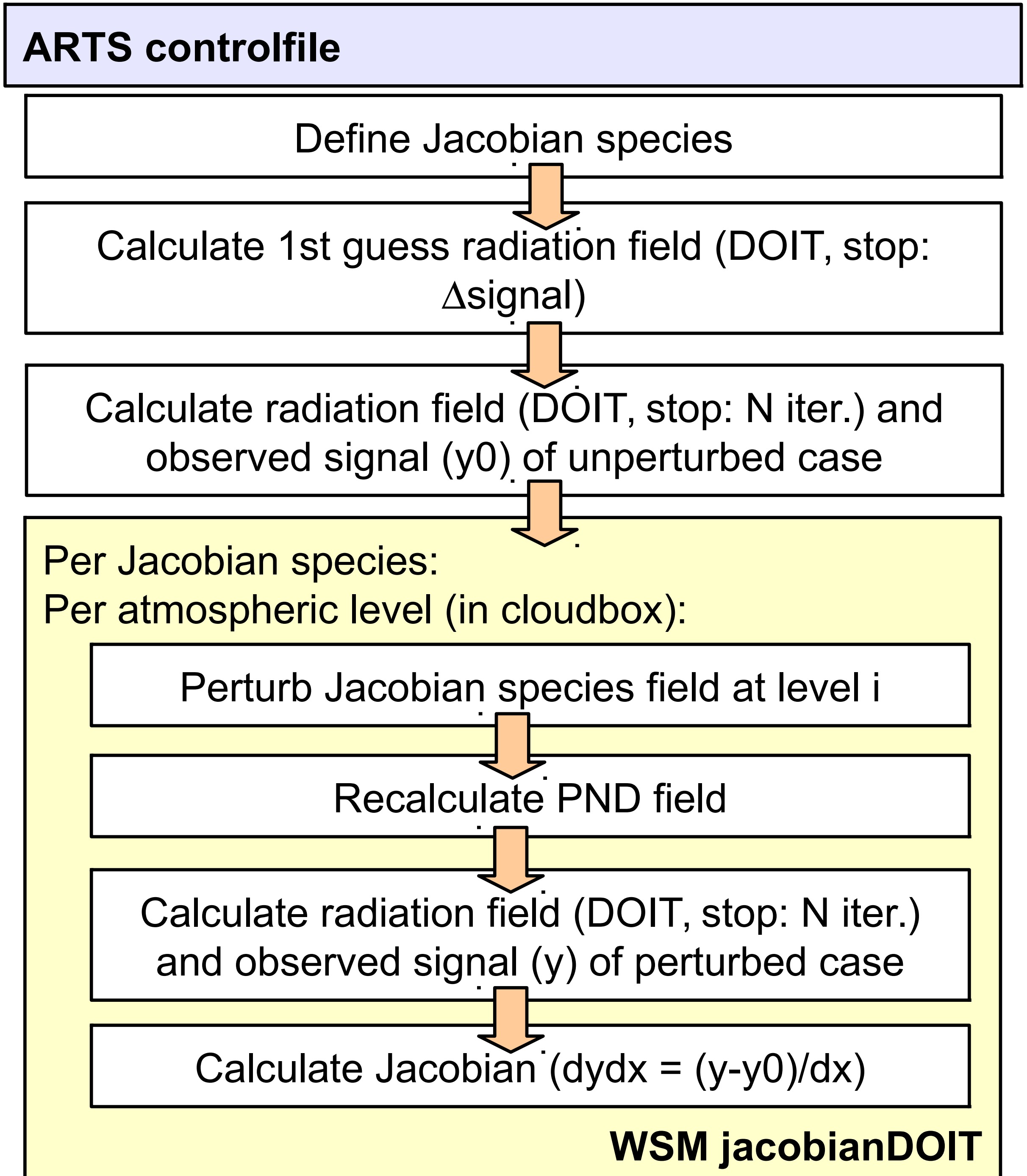
ARTS & ISMAR cont.: details on selected issues

Contents

- cloudy-sky Jacobians
- in-ARTS calculation of particle number density (PND) fields
- frequency setup optimization for ISMAR simulations

Jacobians for cloudy atmospheres: Approach



Capabilities:

- can provide abs. species, scat. species, and T Jacobians
- in cloudy atmospheres
- abs and rel perturbations

⇨ all of that could be done before "by hand". now formalized & put into a WSM.

