Status of GPS Radio Occultation Processing at JPL

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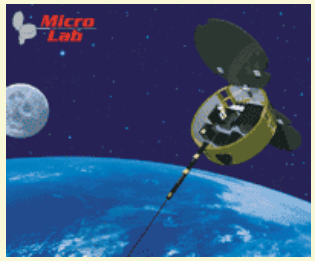
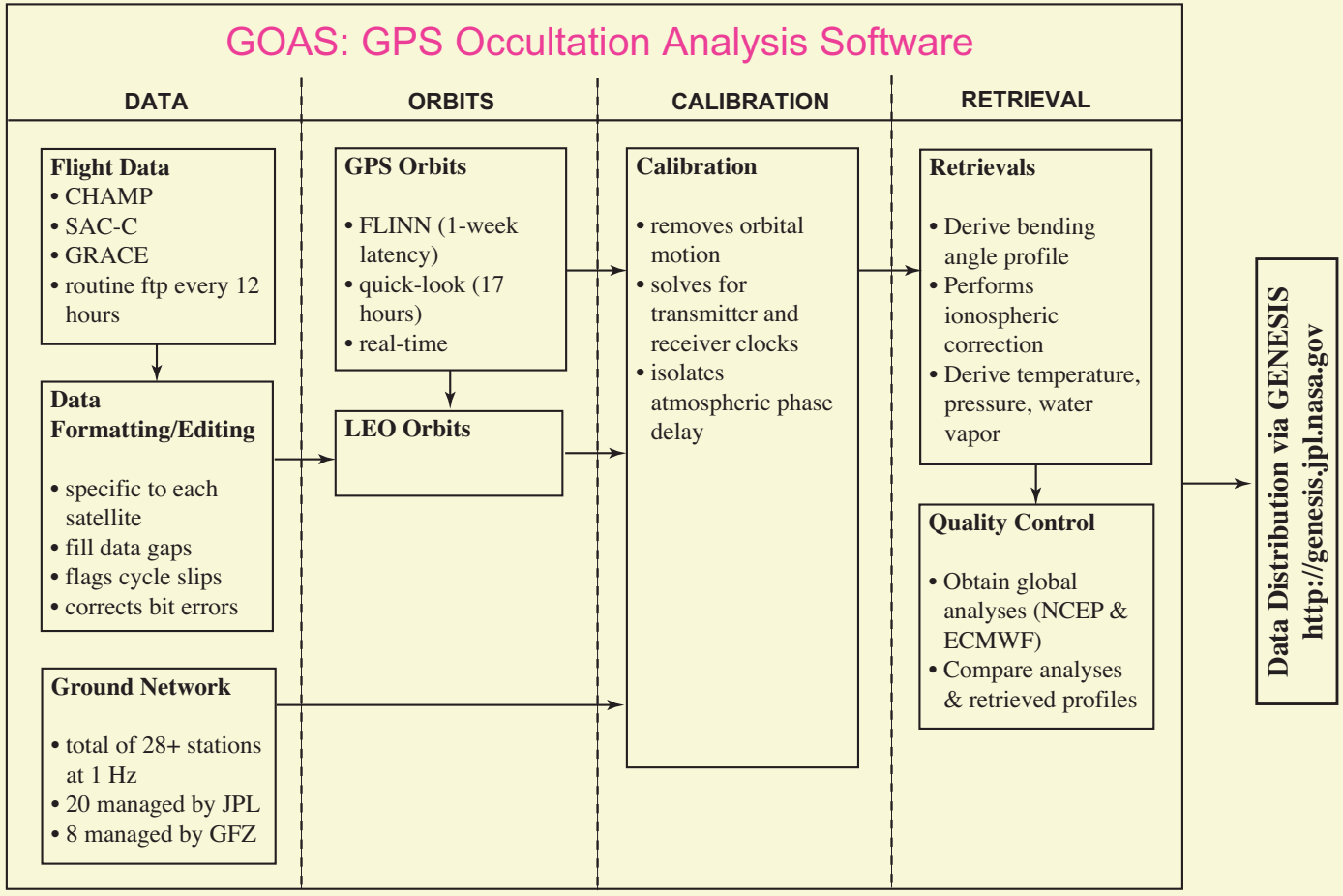


Outline

1. Data processing status (CHAMP, SAC-C, GRACE)
2. Retrieval evaluation, comparison with analyses
3. Main areas of retrieval uncertainty

