S and Ka-band reflectivity comparison

- For Rayleigh scattering and in the absence of propagation effects, the true S and Ka-band reflectivity values are equivalent
- Measured S and Ka-band radar reflectivity values compared
  - Remove propagation effects
    - Gaseous attenuation
    - Liquid attenuation
  - Ensure Rayleigh scattering
  - Assume well calibrated S-band reflectivity

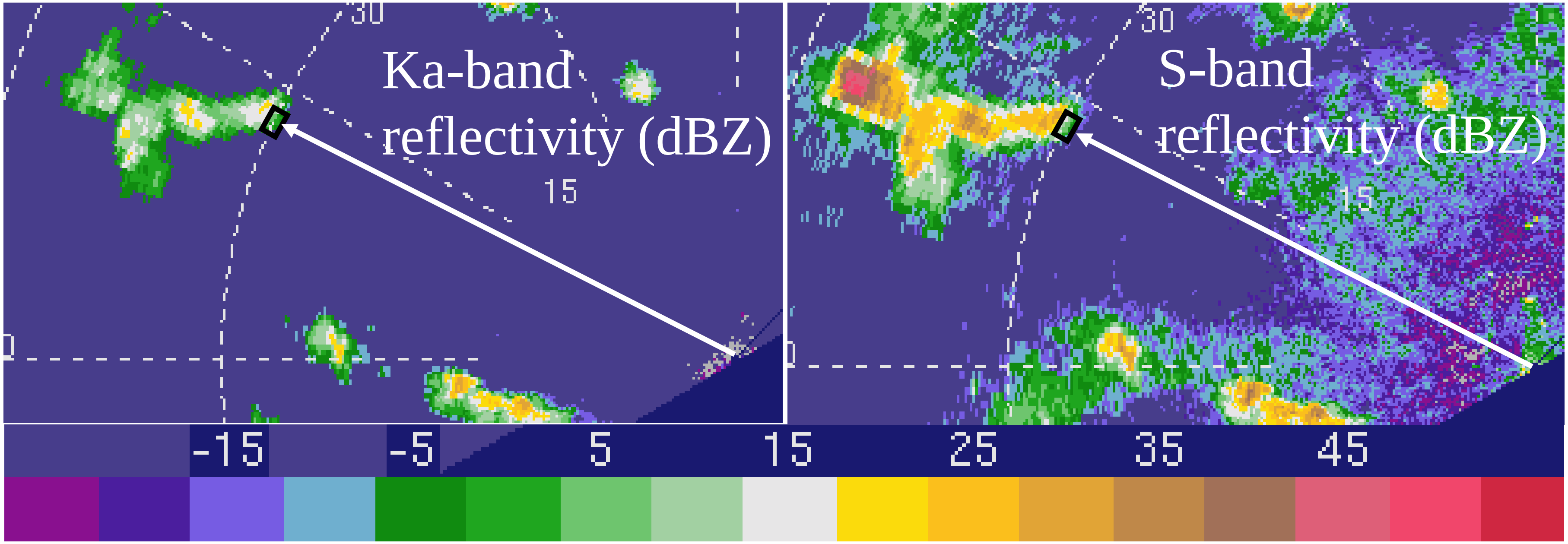
S and Ka-band reflectivity comparison

- Removing propagation effects
  - Use only front edge of cloud (< 0.5 km) to avoid liquid attenuation
  - Compute atmospheric attenuation by inputting sounding P, T and RH into radiative transfer model
    - Computed over layer or layers appropriate for each radar path
    - Use very short paths, i.e. < 20 km (< 10 is better)
    - Typical atm attenuation values around 0.4 dB km^{-1} (2-way)

S and Ka-band reflectivity comparison

- Hand select small 2-D patches of cloud or precipitation echo (10 to 20 range gates)

(Notice the Bragg scatter at S-band)



