- Part 1 : Modular Retrieval System for consistent microwave retrievals

- Part 2: Testing beta-version of new ATMS brightness temperatures

Part 1: A Modular Retrieval System to Create/Test Consistent Microwave-Sounder Retrievals

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Motivation for modular Retrieval

- Variety of Level 1b
  - ❑ Various ways of in re-calibration or side-lobe correction
    => you want to avoid such “tweaking” within the retrieval, keep it outside

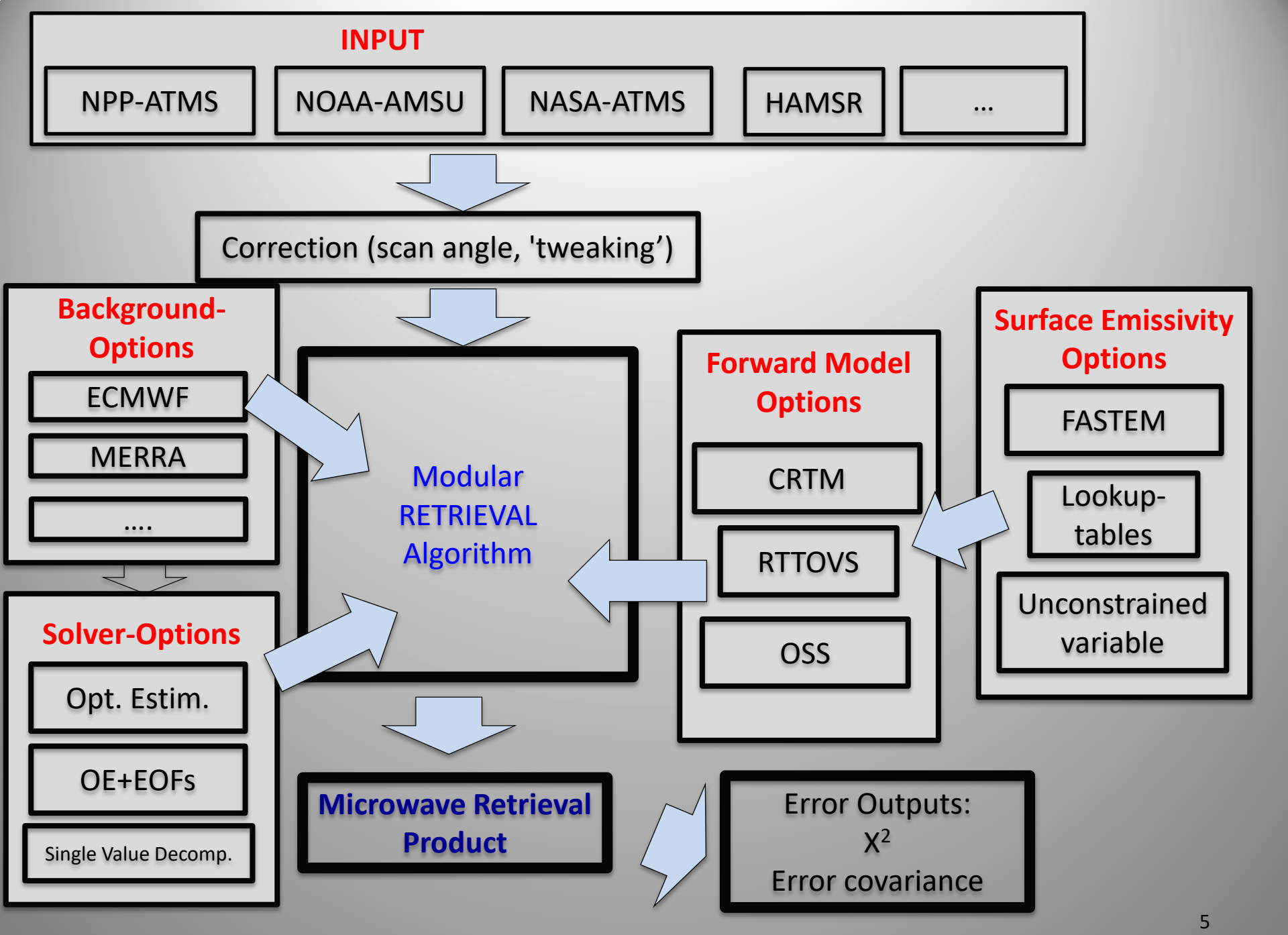
- Variety of forward models, which provide Jacobians, Adjoints, ...
  - ❑ CRTM, RTTOVS, ARTS,...
    => No need to do it yourself, but it affects speed and accuracy

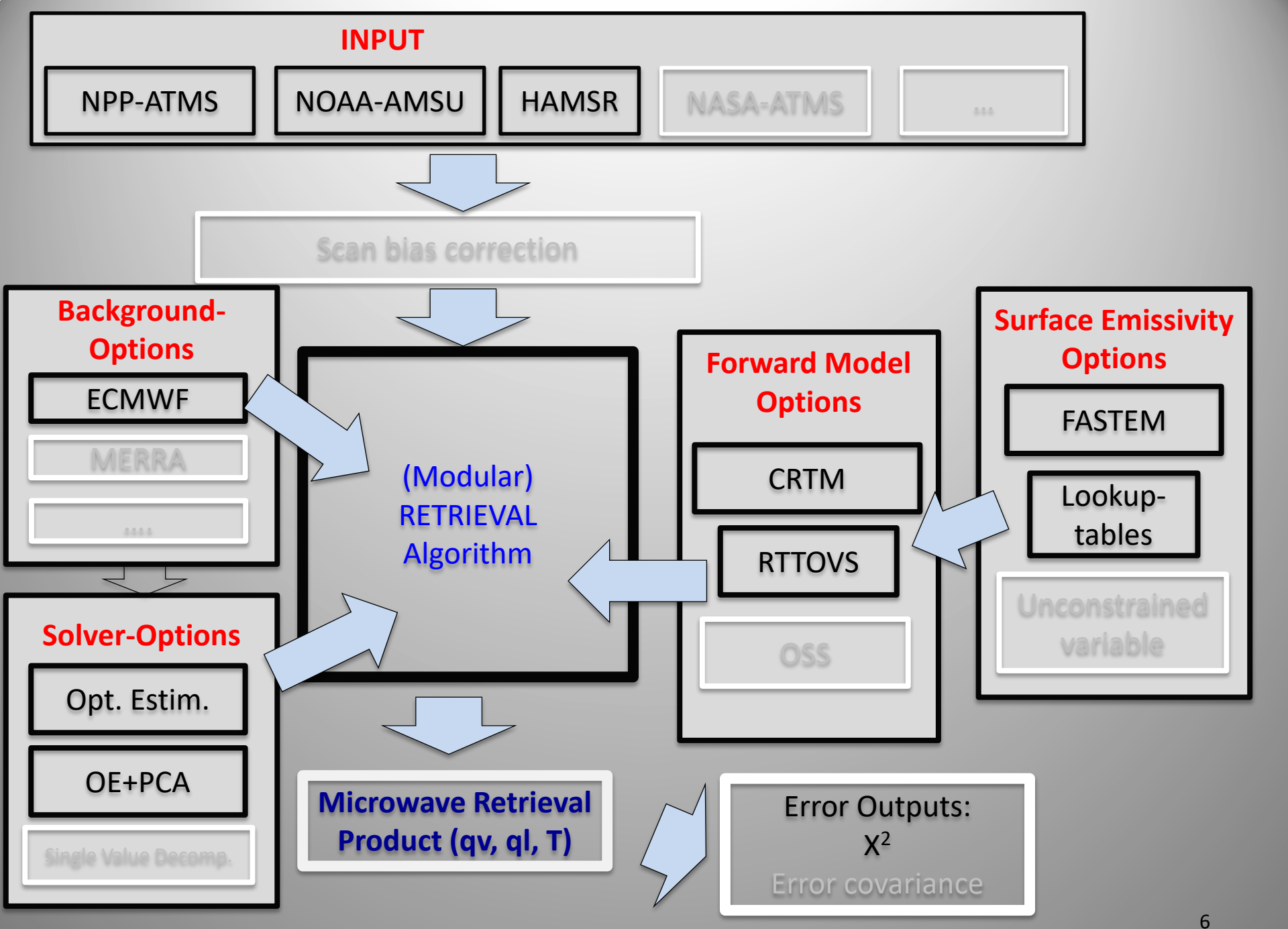
- Variety of retrieval approaches:
  - ❑ Optimal Estimation (with or without PCA), single value decomposition, ...
    => Hard to compare approaches and results if you don’t keep it modular