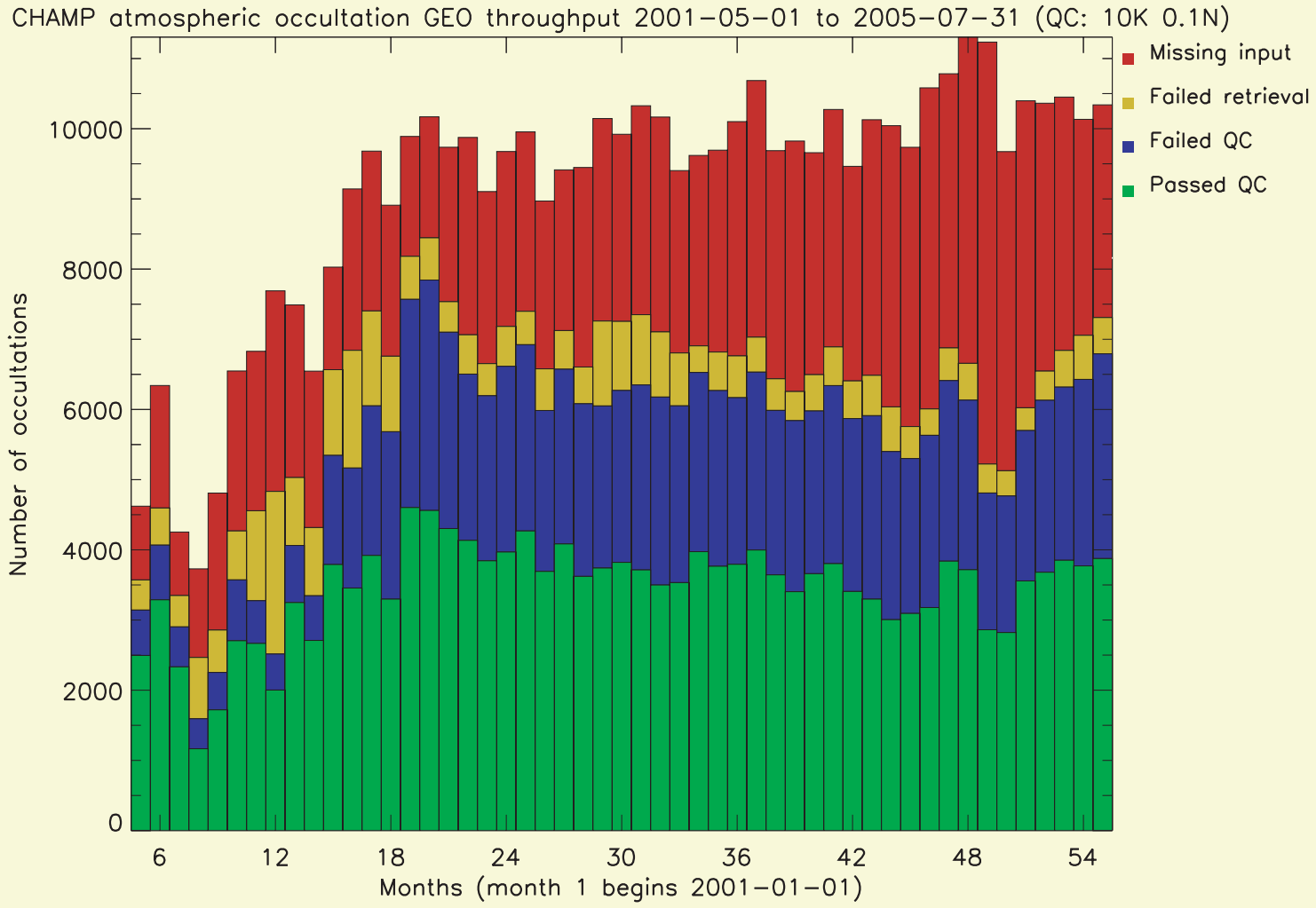
Processing System



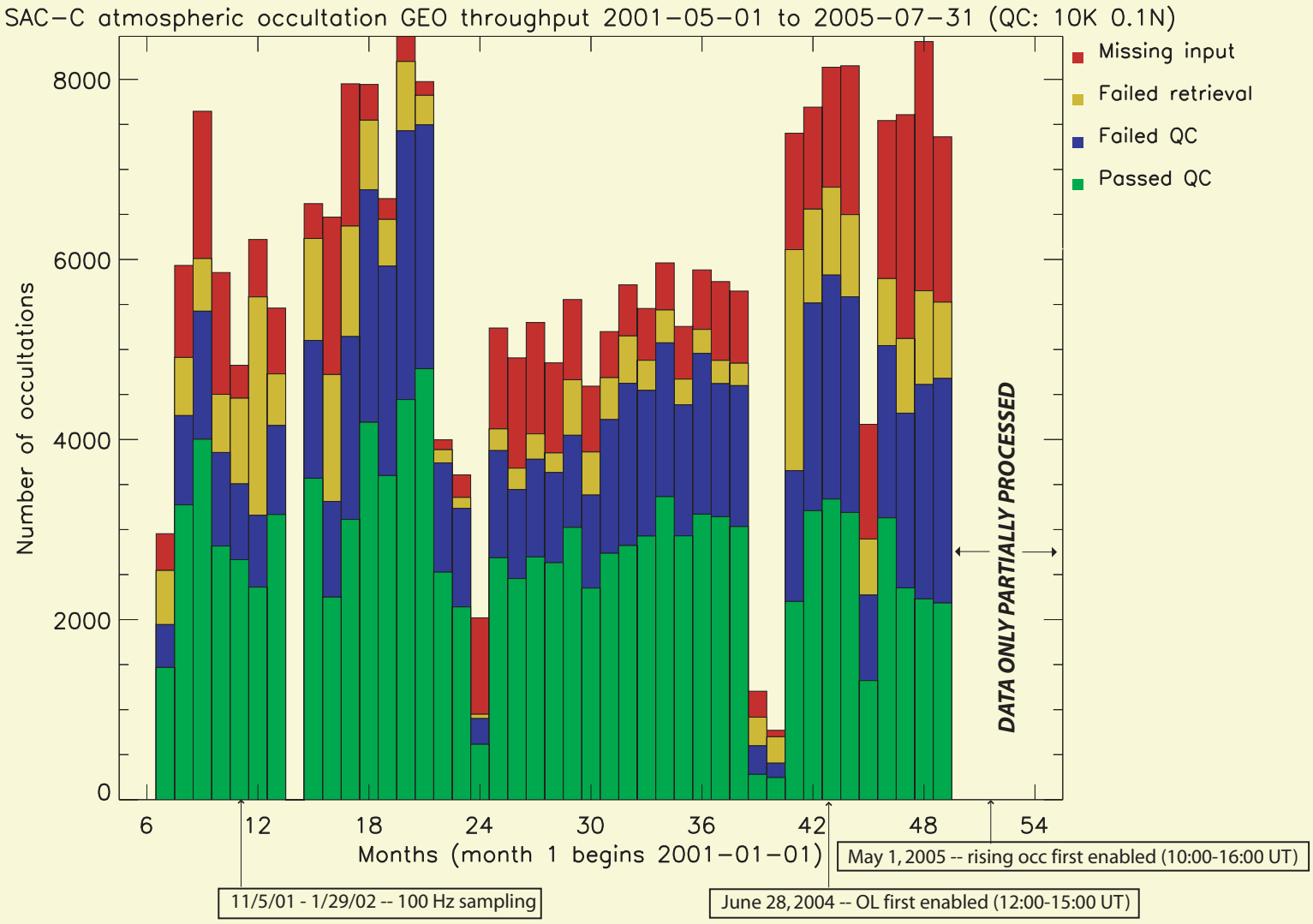
ROSS: Radio Occultation Simulation Software

End-to-end simulation tools include simulation of receiver tracking software, ray-tracing and diffraction-based forward simulations

CHAMP (v.1)

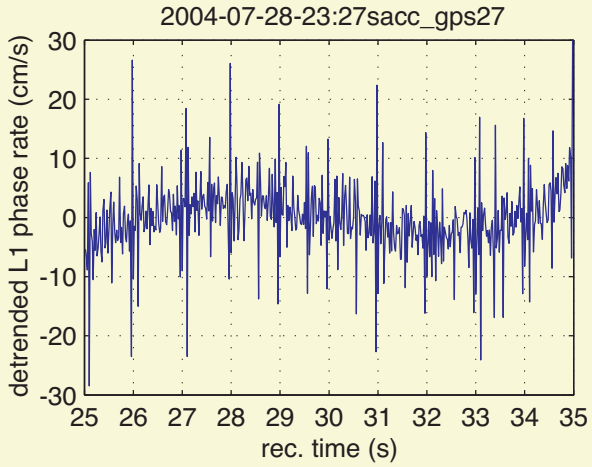

CHAMP atmospheric occultation GEO throughput 2001−05−01 to 2005−07−31 (QC: 10K 0.1N)
Missing input
Failed retrieval
Failed QC
Passed QC
Number of occultations
0
2000
4000
6000
8000
10000
6
12
18
24
30
36
42
48
54
Months (month 1 begins 2001−01−01)

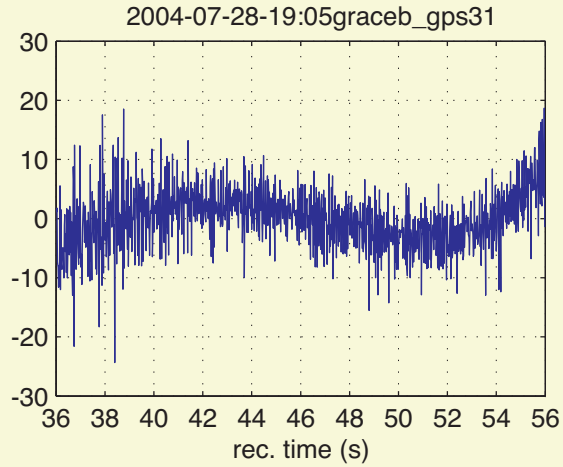
SAC-C (v.1)

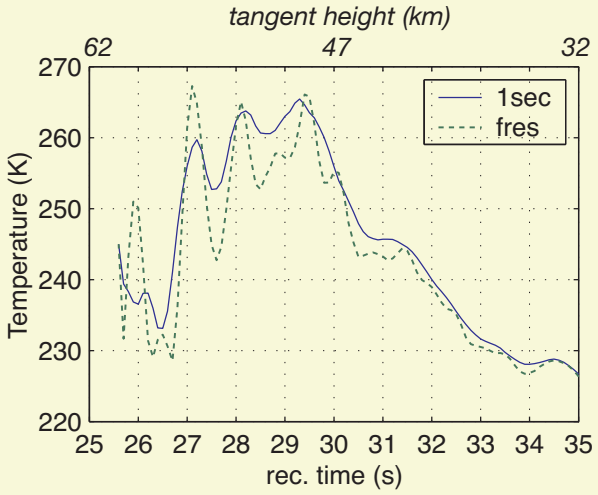

SAC−C atmospheric occultation GEO throughput 2001−05−01 to 2005−07−31 (QC: 10K 0.1N)
Missing input
Failed retrieval
Failed QC
Passed QC
Number of occultations
0
2000
4000
6000
8000
6
12
18
24
30
36
42
48
54
Months (month 1 begins 2001−01−01)
DATA ONLY PARTIALLY PROCESSED
11/5/01 - 1/29/02 -- 100 Hz sampling
June 28, 2004 -- OL first enabled (12:00-15:00 UT)
May 1, 2005 -- rising occ first enabled (10:00-16:00 UT)