- **example: wfuns/TestDoitJacobians.arts**

Jacobians for cloudy atmospheres: Approach

ARTS controlfile

1. Define Jacobian species
2. Calculate 1st guess radiation field (DOIT, stop: Δsignal)
3. Calculate radiation field (DOIT, stop: N iter.) and observed signal (y0) of unperturbed case
4. Per Jacobian species:
   Per atmospheric level (in cloudbox):
   - Perturb Jacobian species field at level i
   - Recalculate PND field
   - Calculate radiation field (DOIT, stop: N iter.) and observed signal (y) of perturbed case
   - Calculate Jacobian (dydx = (y-y0)/dx)

   WSM jacobianDOIT

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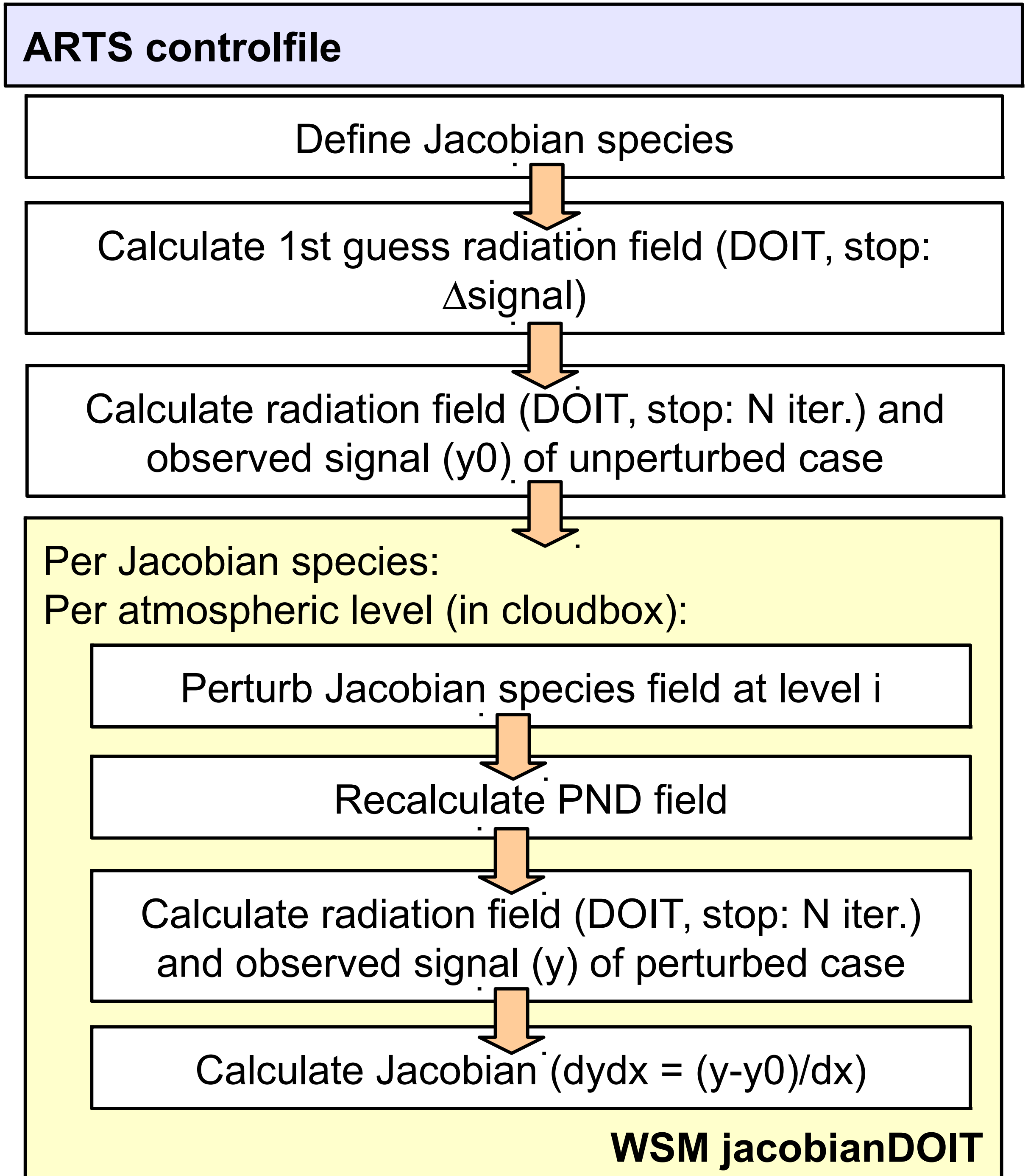
Implementation notes:

- Precision: unperturbed and perturbed cases apply identical convergence. Strongly suggested: fixed number of DOIT iterations.