- Variety of possible a-priori information
  - ❑ ECMWF (Forecast, ERA-Interim) , MERRA, single standard profile

- Variety of interests:
  - ❑ Stratosphere, boundary Layer, polar regions, tropics

The big plan…


INPUT
NPP-ATMS
NOAA-AMSU
NASA-ATMS
HAMSR
...
Correction (scan angle, 'tweaking')
Background-Options
ECMWF
MERRA
....
Solver-Options
Opt. Estim.
OE+EOFs
Single Value Decomp.
Modular RETRIEVAL Algorithm
Forward Model Options
CRTM
RTTOVS
OSS
Surface Emissivity Options
FASTEM
Lookup-tables
Unconstrained variable
Microwave Retrieval Product
Error Outputs:
X2
Error covariance


INPUT
NPP-ATMS
NOAA-AMSU
HAMSR
NASA-ATMS
...
Scan bias correction
Background-Options
ECMWF
MERRA
....
Solver-Options
Opt. Estim.
OE+PCA
Single Value Decomp.
(Modular) RETRIEVAL Algorithm
Forward Model Options
CRTM
RTTOVS
OSS
Surface Emissivity Options
FASTEM
Lookup-tables
Unconstrained variable
Microwave Retrieval Product (qv, ql, T)
Error Outputs:
X2
Error covariance

For now:

- Established a modular environment in Fortran 2003 (gfortran)
- Connected Radiative Transfer Codes:
  - CRTM
  - RTTOVS
- Algorithm: PCA-based Optimal Estimation
  - Solver: lmbm (limited memory bundle method, Napsu Karmitsa)
- Possible input files:
  - ATMS-NPP (h5)
  - AMSU and MHS (binary CLASS-files)
  - HAMSR (netcdf)
- A-priori:
  - ECMWF (grib)
  - Single profile
- The only “tweaking-parameters” : Covariance Matrix and Noise
  - These Matrices may be updated by stay the same for all calculations

Some very preliminary Comparisons

Shown:

- X^2 (difference observed, calculated)
- Retrieved profiles: Temperature, water vapor, liquid water

Parameters, which can change from slide to slide (indicated in red):

- RTA: CRTM or RTTOVS
- A-priori : FIXED profile or ECMWF
- Instrument data : ATMS, AMSU-A, MHS, ATMS-NASA – no corrections

What will - most times - stay the same:

- Approach: PC-based OE, using Adjoints
- Solver: lmbm
- Surface calculation: FASTEM-5
- Principal Components: 5
- Always 20 iterations, no convergence stopping point
- Very open “constraints”: Covariance matrix

RTA: CRTM vs. RTTOV

INPUT:

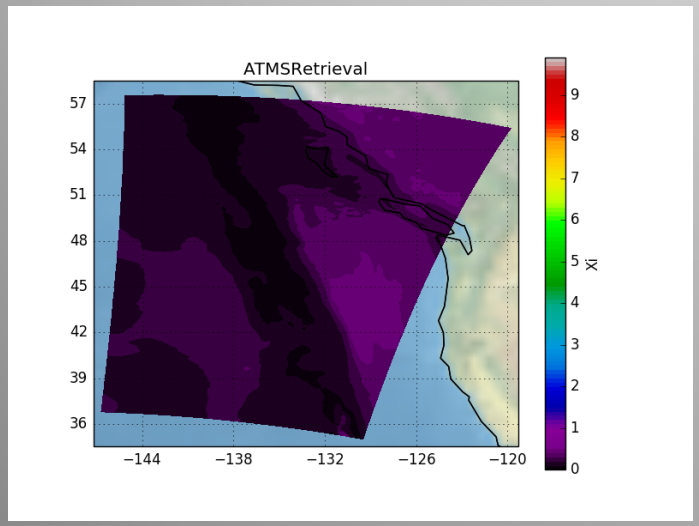
- Instrument data : ATMS – no corrections
- A-priori : FIXED standard profile
- Solver: OE (5 PC, 20 iterations)

RESULT:

- Similar Speed
- RTTOV needs more initialization time
- Overall similar outcome

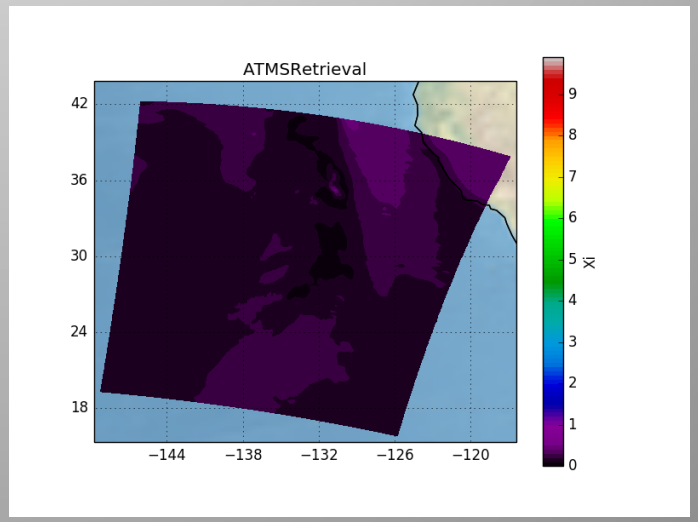
RTTOV

- Speed : ~50 ms/iteration, init : 5 s



CRTM

- Speed: ~50 ms/iteration, init: ~1s



Temperature retrieved against ECMWF

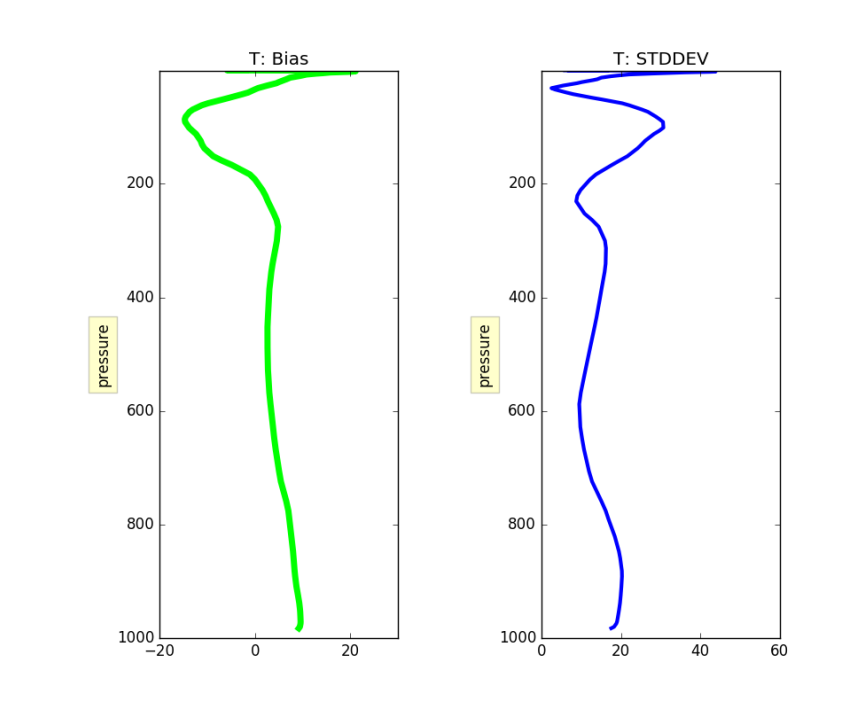
INPUT:

- Instrument data : ATMS – no corrections
- A-priori : FIXED
- Solver: OE (5 PC)