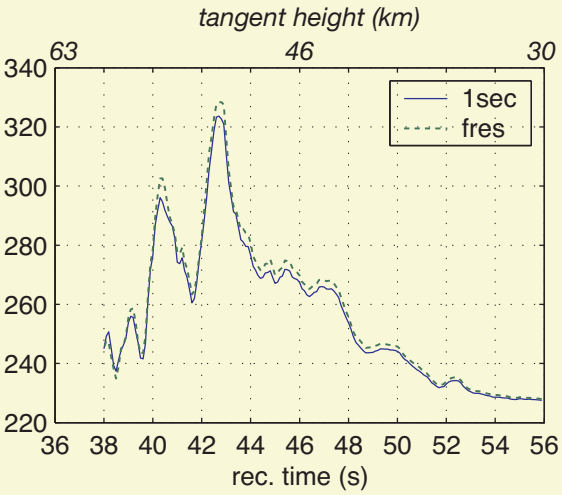
GRACE

- Setting occultation from GRACE-B was turned on for testing during July 28–29, 2004, Nov. 27–Dec. 8, 2004.





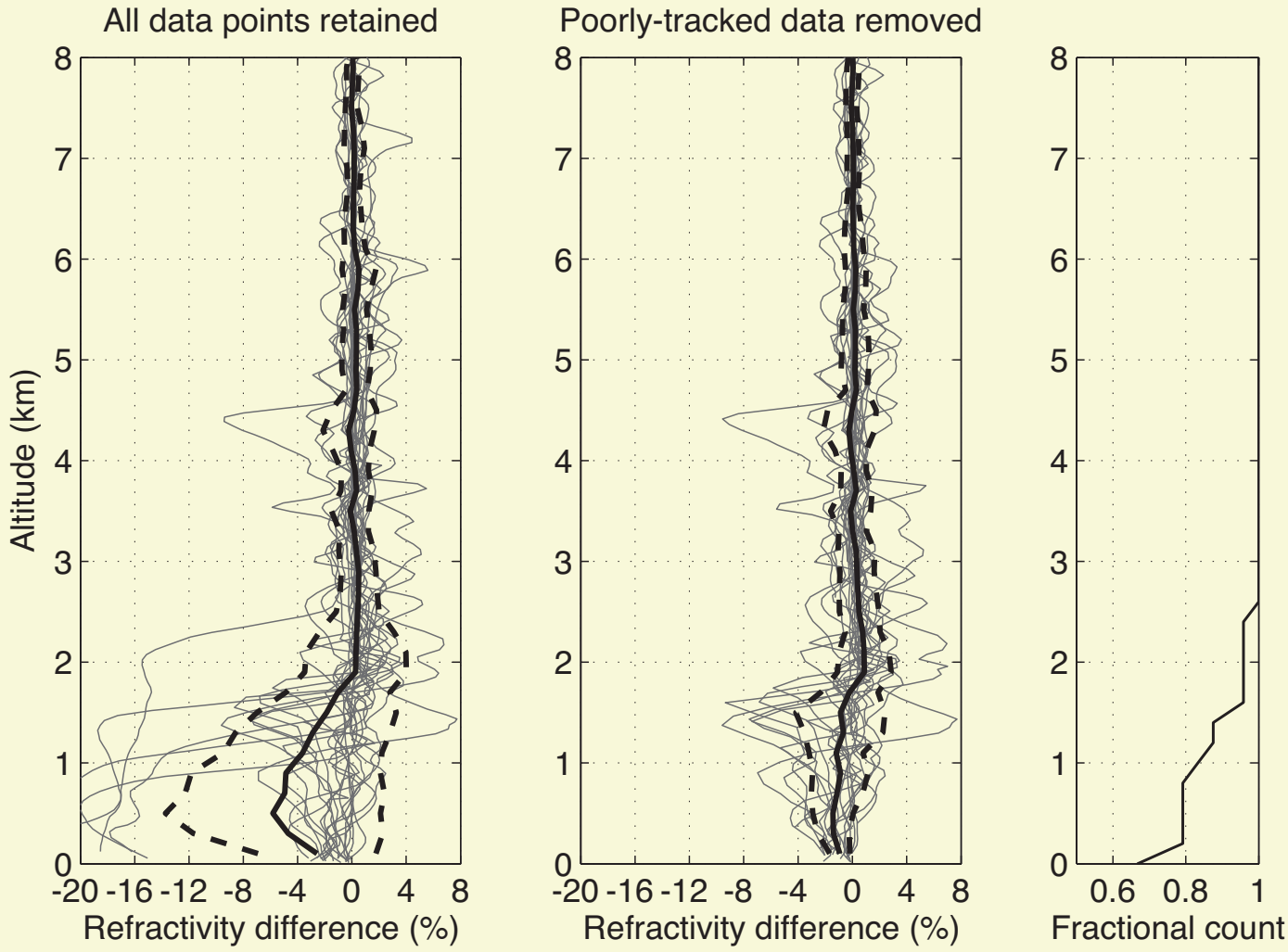




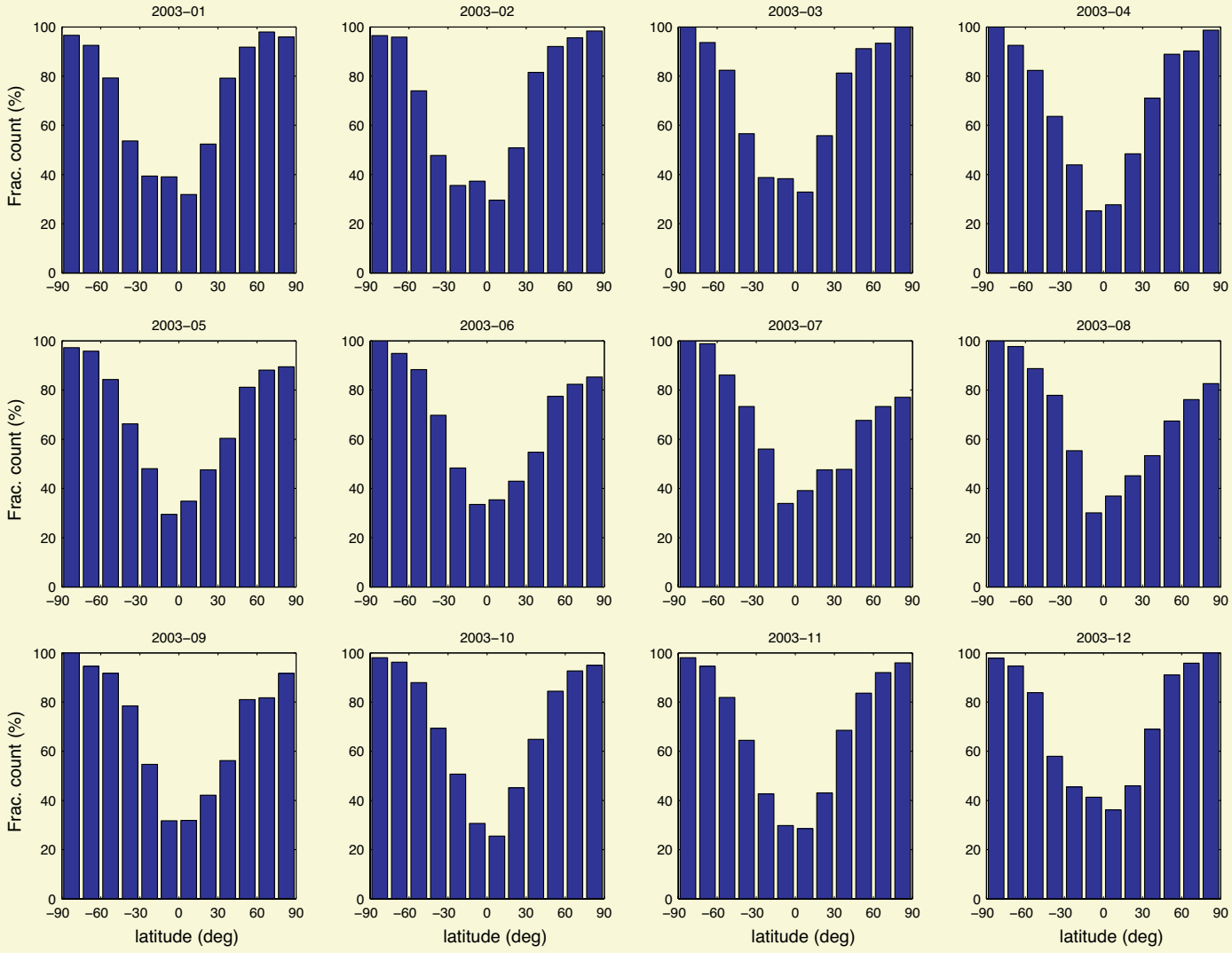
V2 Retrieval Features

- Canonical transform (FFT implementation) used below 30 km
- 200 m vertical resolution below 20 km
- Lowest altitude cutoff based on two criteria
  - Pre-CT (based on a model of how far the receiver Doppler is off) and
  - Post-CT (by minimizing the least-square difference between CT amplitude and step function)
- Temperature initialization of hydrostatic equation at 40 km with ECMWF
- Other improvements
  - FLINN orbits (where available)
  - Accounting for antenna phase center offset
  - Corrected time-tag errors due to ground station clock offset

