

An Evaluation of FITACF 3.0

Part 1: Backscatter Occurrence in Range-Time Space

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Major issues with FITACF2

Confusing organisation of the package

- Lack of transparency ('black box')
- Strong interdependence between different routines

Questionable implementation of some analysis procedures

- Empirical data selection procedures
e.g. cutoff power level, treatment of cross-range interference
- Non-optimal implementation of least squares fitting

FITACF has been looked at carefully & rewritten from scratch → FITACF3

Data pre-selection

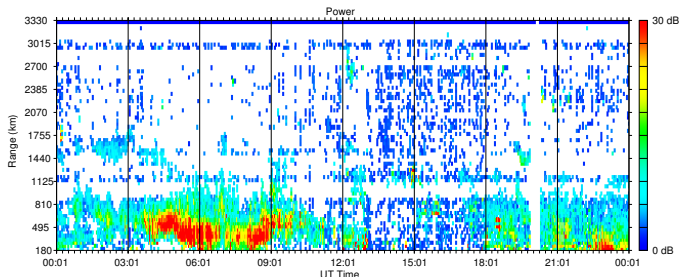
Major changes in FITACF3.0

Background noise level and cutoff power

- Noise level is corrected for the effective number of actual noise samples (FITACF2 underestimates the noise level by 1–2 dB)
- Simpler power cutoff

FITACF2: Average power at all non-zero lags of all ACFs which have lag0 power $< 1.6 * (\text{noise level})$, plus 1 standard deviation from that average power level

FITACF3: SNR = 1



FITACF2.5 (Longyearbyen, 16 August 2017)

Data pre-selection

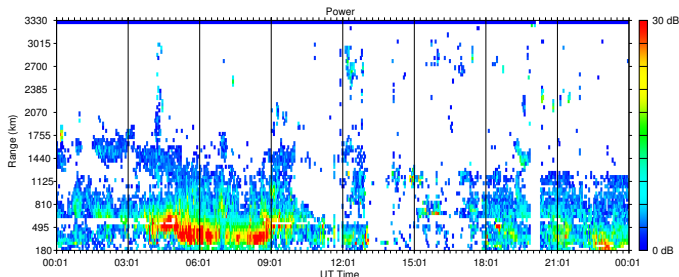
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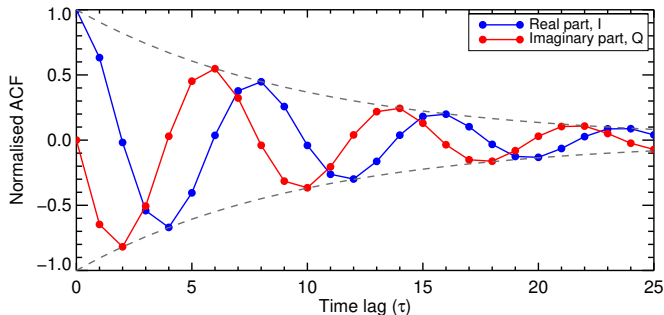
FITACF3.0 (Longyearbyen, 16 August 2017)

Data pre-selection

Major changes in FITACF3.0

'Bad' lag determination

- No lag rejection based on 'bad shape' or cross-range interference
- Only Tx-overlap lags are removed from both power and phase
- Low-power 'tail' is removed from power only



Fitting

Major changes in FITACF3.0

Textbook least-square method

Weighting coefficients

- Inversely proportional to the square of the statistical fluctuation level
- Weights account for cross-range interference from all interfering ranges
(In FITACF2, lags with high CRI levels are rejected outright)
- Separate coefficients for phase and power fits
(Phase and power are statistically independent)

Phase fitting includes all available lags except those affected by Tx-overlap

No power fits are performed on XCFs

Echo parameter determination

Major changes in FITACF3.0

Velocity, SNR & spectral width determination is unchanged

XCF power, velocity & spectral width are not recorded

Error estimates

- Calculated using textbook formulas for the least-square method
- Now include CRI effects

Elevation

- Calculated based on lag 0 phase from ACF itself
Provides more stable estimates compared to fitting
- Fitted values are also provided in `fit.elv_high`
- Least-square error is stored in `fit.elv_low`

Structure of the package

Major changes in FITACF3.0

The source code has been completely restructured

- More modularity: easier to add, modify or remove features
- Self-contained data structure (arrays replaced by linked lists)
- Self-explanatory filenames
e.g. `fitacftoplevel.c`, `preprocessing.c`, `fitting.c`, `determinations.c`