- Safety: PND field is recalculated for each case (even if one does not expect effects on pnd's, e.g., for H2O Jacobians)

- Efficiency: precalculated 1st guess field (identical for ALL – unperturbed and perturbed – cases)
- Efficiency: ScatSpeciesMerge can be used

Jacobians for cloudy atmospheres: Approach



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Limitations:

- 1D only
- DOIT only (deterministic solver required)
- restricted to cloudbox
- no simultaneous use with clearsky Jacobian module so far

- scat. species Jacobians so far only with PND fields derived internally from hyrometeor fields (abs_species and T work with externally derived PND fields, too)

- computationally expensive (read: very slow)
- not fully “fool-proof” (due to data management approaches of DOIT & yCalc)

ARTS-internally derived PND fields from GCM data

- reminder: scatterers fully characterized by single scattering data (scat_data) and associated particle number density fields (pnd_field)

- the “classical” way: calculate both scat_data and pnd_field externally (e.g. using atmlab and/or PyARTS routines)
- since ARTS 2.2: internal calculation of pnd_field
  - **input: GCM-type hydrometeor fields** (mass content, mass flux, number density, and/or mean mass)
  - particle size distribution specified per hydrometeor species (note: a PSD can require multiple parameter fields for this hydrometeor type)
  - multiple PSDs covered, e.g. MH97, F07 (tropical & midlat), MP48, ICON 2-moment schemes, ...

- AUG documentation coming
- related WSM and WSV (check doc server):
  - WSV: scat_species, scat_species_*_field
  - WSM: pnd_fieldCalcFromscat_speciesFields
- **example: doitbatch/TestDOITBatch.arts**

Frequency setup optimization

- motivation: scattering calculations are very costly
- goal: find small set of monochromatic frequencies that represents (instrument function convolved) radiometer channel signal
- approach(es):
  - pick “optimal frequencies” out of larger set
  - determine minimum number of equally spaced frequency bins (in line with ARTS' met_mm system)
- setup used:
  - clear-sky
  - Garand atmospheres (42 states) incl. all (6+2) species provided
  - specular surface, emissivity = 0.95, 0.6, 0.4
  - “all” ISMAR observation angles (incl. calib. target)
  - platform altitudes 1-16km
  - 1MHz frequency spacing (400-5000 points per sideband)
  - scalar RT

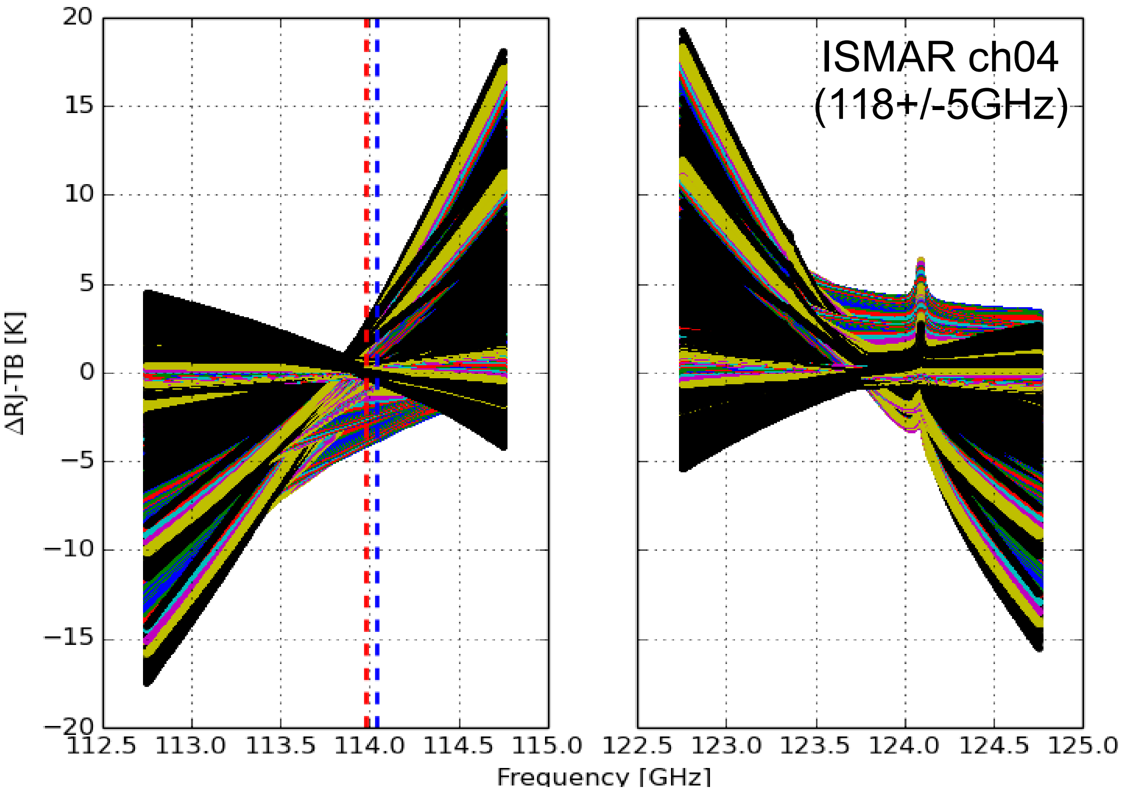
  - optimization separate for up- & downlooking
    - over ~14100 (4700) cases down- (up-) looking
  - only in-band frequencies allowed so far (problematic for window channels)