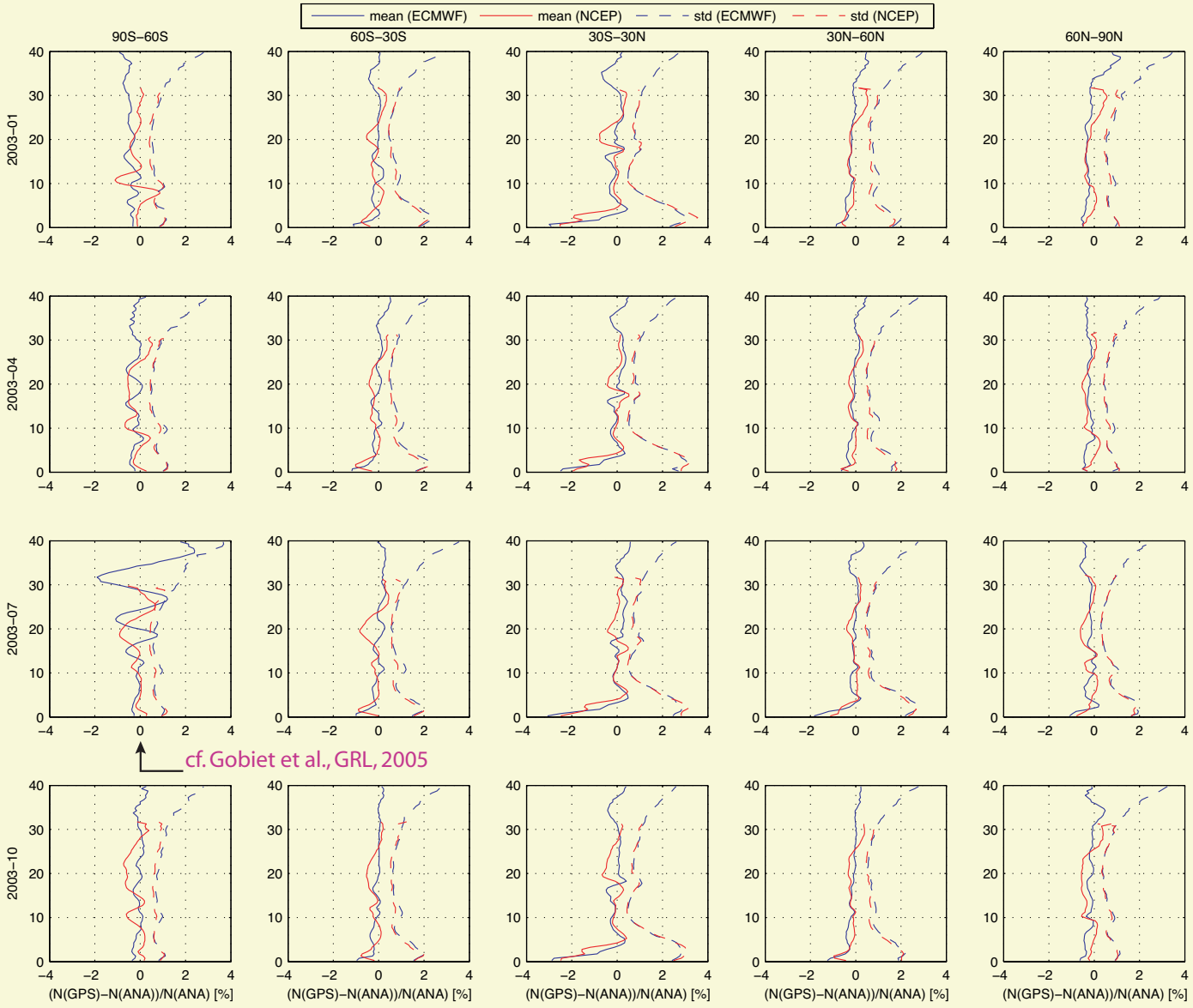
Effects of Tracking Errors



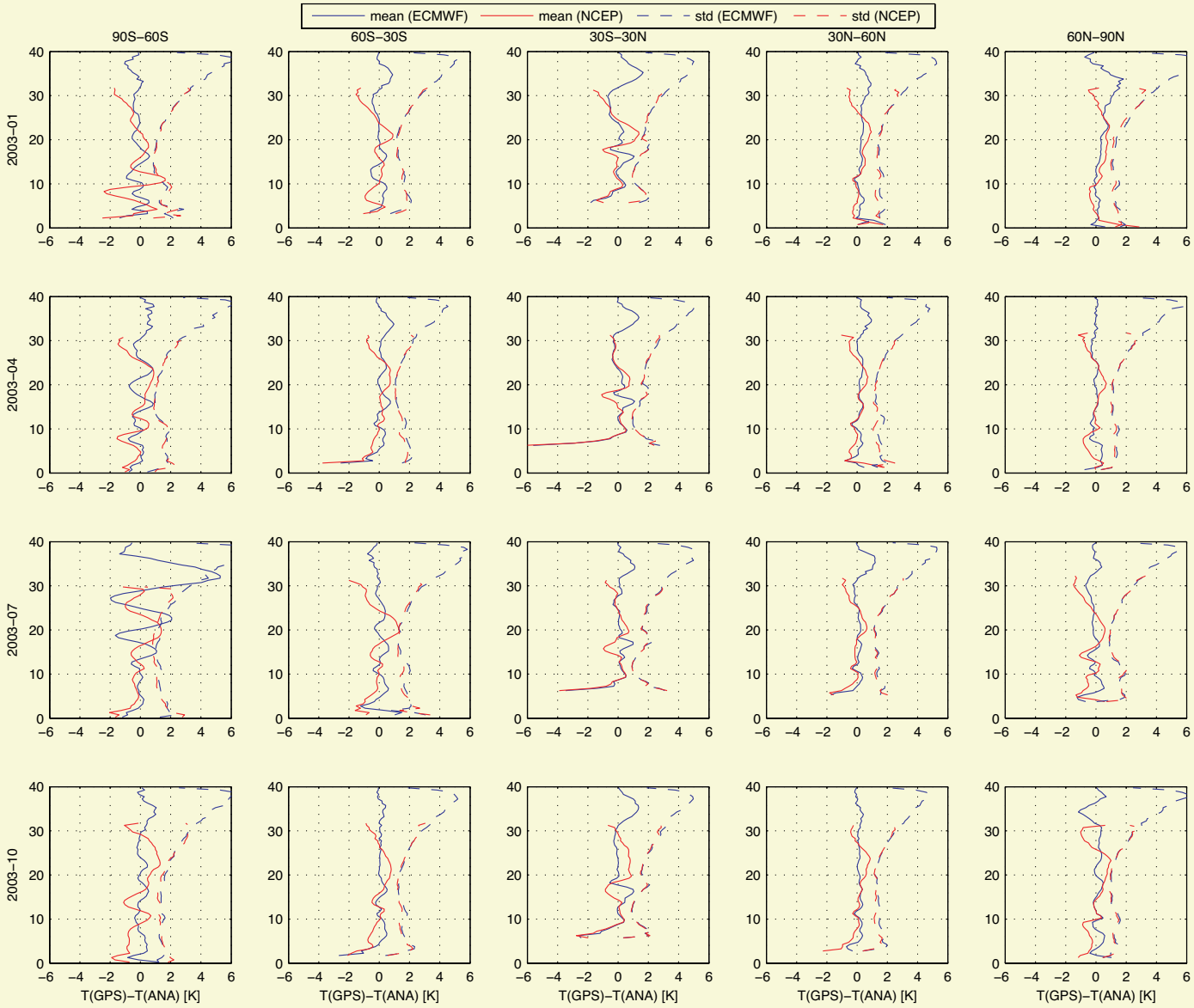
Minimum altitudes



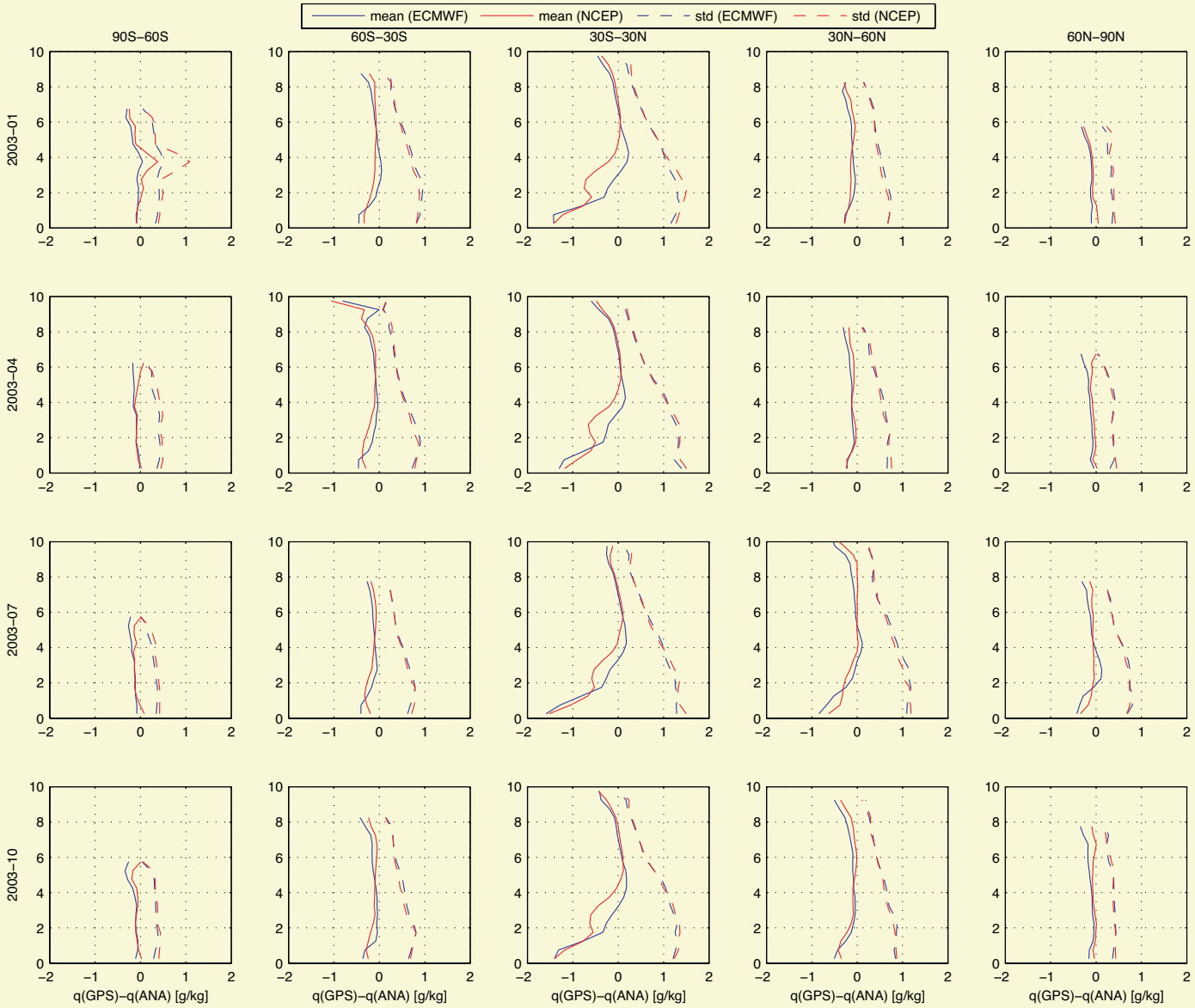
Refractivity



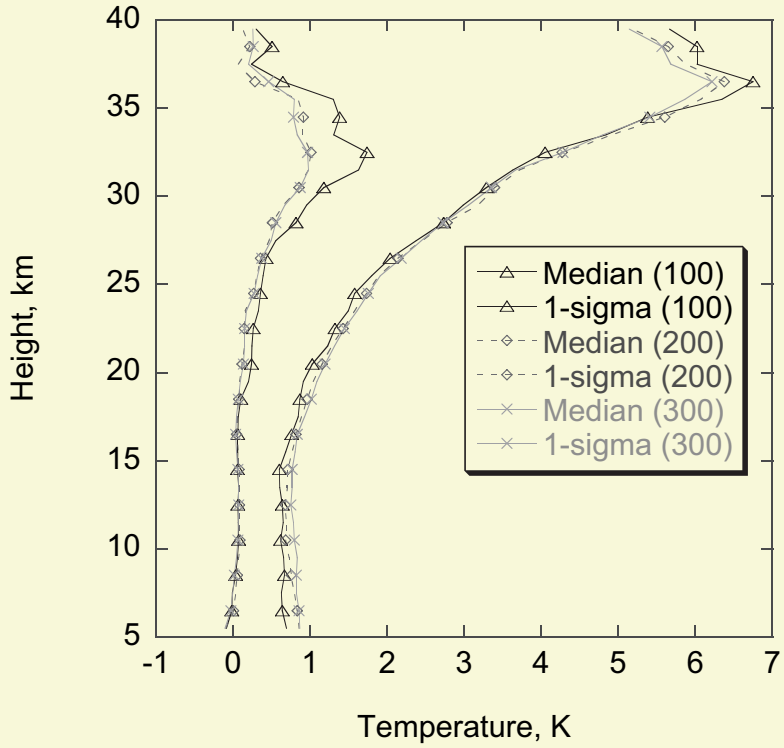
Temperature



Water vapor


mean (ECMWF)
mean (NCEP)
std (ECMWF)
std (NCEP)
90S–60S
60S–30S
30S–30N
30N–60N
60N–90N
2003–01
2003–04
2003–07
2003–10
q(GPS)–q(ANA) [g/kg]

CHAMP & SAC-C Intercomp



- GPS RO soundings are free of instrumental bias and drift
- Individual temperature profiles are accurate to < 0.5 K between $\approx$ 5 to 20 km.
- Averaged profiles can be accurate to < 0.1 K at these altitudes.