S and Ka-band reflectivity comparison

- Avoid non-cloud/precipitation echoes
  - Bragg scatter (S-band)
    - Ka band doesn't detect much Bragg scatter
    - S-band cloud/precipitation echo > 5 dB stronger than surrounding Bragg echoes
  - Point targets (birds, planes)
  - Ground/sea clutter
  - Correlation of S and Ka band reflectivity > 0.7

S and Ka-band reflectivity comparison

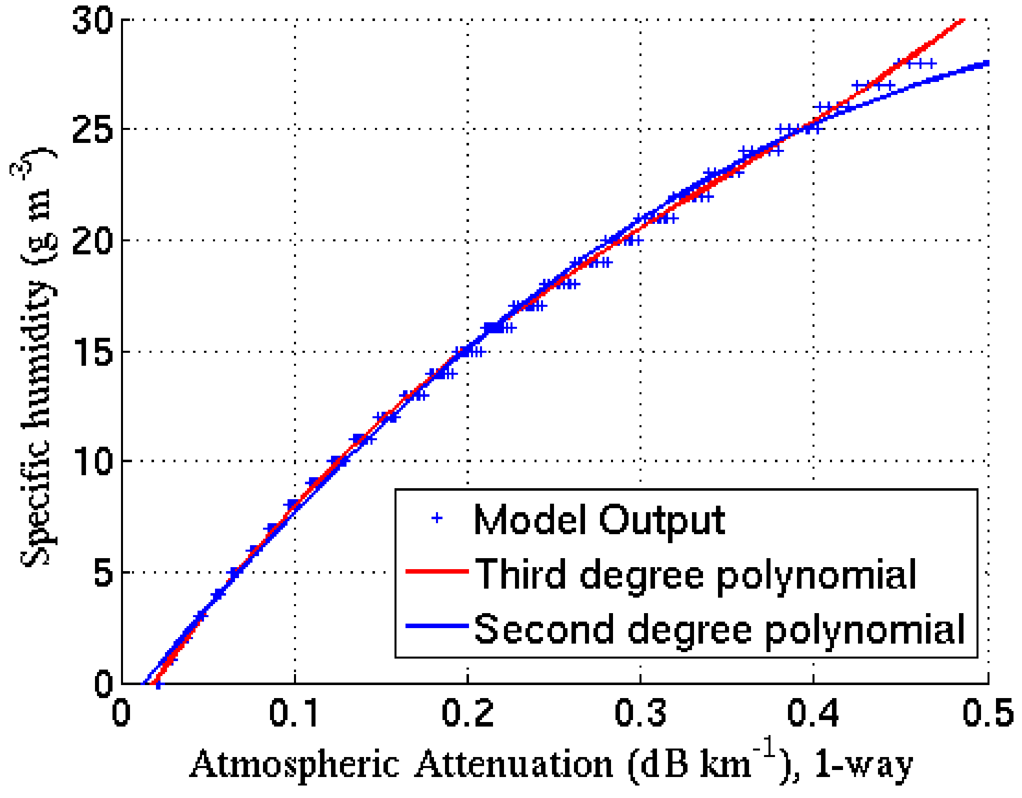
- Require Rayleigh scattering approximation valid at Ka-band
  - $<$ 1 mm drops
    - Estimate D_0 from S-band Z and ZDR
    - D_0 must be < 0.5 mm
  - Z at S-band $<$ 20 dBZ
  - ZDR $<$ 0.4 dB
- Avoid the lee of the island, i.e. “tail” echoes

Comparison results

- Analyzed data from 7 days, resulting in 35 comparisons

dates	Mean difference S – Ka (dB)	Standard deviation (dB)
15, 19, 24 Dec	8.24	0.55
6, 10, 16, 23 Jan	8.47	0.58
All 7 days above	8.41	0.57

Humidity/attenuation relationship for RICO



Results of running radiation model over range of observed T and P at RICO over 0 to 3 km layer