Frequency optimization: downlooking

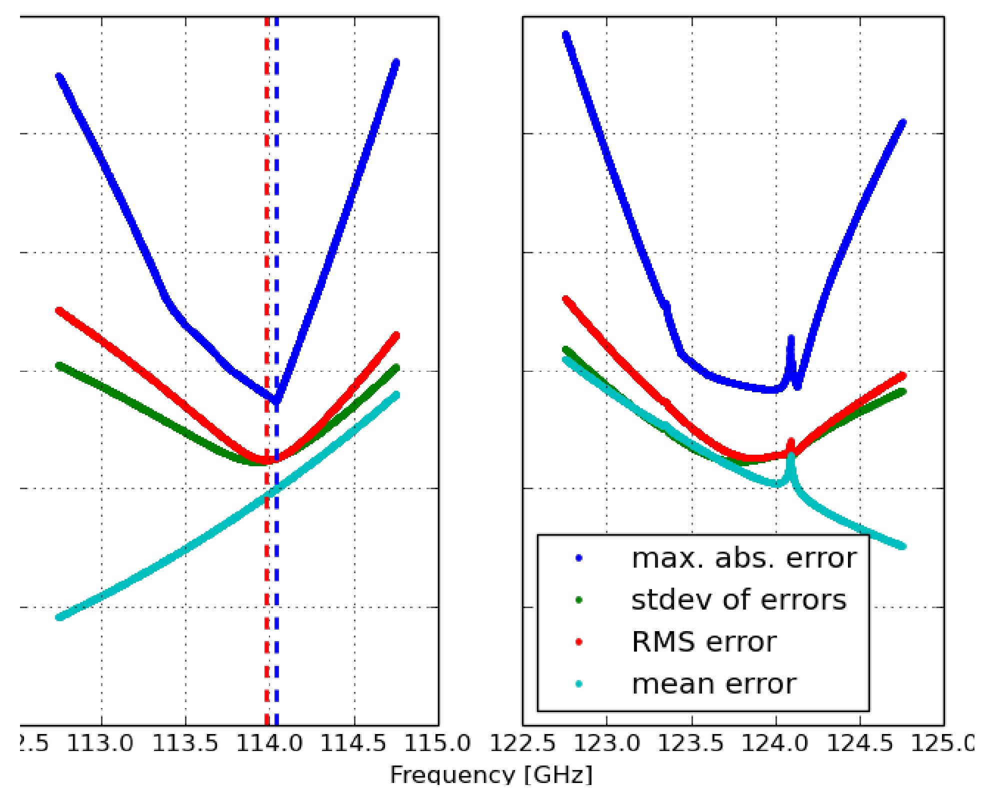
- single optimal frequency (1 per channel) vs. center-of-each-passband (2 per channel; simplest met_mm setup)
- definitions of "optimal":
  - min. RMSE
  - min. maximum absolute error

(trade RMSE for better max deviation?)