Hajj et al., JGR, 2004

Main Sources of Uncertainty

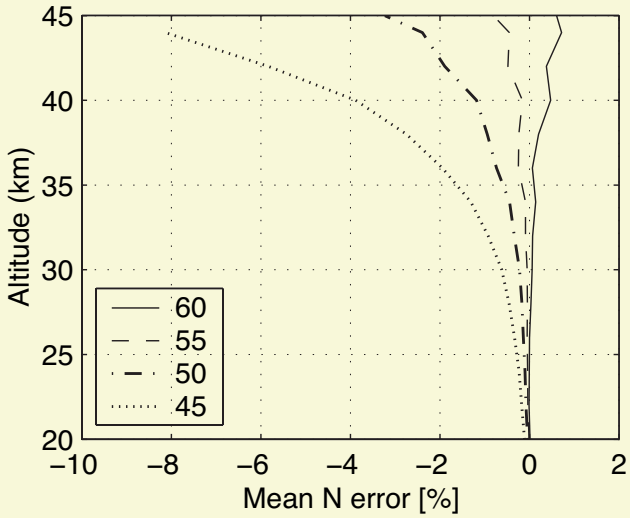
Mid-to-Upper Strat. (Above 25 km)

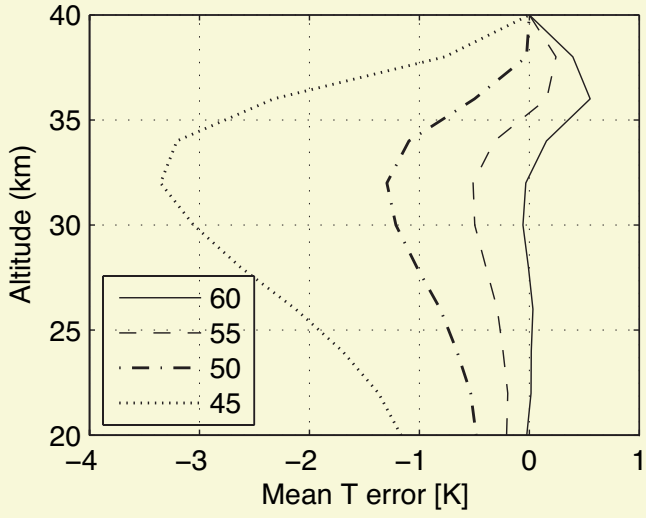
- Abel upper boundary condition
- Initialization of hydrostatic equation (for temperature profiles)

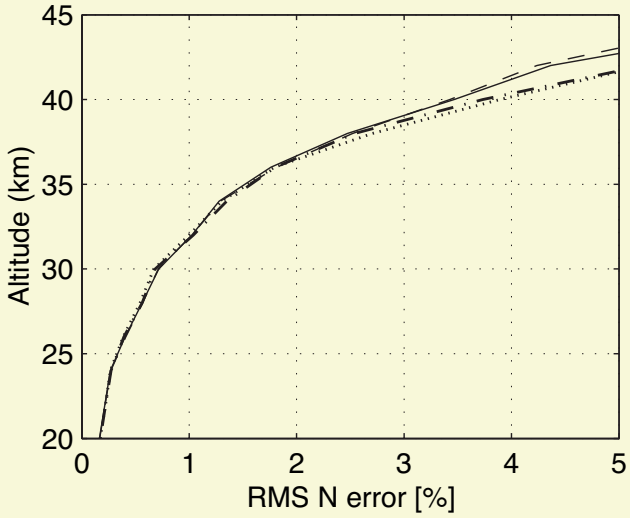
Lower Troposphere (Below 4 km)

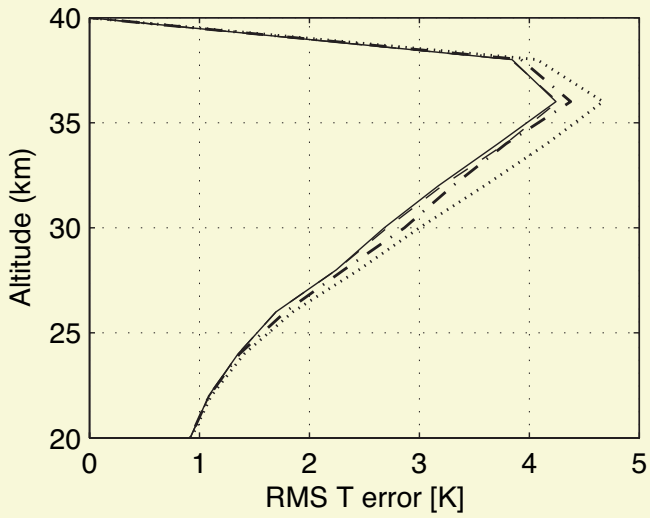
- Receiver closed-loop tracking errors
- Ducting (super-refraction)