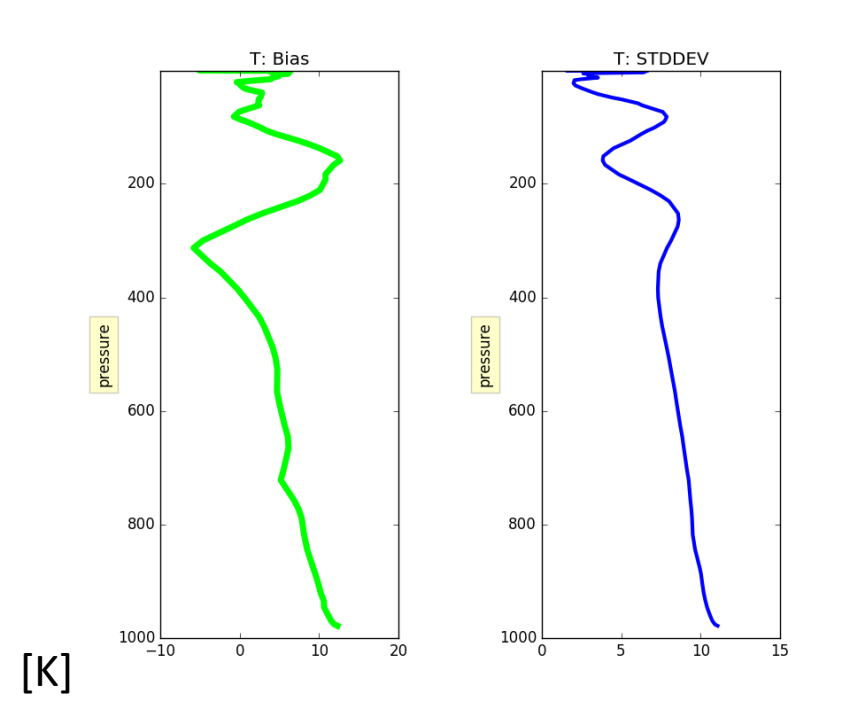
RESULT:

- With RTTOV: lower bias, opposite to before
- With CRTM : higher bias

RTTOV



CRTM



Temperature retrieved against ECMWF

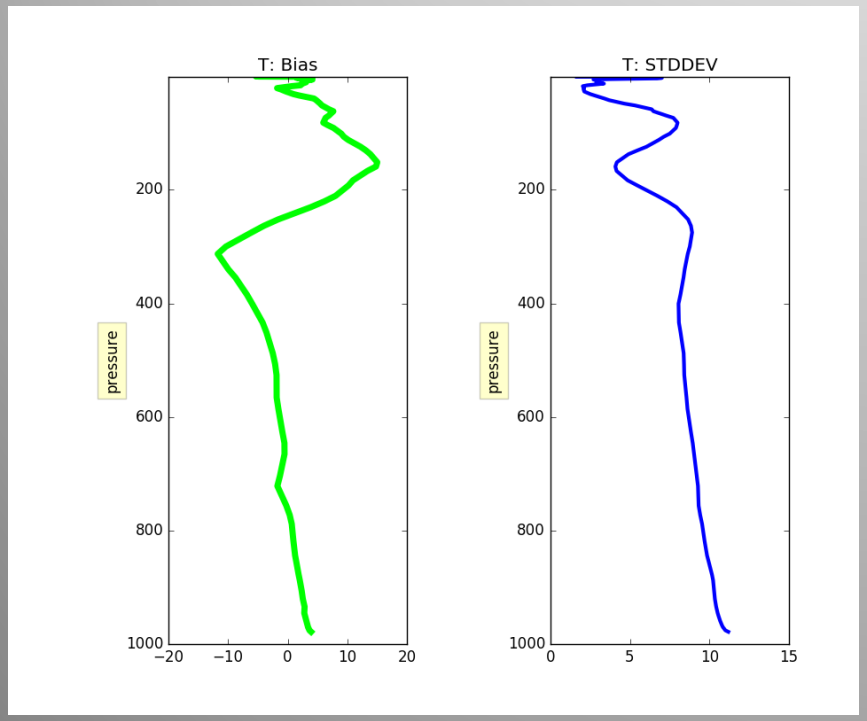
INPUT:

- Instrument data : ATMS – no corrections
- A-priori : ECMWF
- Solver: OE (5 PC)

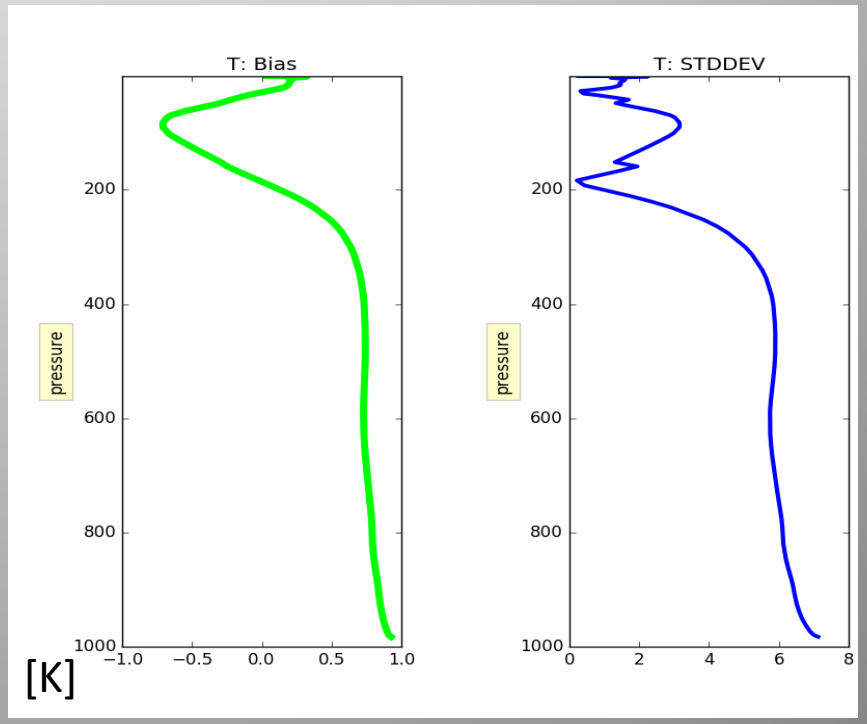
RESULT:

- With RTTOV : Warmer than ECMWF in troposphere, warmer above
- With CRTM : smaller bias

RTTOV



CRTM



Water vapor retrieved against ECMWF

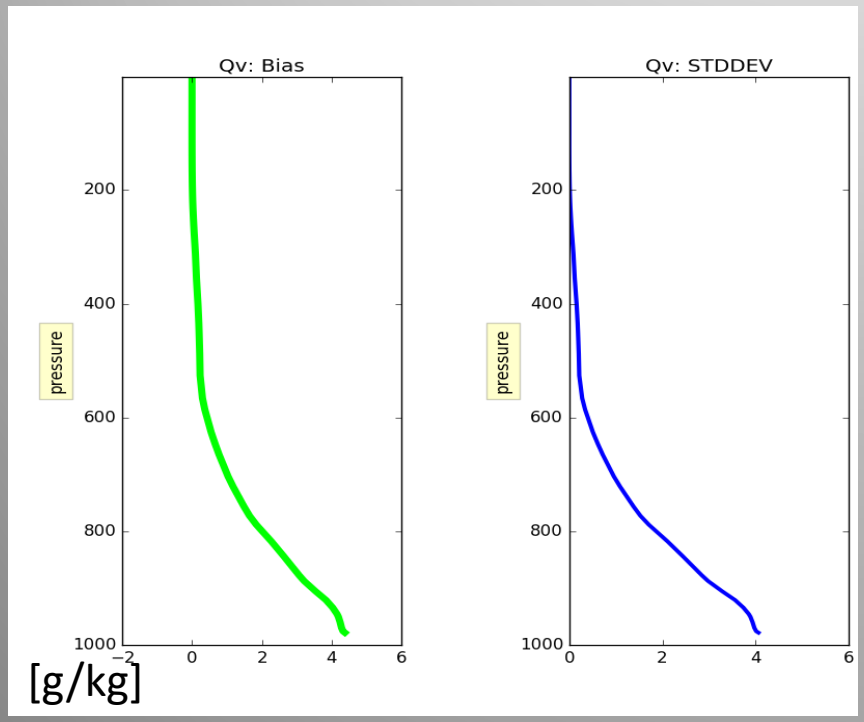
INPUT:

- Instrument data : ATMS – no corrections
- A-priori : FIXED
- Solver: OE (5 PC)