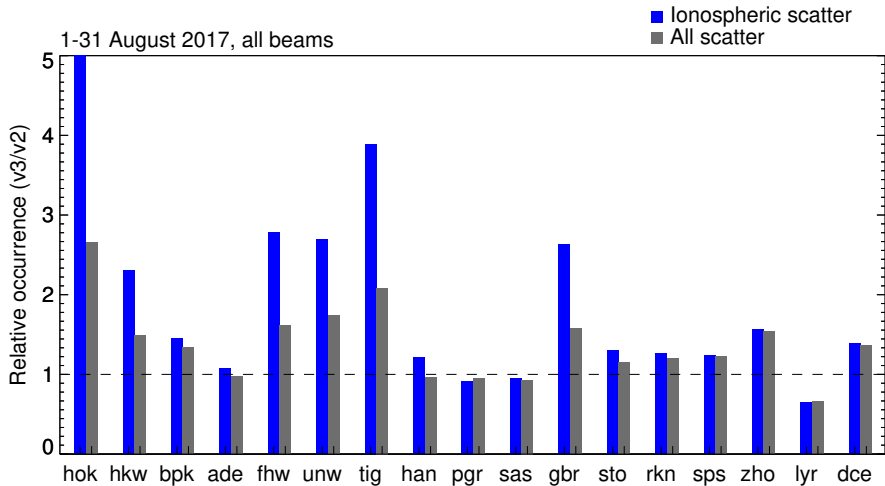
Echo Occurrence Statistics

Test data set

Date range: 1–31 August 2017

Radars: ade, bpk, dce, gbr, fhw, han, hkw, hok, lyr, pgr, rkn, sto, tig, sas, sps,
unw, zho

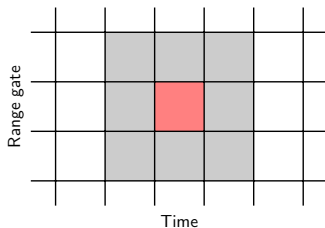
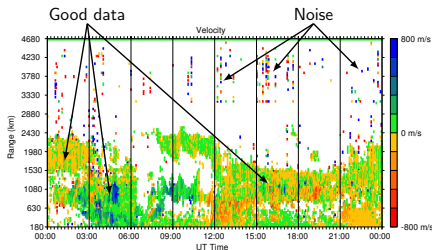
Echo occurrence



How do we define 'good' data?

In range-time plots...

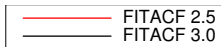
- 'Good' echoes are grouped into populations
- 'Noise' appears as grainy, unconnected echoes



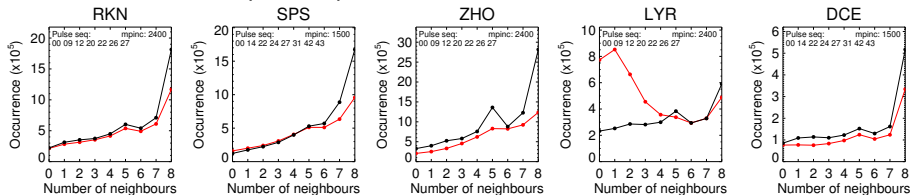
Identify 'good' echoes and 'noise' based on the number of neighbouring echoes in range-time space

Polar cap radars

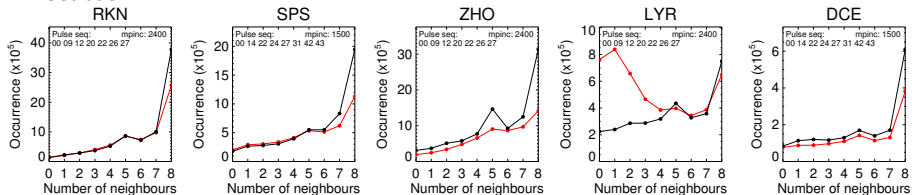
Number of neighbours



Ionospheric scatter (gflg=0)

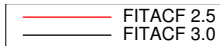


All scatter

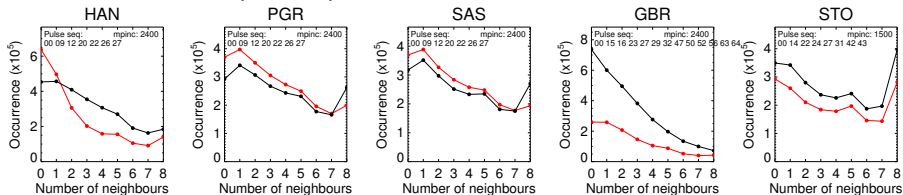


High-latitude radars

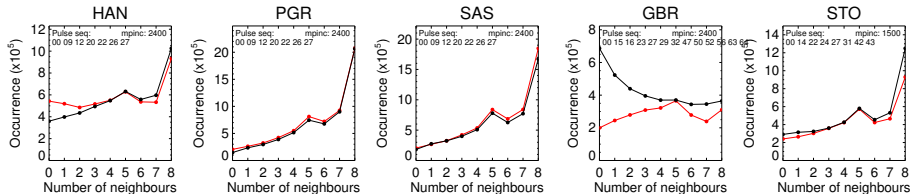
Number of neighbours



Ionospheric scatter (gflg=0)