Deviation of monochromatic from channel signal (all individual cases)



Statistics of deviation of monochromatic from channel signal (over all cases)



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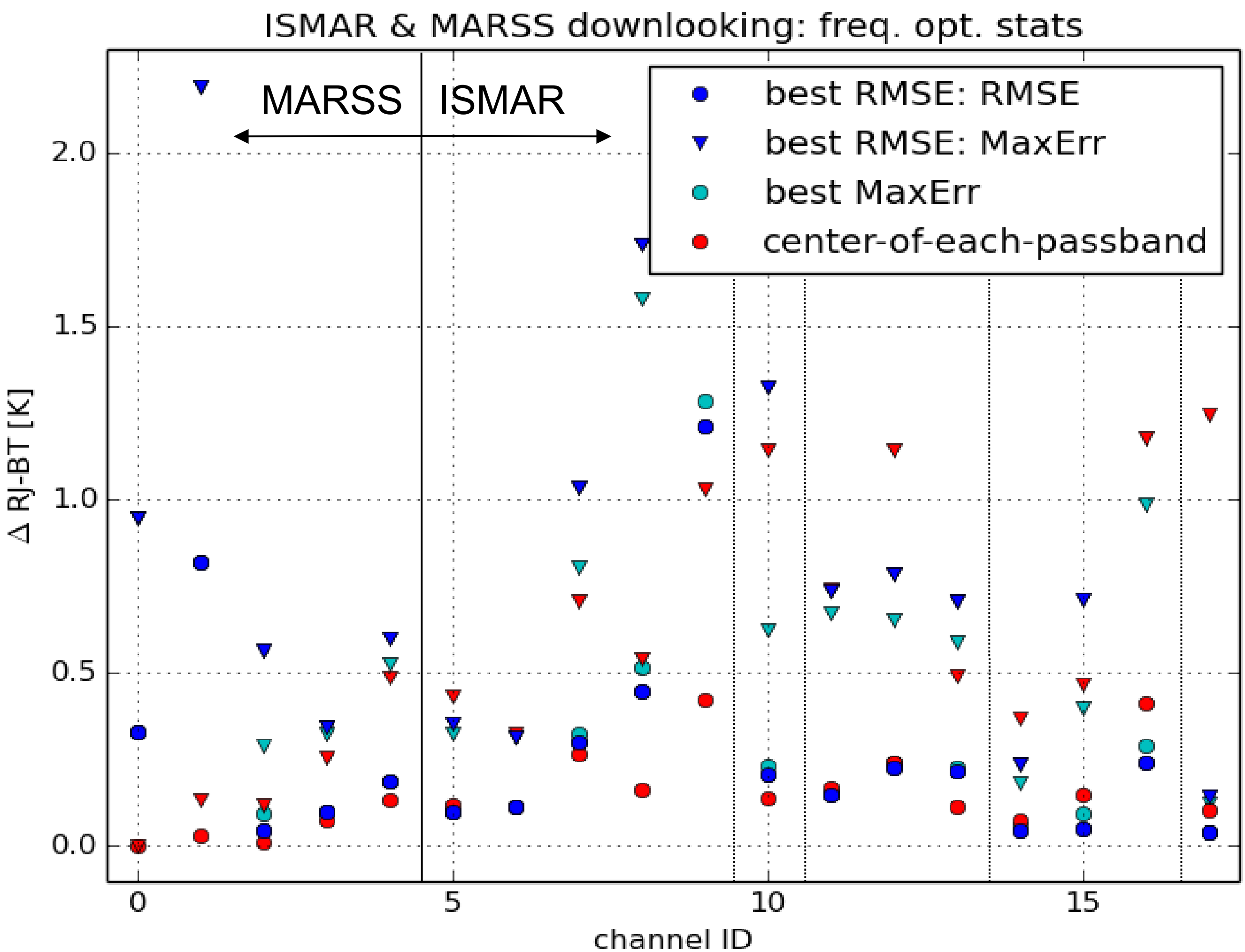
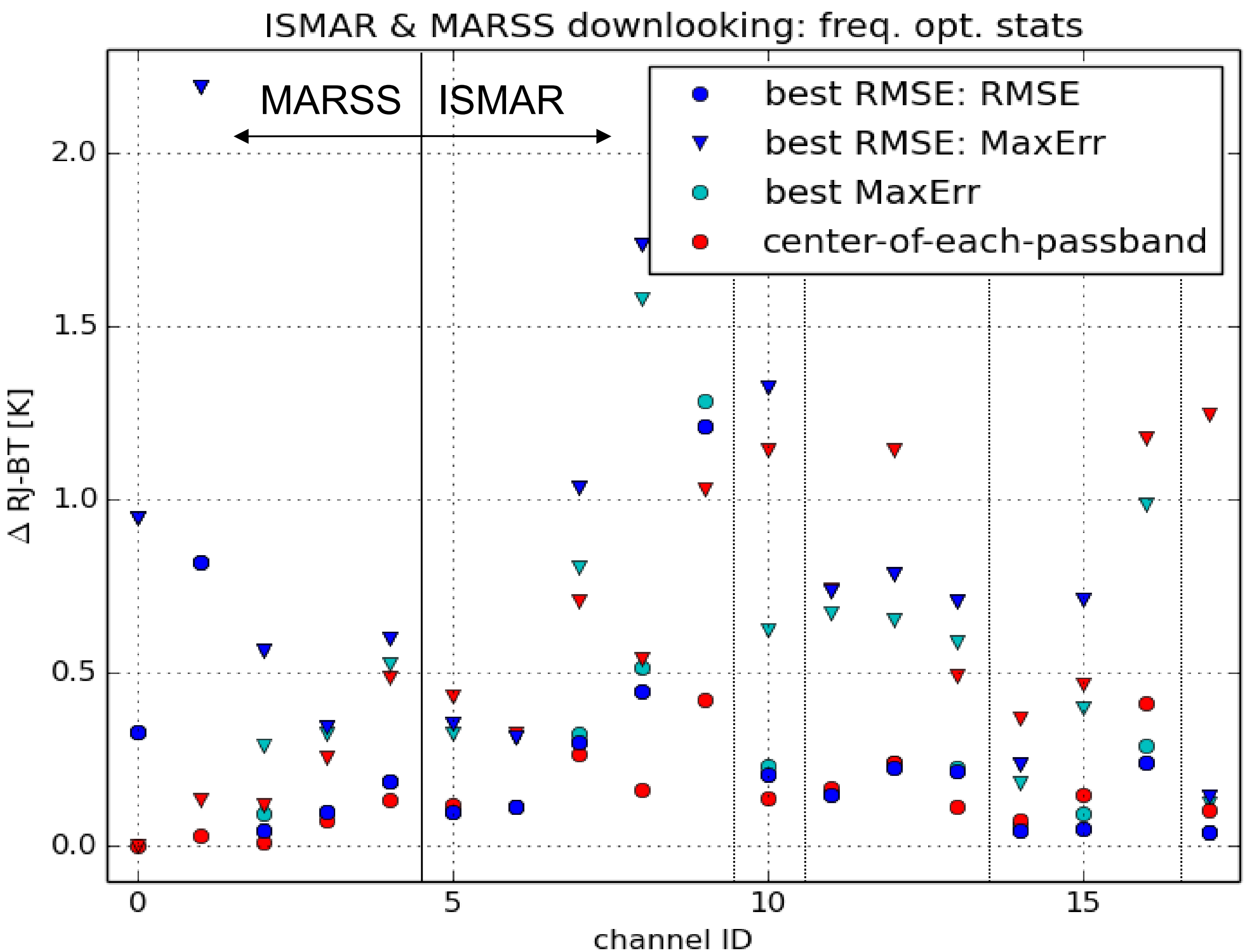