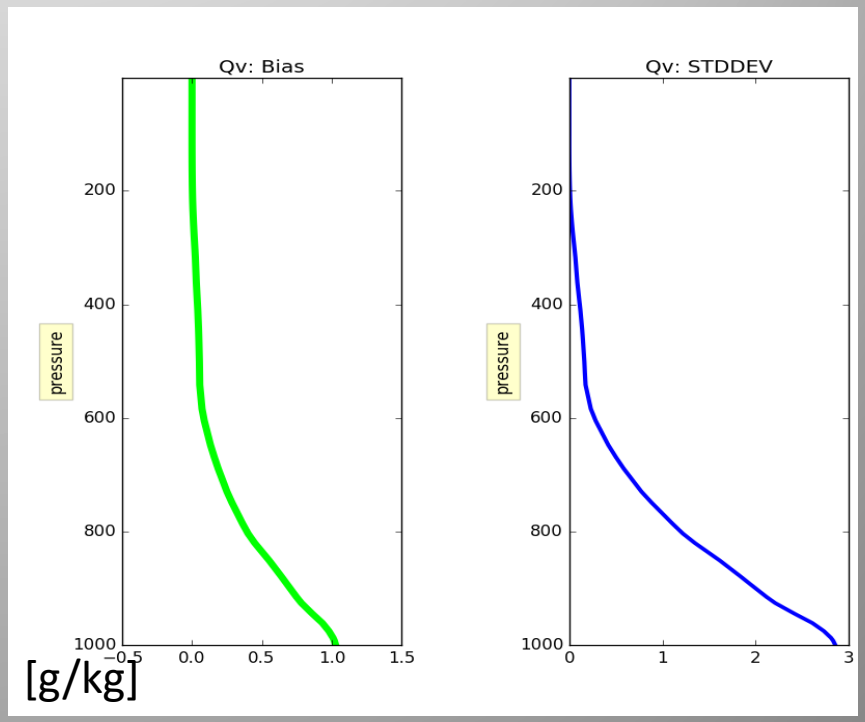
RESULT:

- With RTTOV: strong increase in boundary layer Qv
- With CRTM: still increase, but smaller

RTTOV



CRTM



Water vapor retrieved against ECMWF

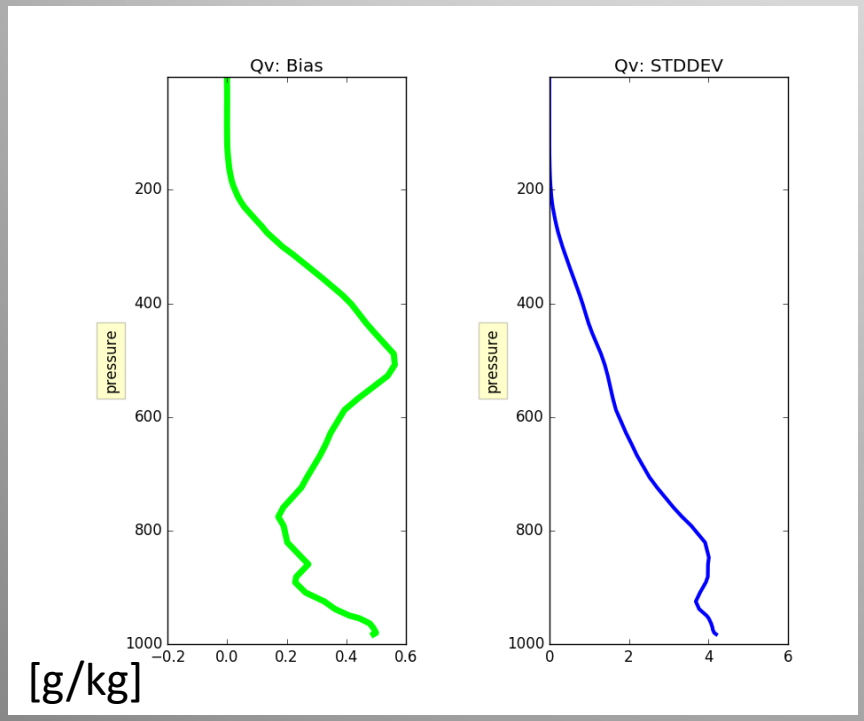
INPUT:

- Instrument data : ATMS – no corrections
- A-priori : ECMWF
- Solver: OE (5 PC)

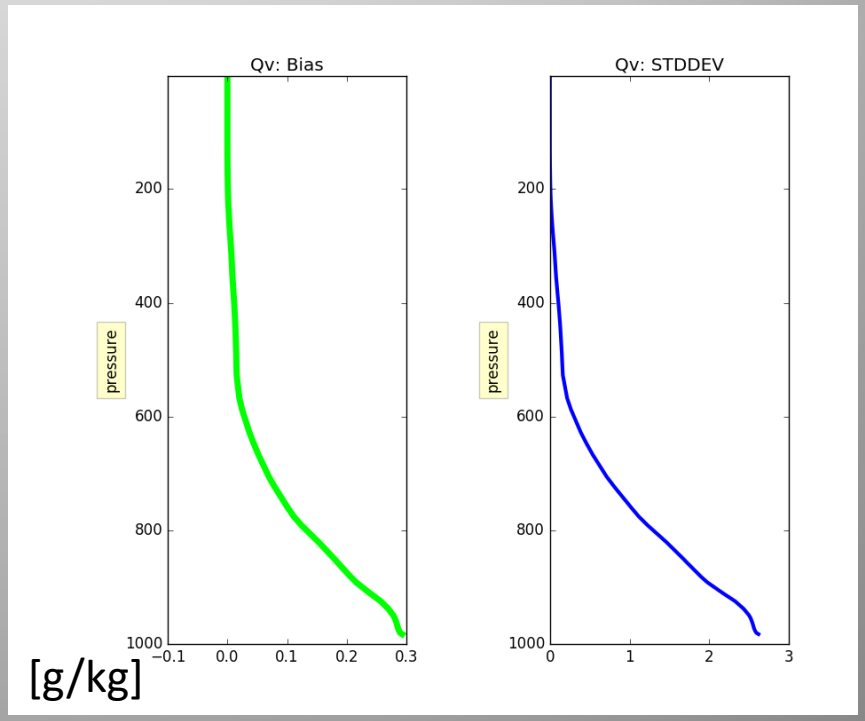
RESULT:

- With RTTOV: slightly higher than ECMWF
- With CRTM : smooth increase, low STD
- Both stay close to ECMWF

RTTOV



CRTM



Liquid water retrieved against ECMWF

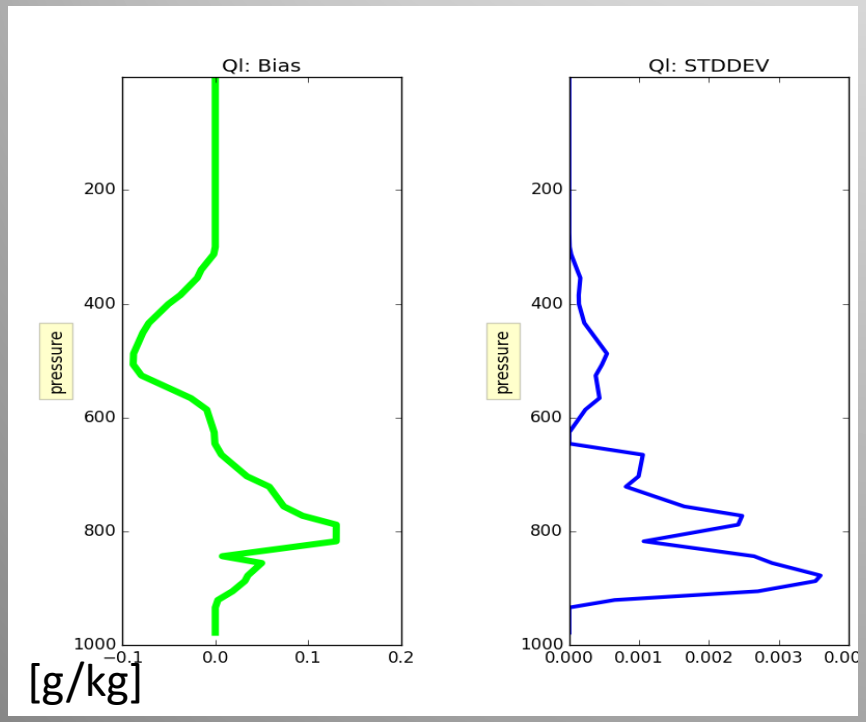
INPUT:

- Instrument data : ATMS – no corrections
- A-priori : FIXED
- Solver: OE (5 PC)