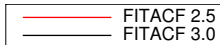


All scatter

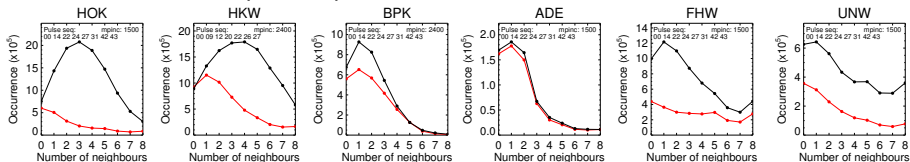


Mid-latitude radars

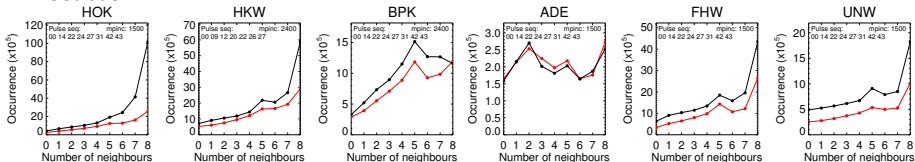
Number of neighbours



Ionospheric scatter (gflg=0)



All scatter



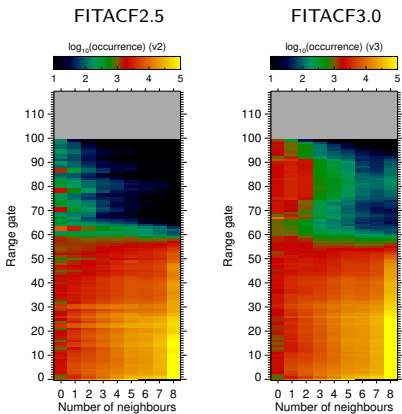
Summary

Key points so far...

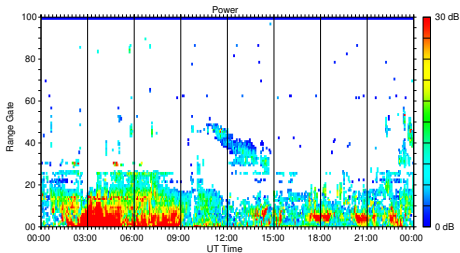
- Large variability between radars, particularly at mid-latitudes
- For most radars, FITACF3.0 produces more echoes with 8 neighbours
→ FITACF3.0 produces more 'good data'
- For some radars, FITACF3.0 produces more echoes with 0–3 neighbours
→ FITACF3.0 produces more 'noise'

Is the additional noise distributed uniformly across the field of view, or is it associated with particular range gates?

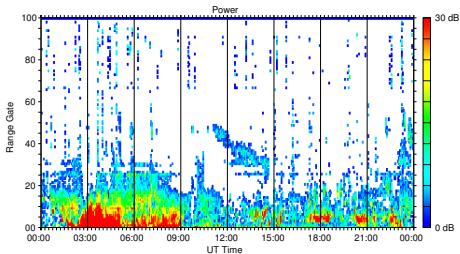
Rankin Inlet



ptab: [0, 9, 12, 20, 22, 26, 27]
mpinc: 2400 μ s

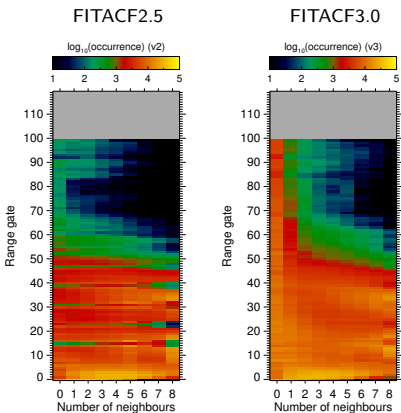


Rankin Inlet, 5 August 2017, FITACF2.5



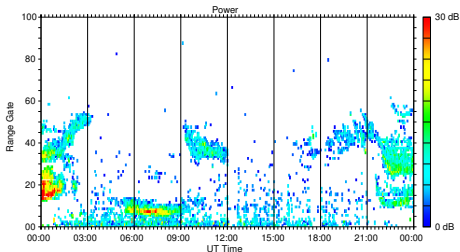
Rankin Inlet, 5 August 2017, FITACF3.0

Goose Bay

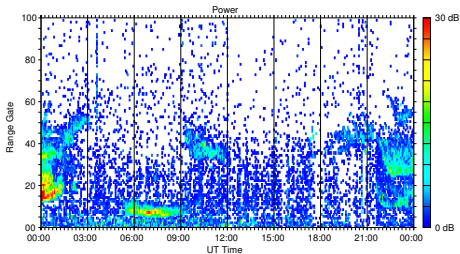


ptab: [0, 15, 16, 23, 27, 29, 32, 47,
50, 52, 56, 63, 64]