channel ID		channel center [GHz]	band offset [GHz]
0	M	88.99	1.075
1	M	157.08	2.600
2	M	183.25	0.975
3	M	183.25	3.000
4	M	183.25	7.000
5	I	118.75	1.100
6	I	118.75	1.500
7	I	118.75	2.100
8	I	118.75	3.000
9	I	118.75	5.000
10	I	243.20	2.500
11	I	325.15	1.500
12	I	325.15	3.500
13	I	325.15	9.500
14	I	448.00	1.400
15	I	448.00	3.000
16	I	448.00	7.200
17	I	664.00	4.200

Frequency optimization: downlooking

- generally RMSE<1K (except: 118+/-5GHz (ch9)), most <0.5K
- max MaxErr ~4K, most ~1K
- slight tendency to worse results at outer (wider?) channels

- passband-center approach slightly, but not significantly better (except: (a) high freq, (b) 118+/-5GHz)



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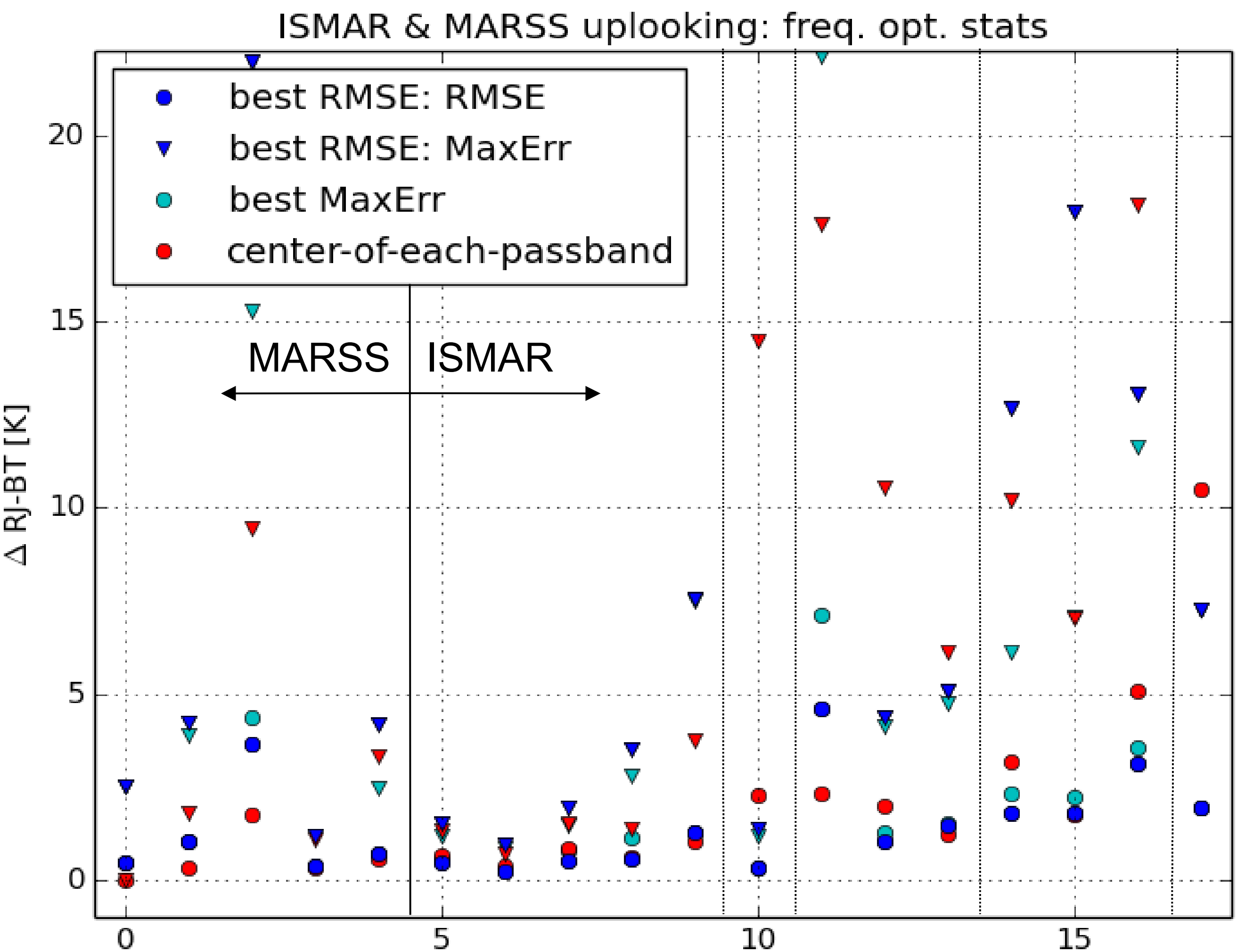
Frequency optimization: uplooking

- significantly higher errors (varying effective line broadening, prominent O3 lines)
- "optimal" frequency approach typically better
- both approaches occasionally provide large max. errors (tens of K)
- preview: 1-freq-per-passband opt. much better results (448GHz has largest devs, RMSE~1.5K)