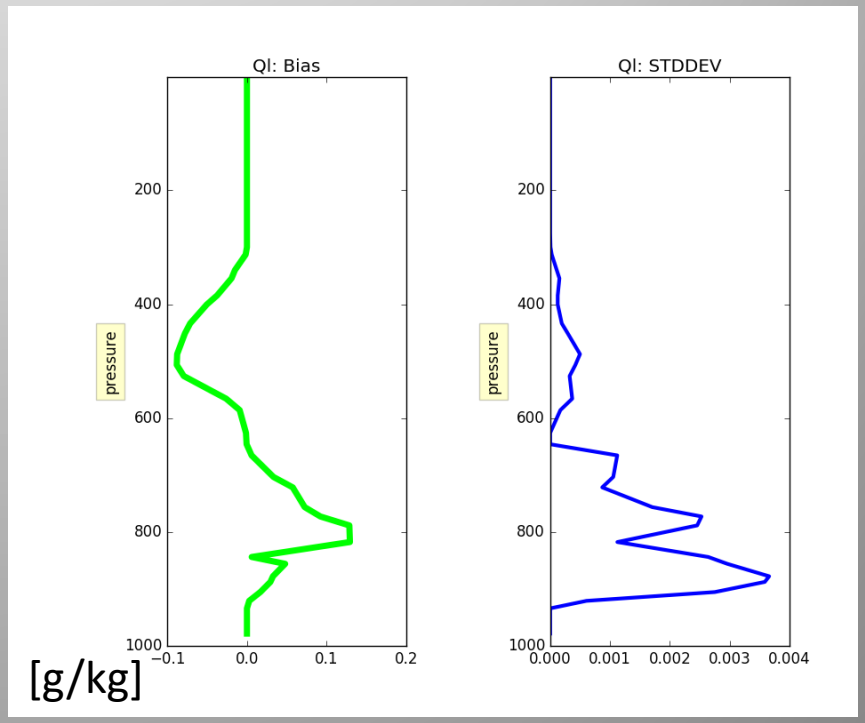
RESULT:

- With RTTOV: strong increase
- With CRTM : surprisingly similar
- A-priori profile/Covariance dominates

RTTOV



CRTM



Liquid water retrieved against ECMWF

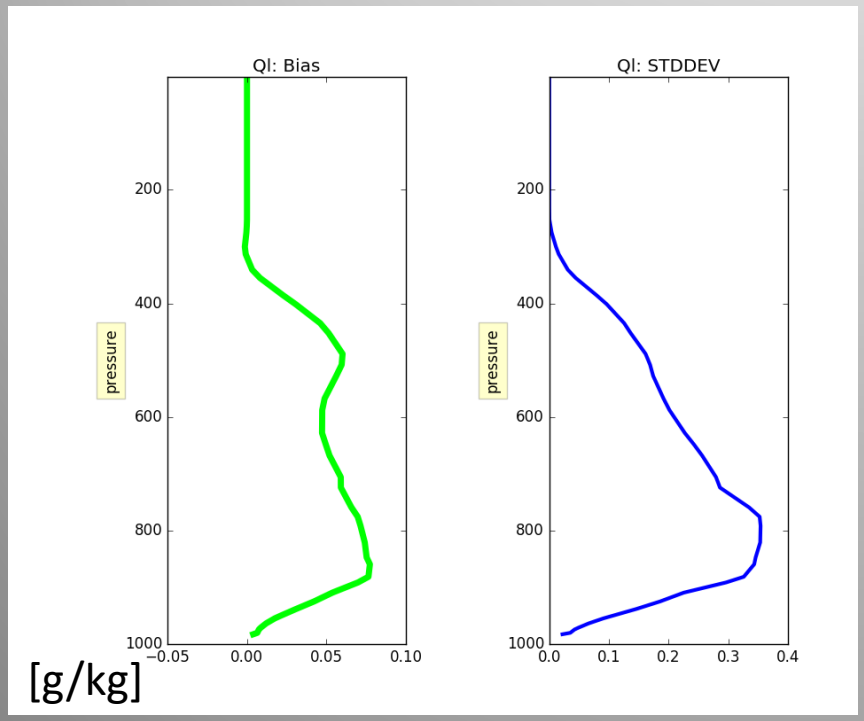
INPUT:

- Instrument data : ATMS – no corrections
- A-priori : ECMWF
- Solver: OE (5 PC)

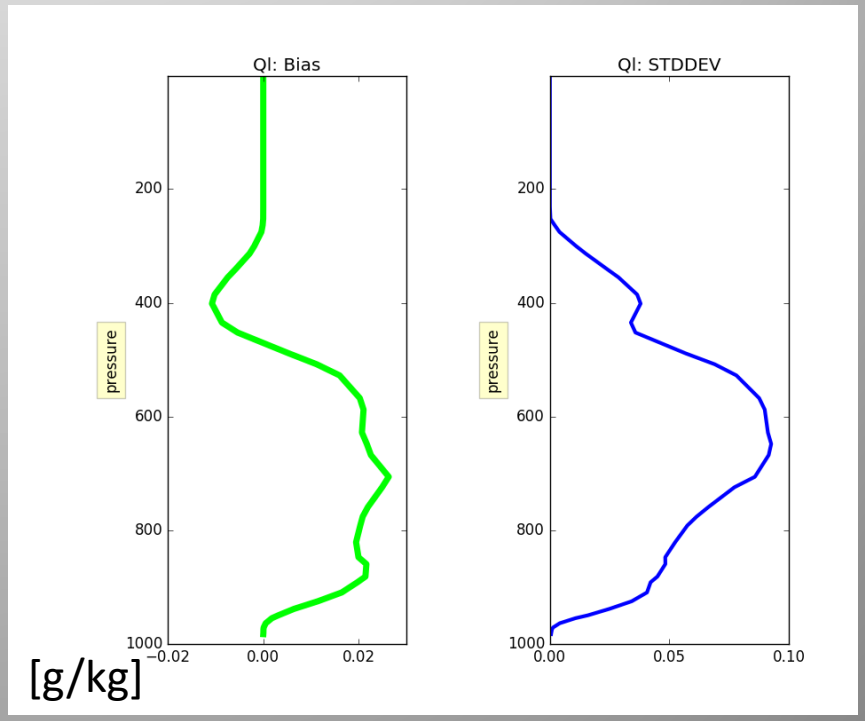
RESULT:

- With RTTOV: only slight increase, but high STDDEV
- With CRTM : similar, lower STDDEV

RTTOV



CRTM



Increase in PCs – water vapor

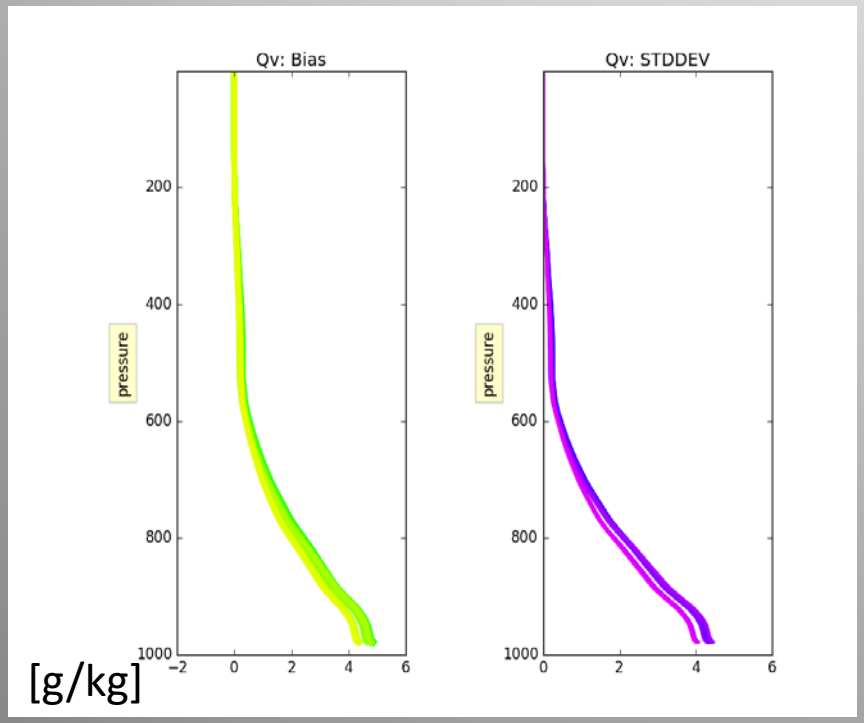
INPUT:

- Instrument data : ATMS – no corrections
- A-priori : FIXED
- Solver: OE (3,5, 7,10, 15, 20 PC)

