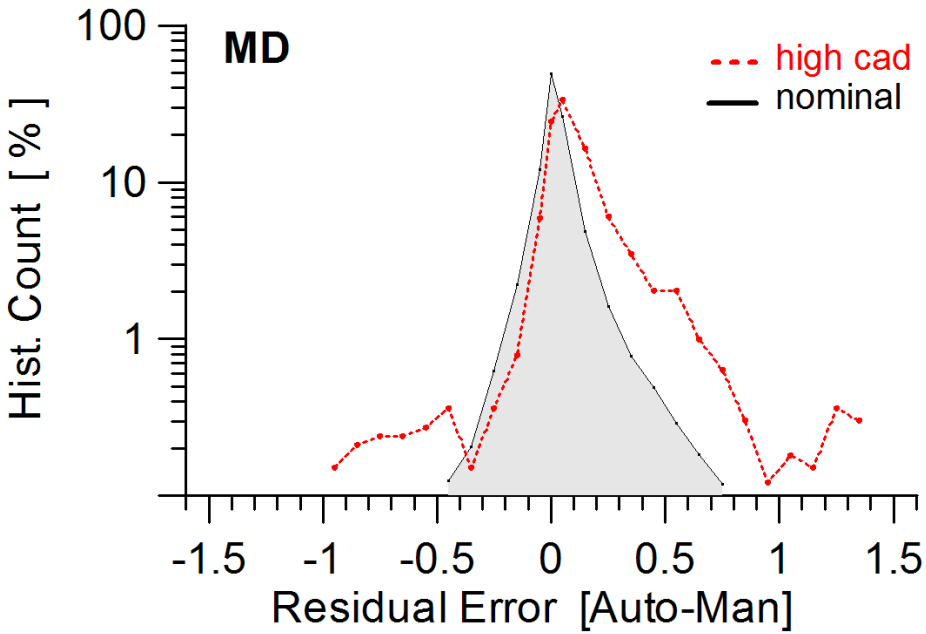
Sporadic layer

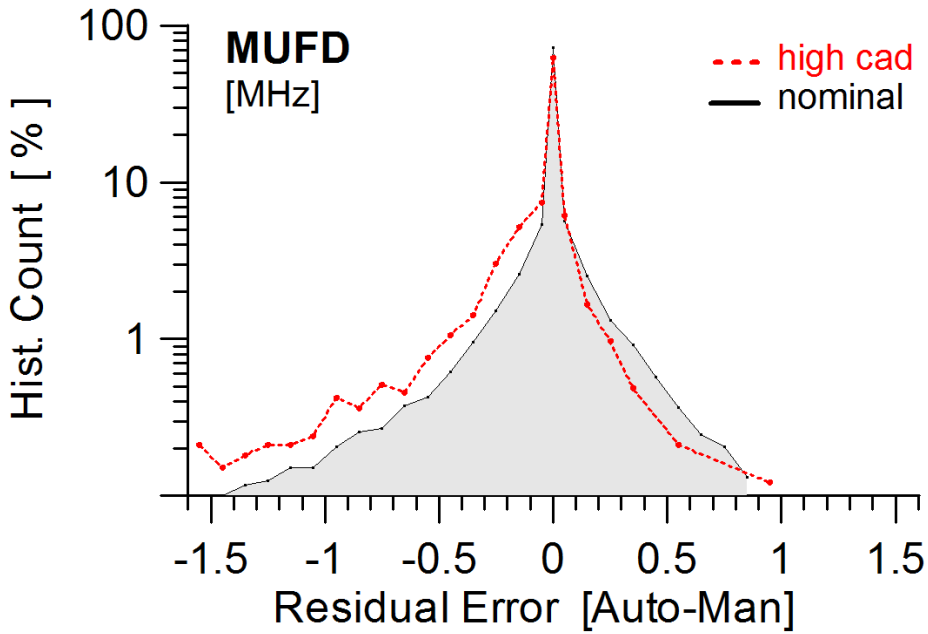




The sporadic layers were scaled quite well by ARTIST, but there were not many extreme cases in the data set.

MUF(3000)





M(3000) in particular is scaled worse for quick run ionograms. Notice the asymmetry of the distribution.

Error bounds

95% confidence bounds for quick-run and standard ionograms:

Characteristic	nominal	quick-run
f_oF_2 [MHz]	(-0.35,+0.25)	(-0.80,+0.20)
$h'F_2$ [km]	(-115,+45)	(-170,+50)
f_oF_1 [MHz]	(-0.60,+0.40)	(-0.70,+0.50)
$h'F$ [km]	(-95,+35)	(-80,+70)
f_oE [MHz]	(-0.30,+0.30)	(-0.20,+0.30)
$h'E$ [km]	(-6,+6)	(-5,+5)
$foEs$ [MHz]	(-0.80,+0.35)	(-0.90,+0.40)
$h'Es$ [km]	(-18,+16)	(-10,+10)
$MUF(3000)$ [MHz]	(-0.55,+0.50)	(-2.60,+1.50)
$M(3000)$	(-0.20,+0.25)	(-0.20,+0.70)

Impact of season and solar activity?

Due to the irregular and sparse distribution of data, we cannot evaluate the potential impact of seasonal and solar activity variations.

If you need auto-scaled quick-run ionograms...

Recommended changes to keep obtaining good ARTIST performance:

1. Limit height and frequency ranges: no impact.
2. Use O-polarisation only: usually no impact.
3. Coarse and fine frequency steps: might affect some characteristics.
4. Integrated repeats or pulse waveform: try not to change.

Following these guidelines, one can obtain autoscaling results of reasonable reliability for 15 sec. ionograms.

Conclusions

1. The autoscaling by ARTIST-5 for quick run ionograms (15 sec.) is comparable in quality to the performance on standard ionograms.
2. Operators should carefully select *how* to shorten sounding times!
3. Auto-scaled quick-run ionograms can—with some data filtering—be suitable for operational, or in some cases for research, purpose.
4. We do not have sufficient data to assess dependency of performance on solar activity and season (but expect limited effects), nor include low and high latitudes (which likely do have effects).

The end, thank you!

A publication is being prepared, combining results for standard and quick-run ionograms.