mpinc: 2400 μ s

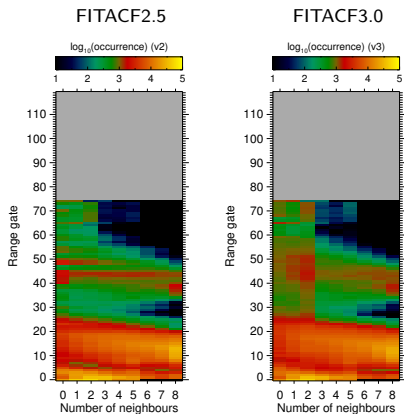


Goose Bay, 25 August 2017, FITACF2.5

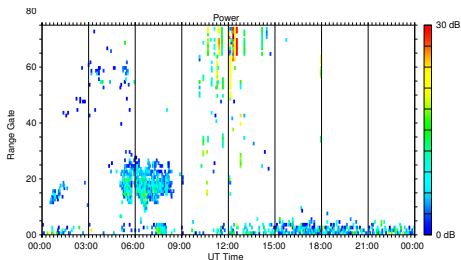


Goose Bay, 25 August 2017, FITACF3.0

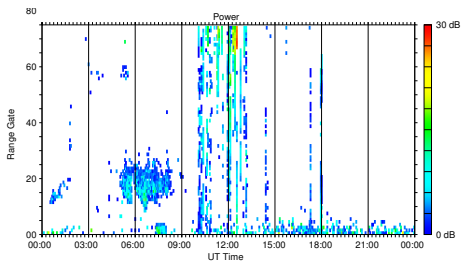
Adak East



Vertical streaks (2 neighbours)
Might be related to lightning strikes

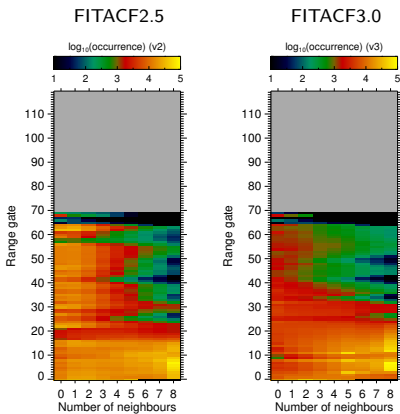


Adak East, 31 August 2017, FITACF2.5

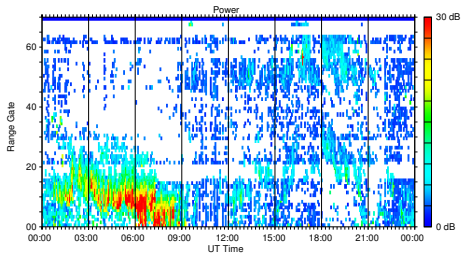


Adak East, 31 August 2017, FITACF3.0

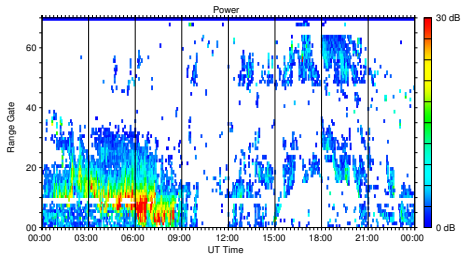
Longyearbyen



Noise level correction → Fewer echoes with $\lesssim 3$ neighbours



Longyearbyen, 31 August 2017, FITACF2.5



Longyearbyen, 31 August 2017, FITACF3.0

Summary

Changes to FITACF are targeted at improving the data quality

Key points

- FITACF3.0 produces more 'good' echoes, but for some radars it also produces more 'noise'
- The additional noise is often confined to the farthest range gates
FITACF2.5 may have overfiltered the data at these ranges
- Vertical streaks in the data, perhaps caused by lightning strikes
- Simpler noise cutoff may help to identify hardware problems

So far we have considered only the presence and absence of backscatter

→ See next talk for evaluation of the actual fitted parameters