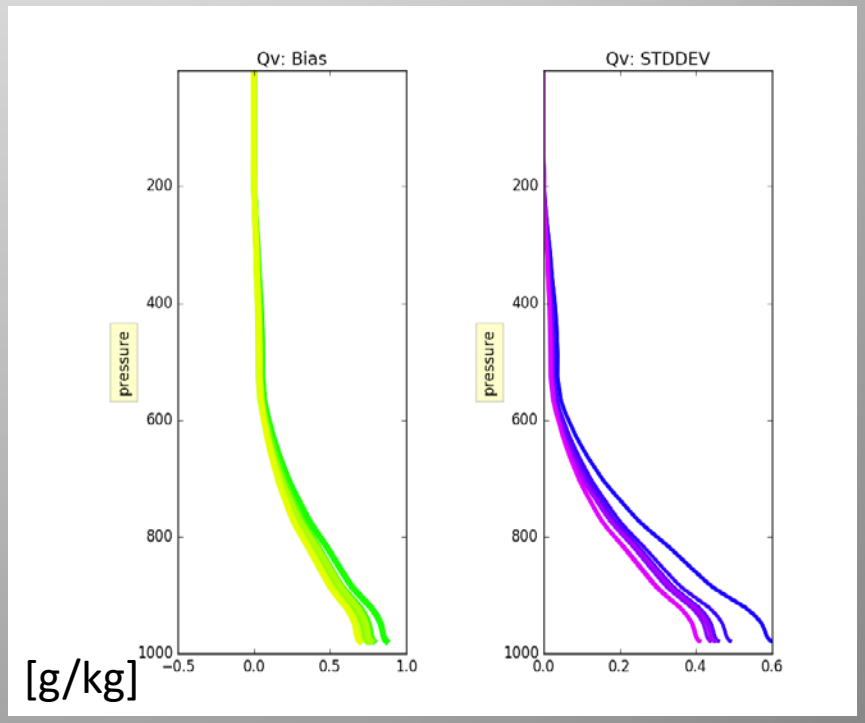
RESULT:

- Negligible impact on speed for RTTOV, small impact on CRTM
- Affects CRTM more than RTTOV calcs

RTTOV



CRTM



AMSU-A retrieval

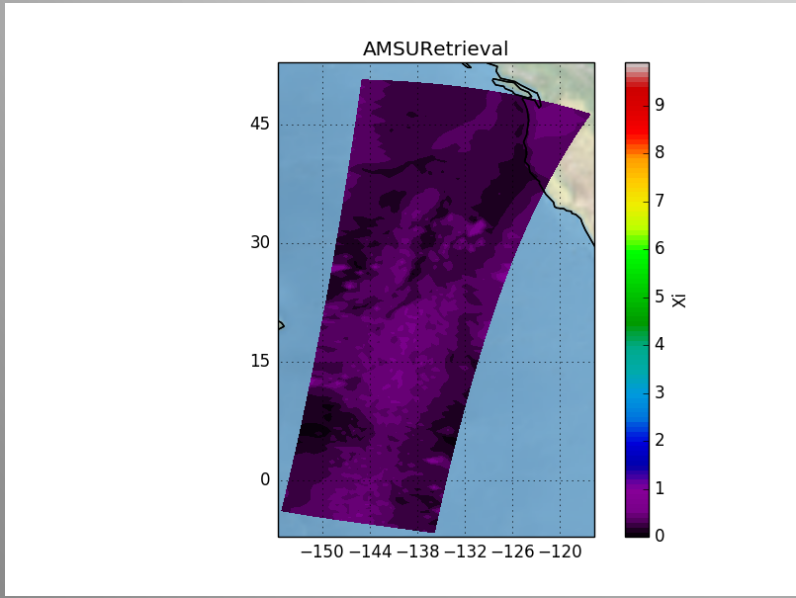
INPUT:

- Instrument data : AMSU-A/B – no corr.
- A-priori : FIX
- Solver: OE (5 PC)

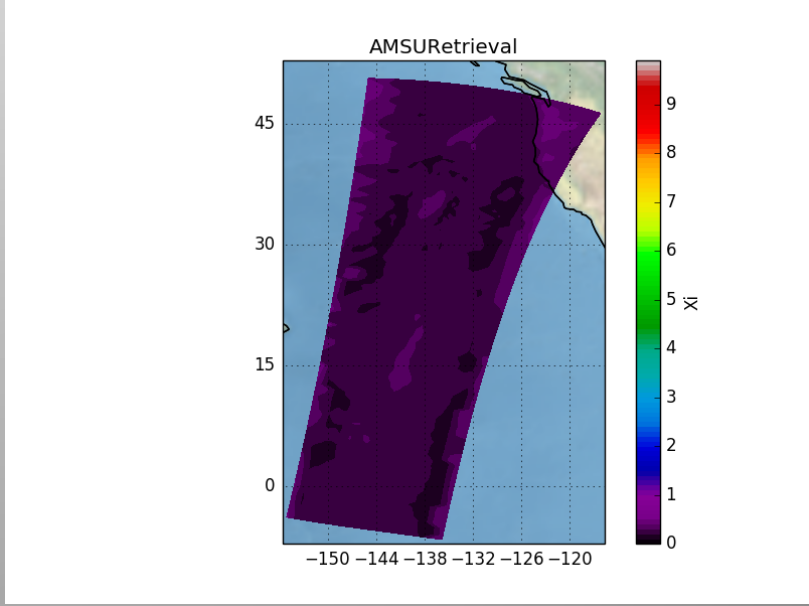
RESULT:

- CRTM looks better than RTTOV

RTTOV



CRTM



MHS retrieval

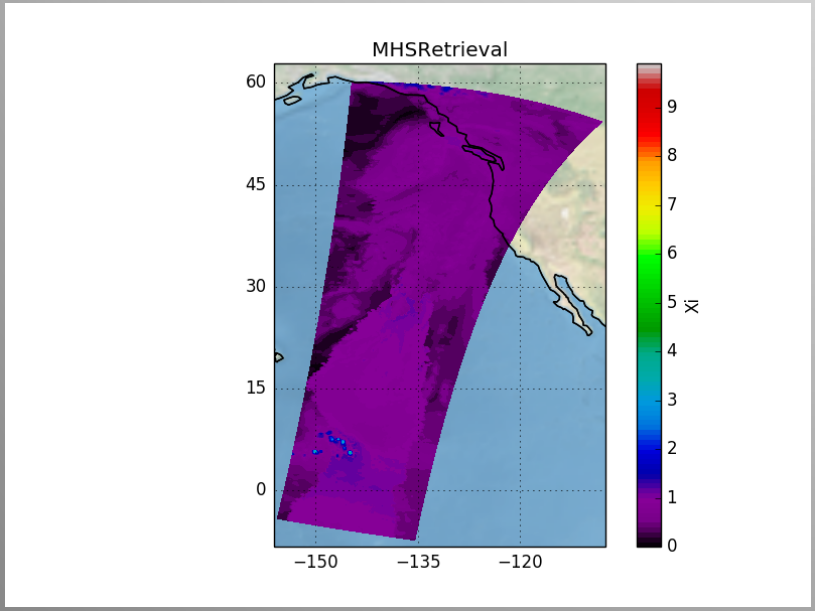
INPUT:

- Instrument data : AMSU-A/B – no corr.
- A-priori : FIX
- Solver: OE (5 PC)

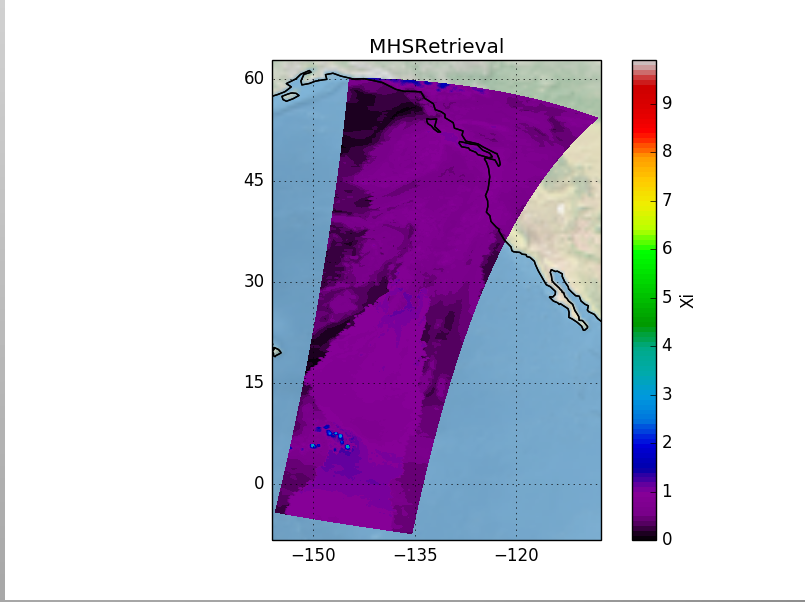
RESULT:

- RTTOV looks good, but CRTM looks better

RTTOV



CRTM



Conclusion

- We developed a upgradable modular retrieval system for MW-Instruments

- The selection of the forward model (RTTOV, CRTM) does only marginally affect the iteration speed
- But it affects the results (Both have a lot of flags ...)
  - CRTM is very sensitive to a-priori
  - RTTOV results seem to be “more resistant”

- Both keep very close to a-priori in the case of liquid water, despite relaxed covariance

- More than principal components then 95% affect mainly the STDDEV, not so much the results

- AMSU and MHS run too, CRTM results look slightly better than RTTOV

Part 2: Testing of new ATMS L1b-data created by SIPS

Motivation

New version of ATMS L1b data in netcdf, created by SIPS at JPL.