Abel Upper Boundary

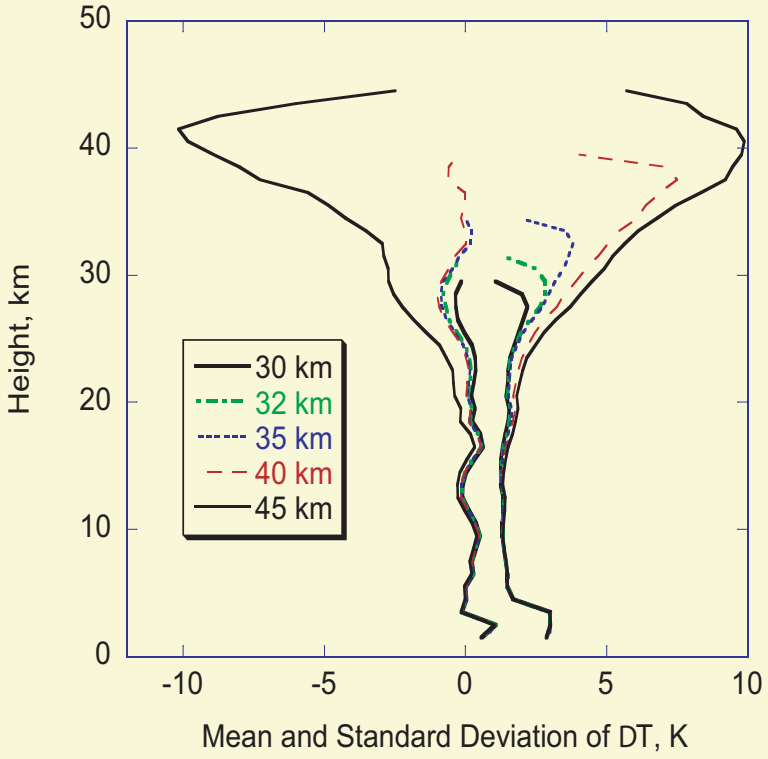


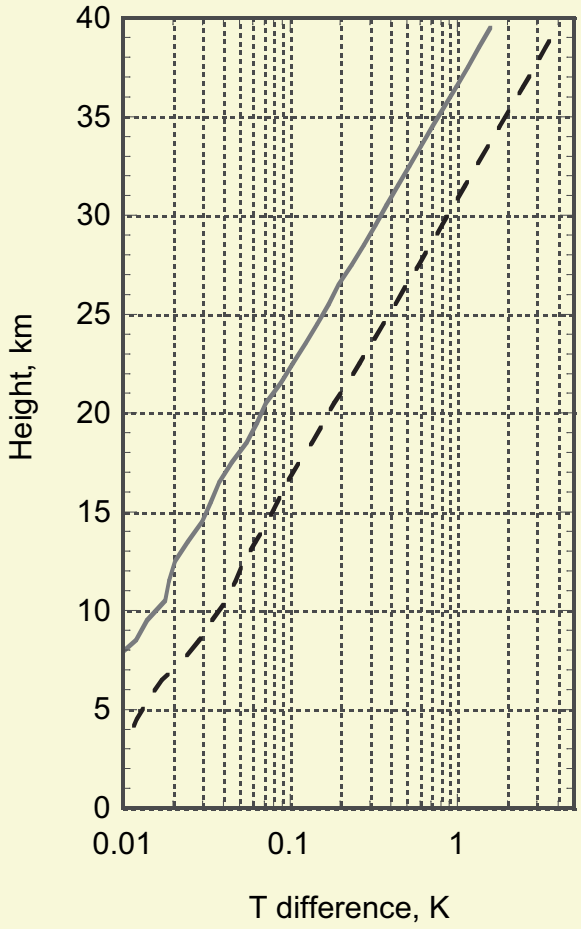




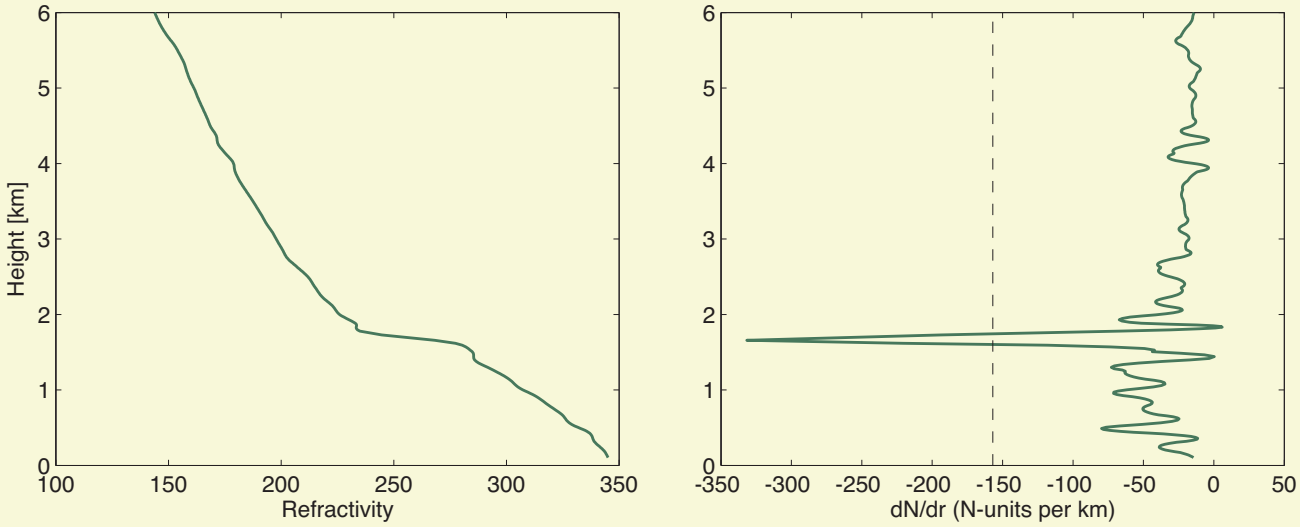


Initialization of Hydrostatic Integral





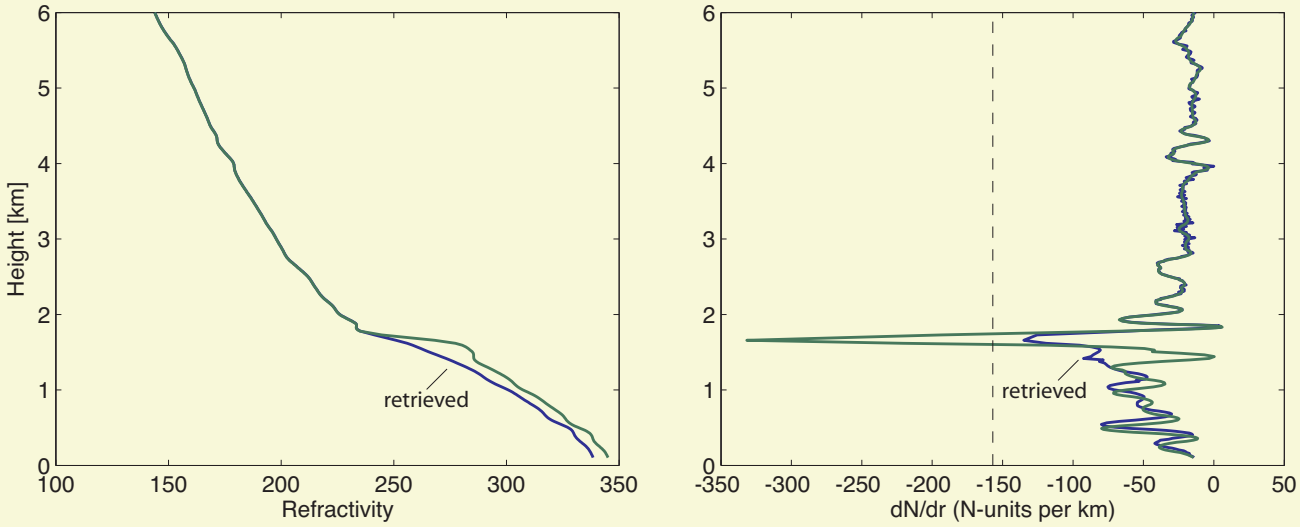
Ducting and Refractivity Bias



Ducting Condition : $\frac{d(nr)}{dr} < 0$

$\frac{dn}{dr} \lesssim -\frac{1}{r}$ or $\frac{dN}{dr} \lesssim -157$ N-units/km