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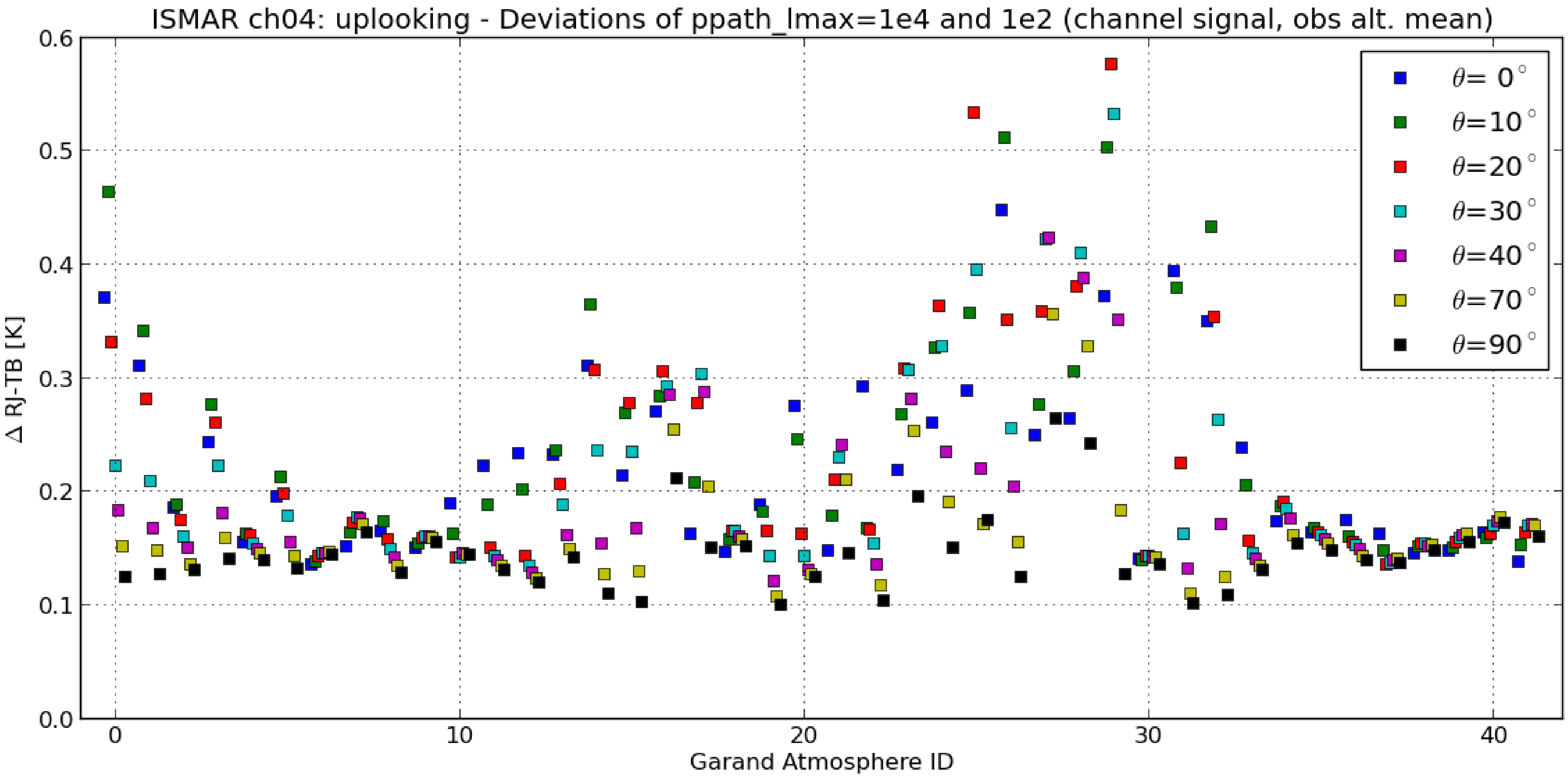
Side note: RT modeling issues

– choice of max. RT step size affects simulated signals

+ so far no effect on freq opt observed



Frequency setup optimization: Conclusions

- single freq or center-of-passband approaches sufficient for downlooking

- uplooking needs further analysis

- further analyzing:
  - 1-freq-per-passband optimal frequencies
  - number-of-bins to accuracy relation
  - allow full channel freq range (instead of in-passband only) for optimization

? develop ARTS routines for ISMAR instrument for non-uniform freq grids (allowing met_mm functionality for individual freqs like “optimal” sets)