The first goal was to get similar results than the old ATMS-data, based on L0-files.

I looked on differences between old ATMS NPP data (h5) and new SIPS data (beta version 0_9) with respect to

- Brightness Temperatures
- Geo-location
- This was done for several randomly selected data from 7-11 April

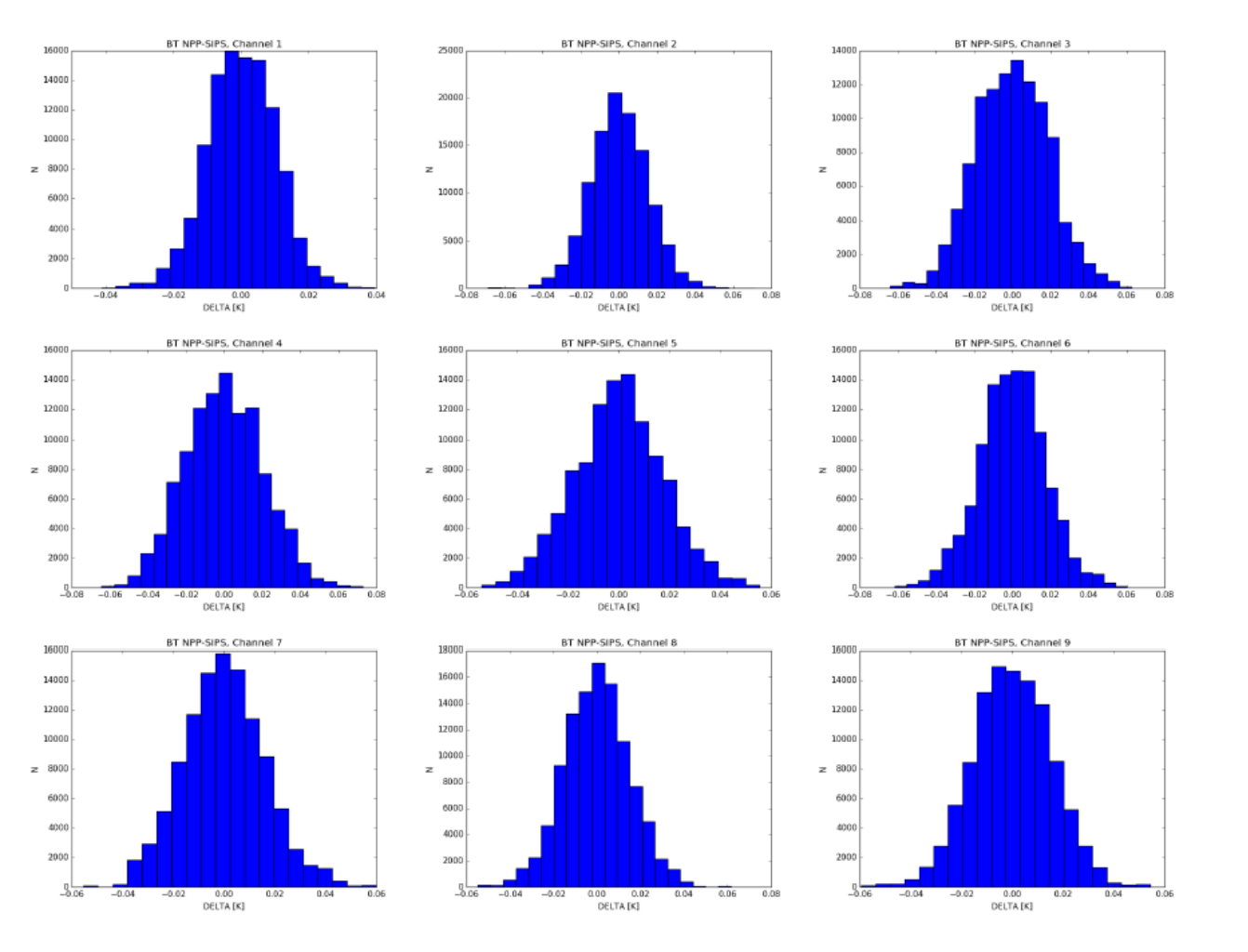
Main results

- Brightness Temperatures fit almost perfectly
- Most channels show differences way below +/- 0.1 K (see attached histograms)
- Exceptions: Channels 13-15 can go up to 0.1 and more
- This s to be expected, because they are supposed to be the most noisy ones and specific things like weighting functions are not exactly the same

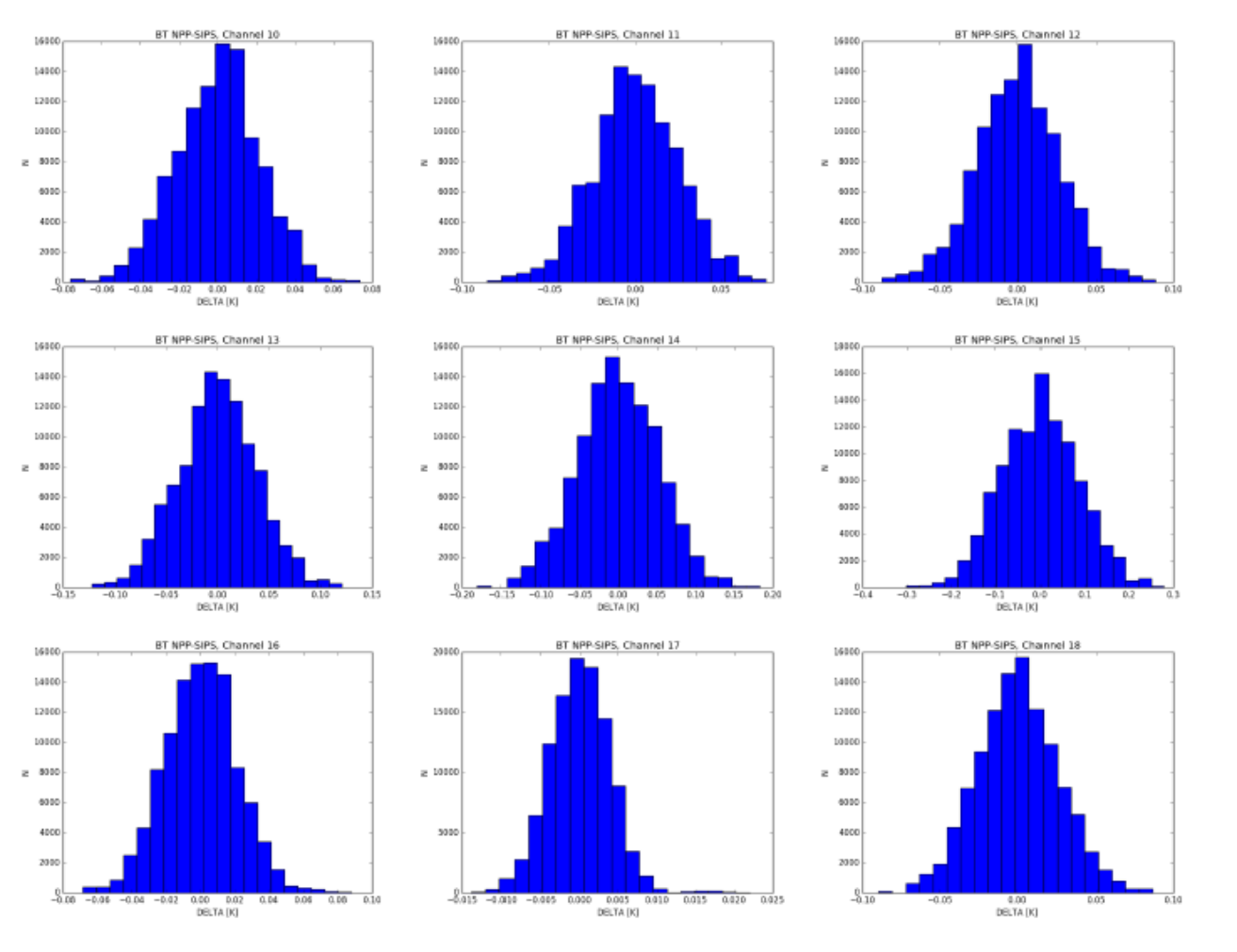
- Geolocation (Lat, Lon) ts within 0.1 km

- EVERYTHING LOOKS FINE !