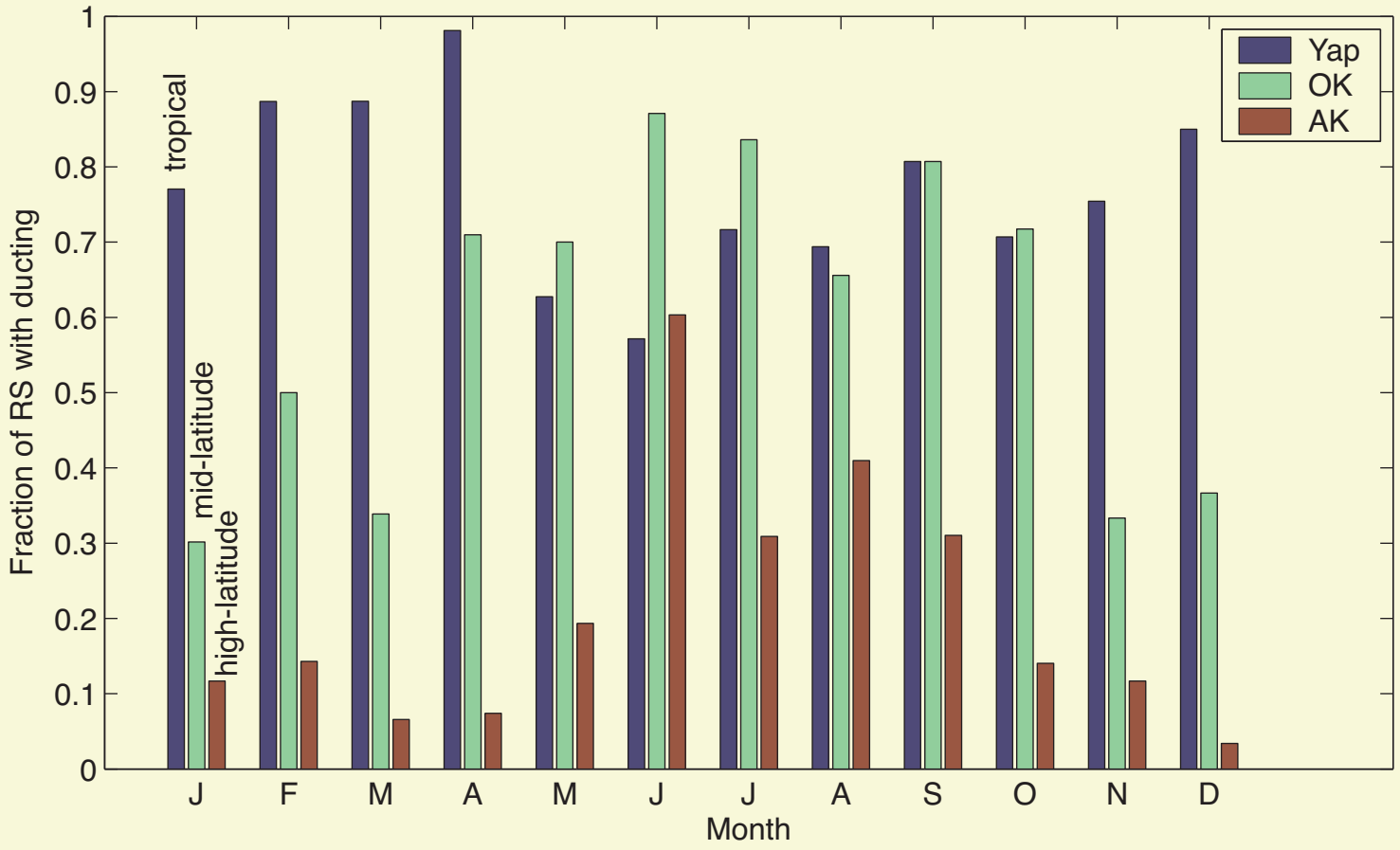
Ducting and Refractivity Bias



Ducting Condition : $\frac{d(nr)}{dr} < 0$

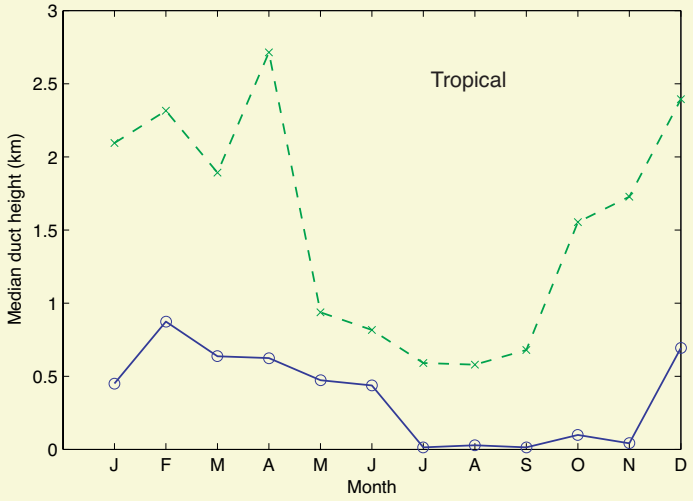
$\frac{dn}{dr} \lesssim -\frac{1}{r}$ or $\frac{dN}{dr} \lesssim -157$ N-units/km

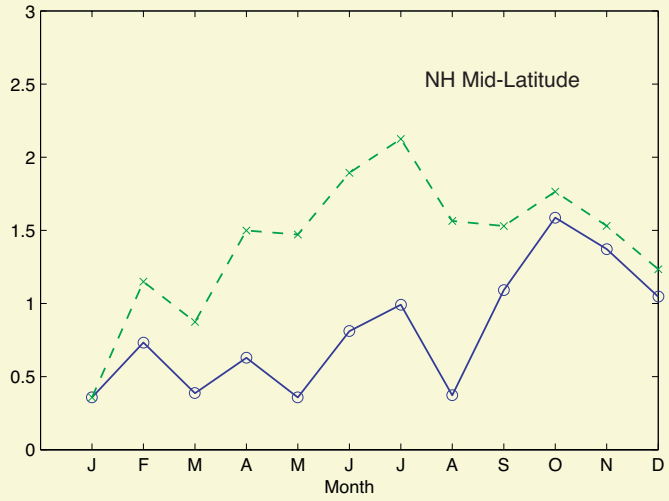
Occurrences of Ducting

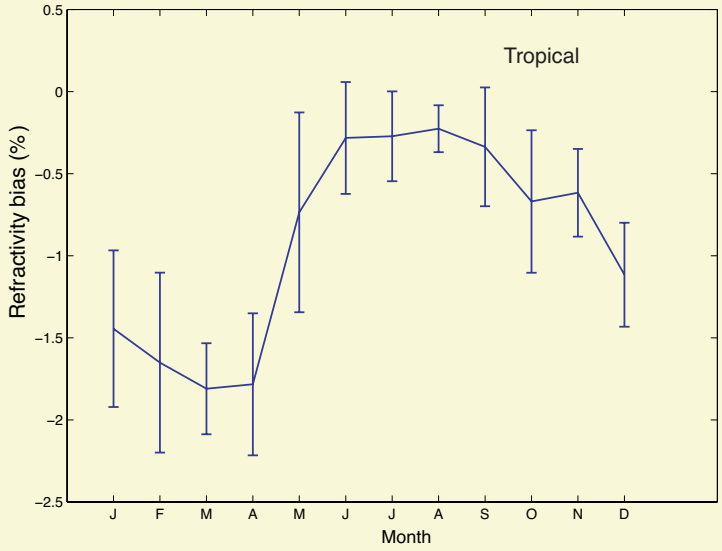


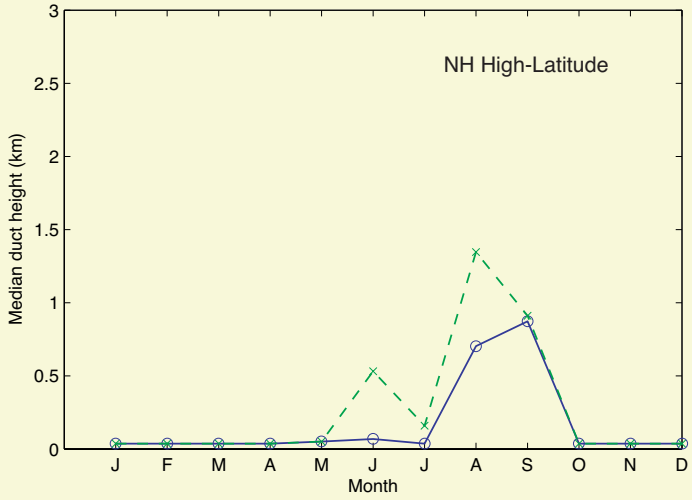
- Based on hi-resolution radiosonde soundings taken twice daily

Ducting Heights and Bias









Ongoing Work

- Model-independent quality control
- More robust high-altitude retrievals
- Continued evaluation of ducting effects and development of mitigation schemes
- Open-loop data assessment and improvements
- Address interesting science questions; climate benchmarking; collaborations