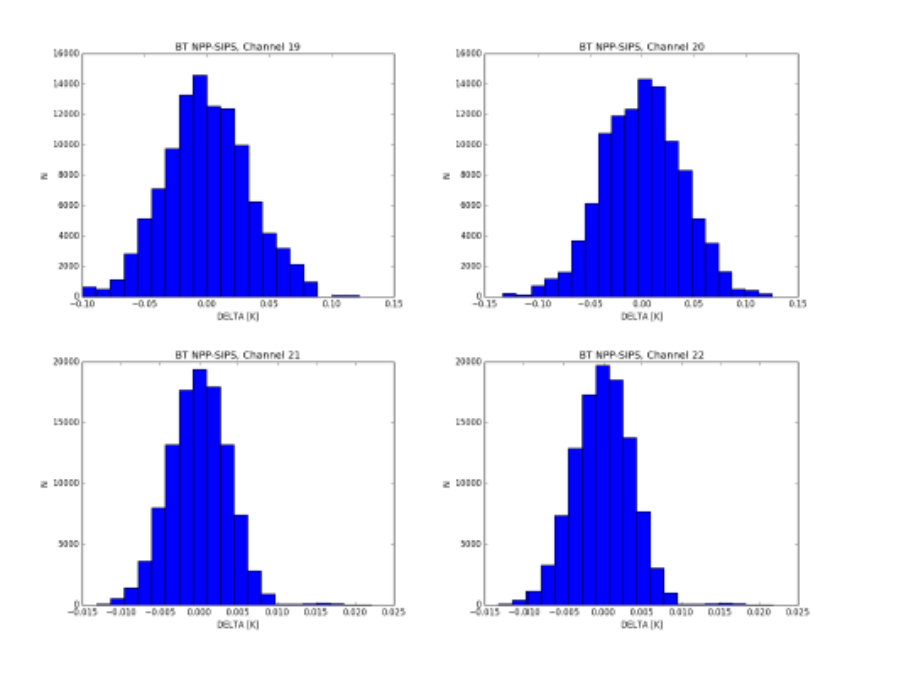
Histograms of ΔT_b



Additional stuff – Histograms of ΔT_b



Additional stuff – Histograms of ΔT_b



Additional stuff

- Brightness Temperature differences show "striping" (see plot after Histograms)
- The striping should be of no concern, because it is small.

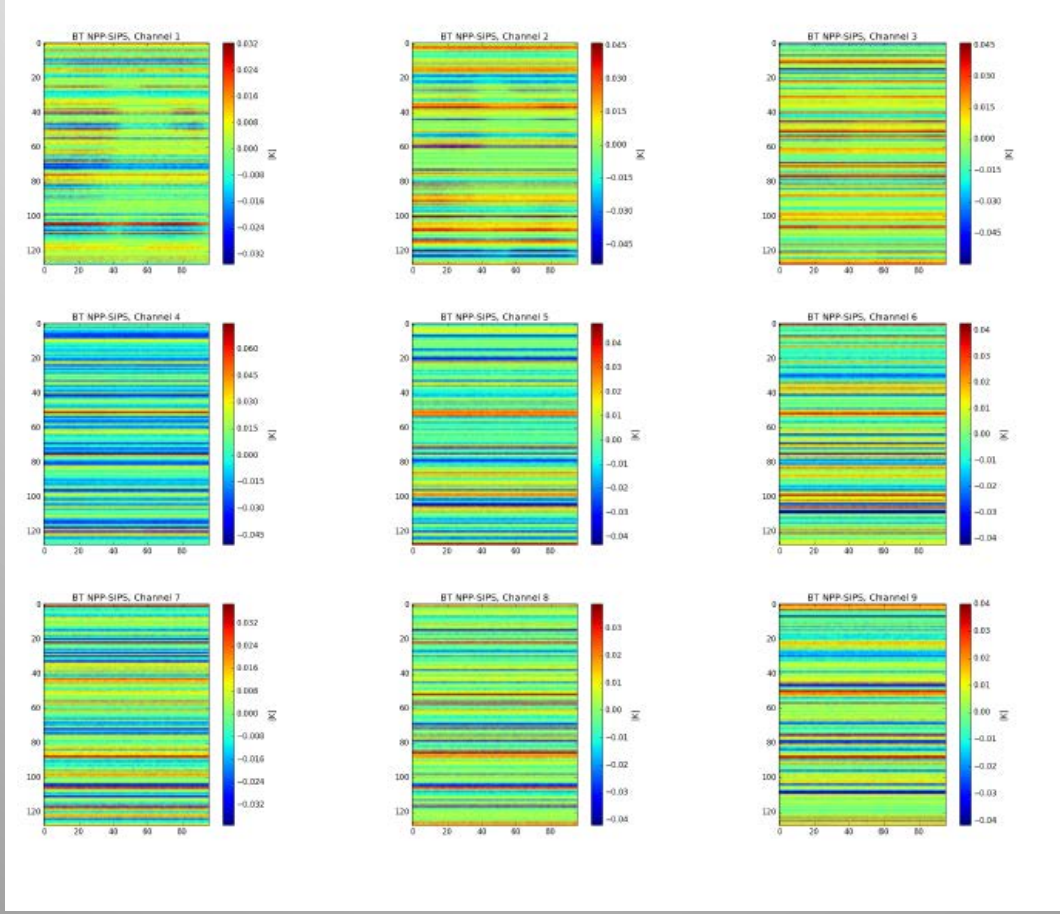
- It seems to be the result of slightly different calibration approaches, weighting functions or rounding errors

- Geolocation shows random differences of up to 4 km (see plot "Distances”)

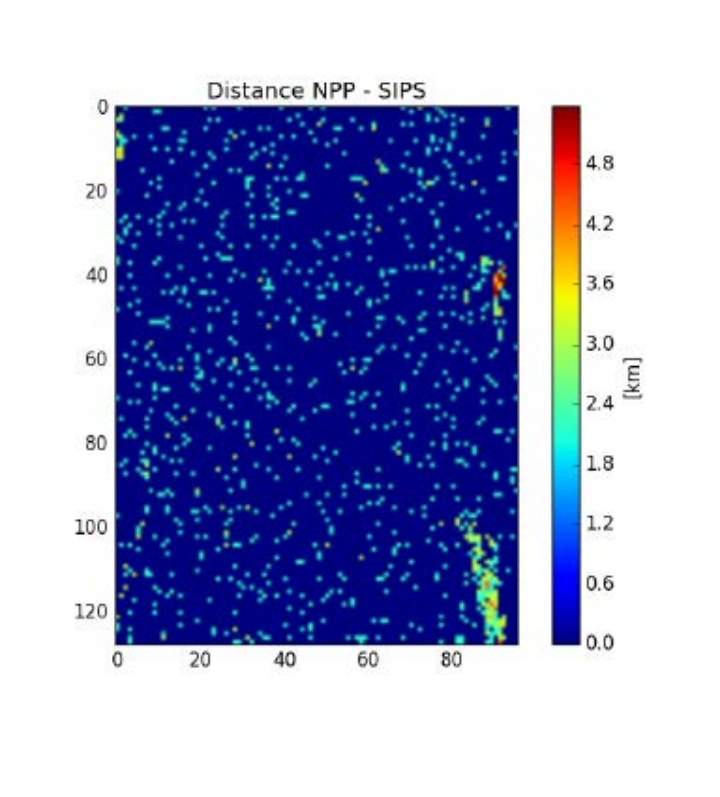
- This random fluctuation is the result of very small differences in lat/lon (see detailed analysis of one selected point)

- It could result of a rounding error, also on my side during the analysis

Additional stuff – Striping



Additional stuff – discrepancy in Lat/Lon



Shows the distance of center points from Lat/Lon data

Center point variation can be up to 5 km

Might be due to differences in Lat/Lon estimate (geoid, terrain)

Additional Remark

The problem of continuity

When I tried to compare data over a whole day, I run into problems because if several reasons:

- Different range of time for nc-files (6 min) and h5-files (8 min)
- Old h5-ATMS-files are not always continuous - seems there are files missing. Not so easy to figure out because of weird time (start/end) stamp
- Old h5-ATMS files are also sometimes double or triple: the archive keeps every reprocessing. Sometimes with variable time (start/end) stamps

Conclusion

New L1b-beta looks almost the same as old L1b.
But files are easier to handle ...