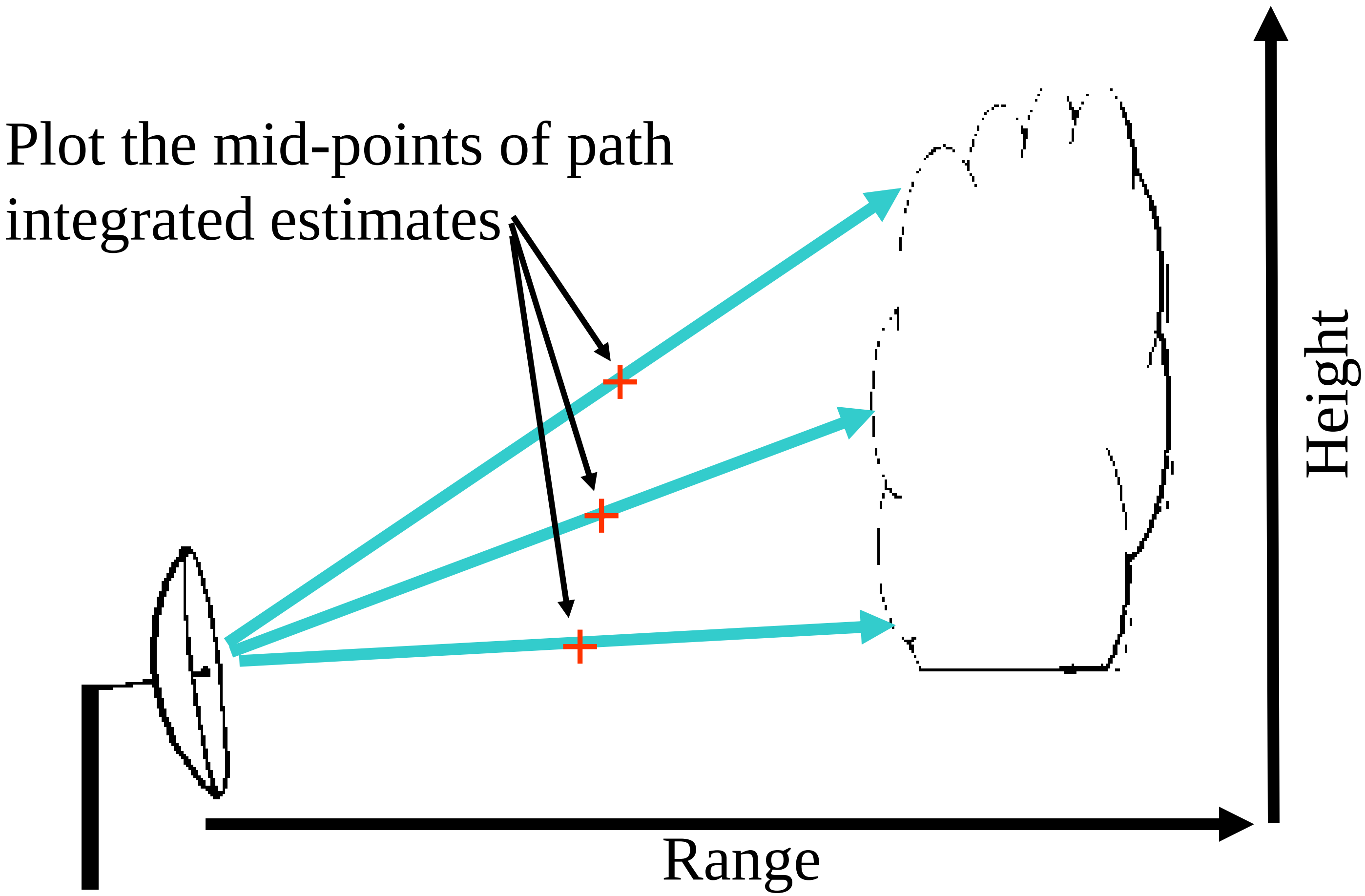
What about the inverse problem?

- Can we retrieve water vapor from estimated Ka-band atmospheric attenuation?
- Need longer paths to minimize errors in estimated attenuation, dB km^{-1} (> 15 km)
- Use best fit relationship derived from radiation simulations to estimate path-integrated water vapor content

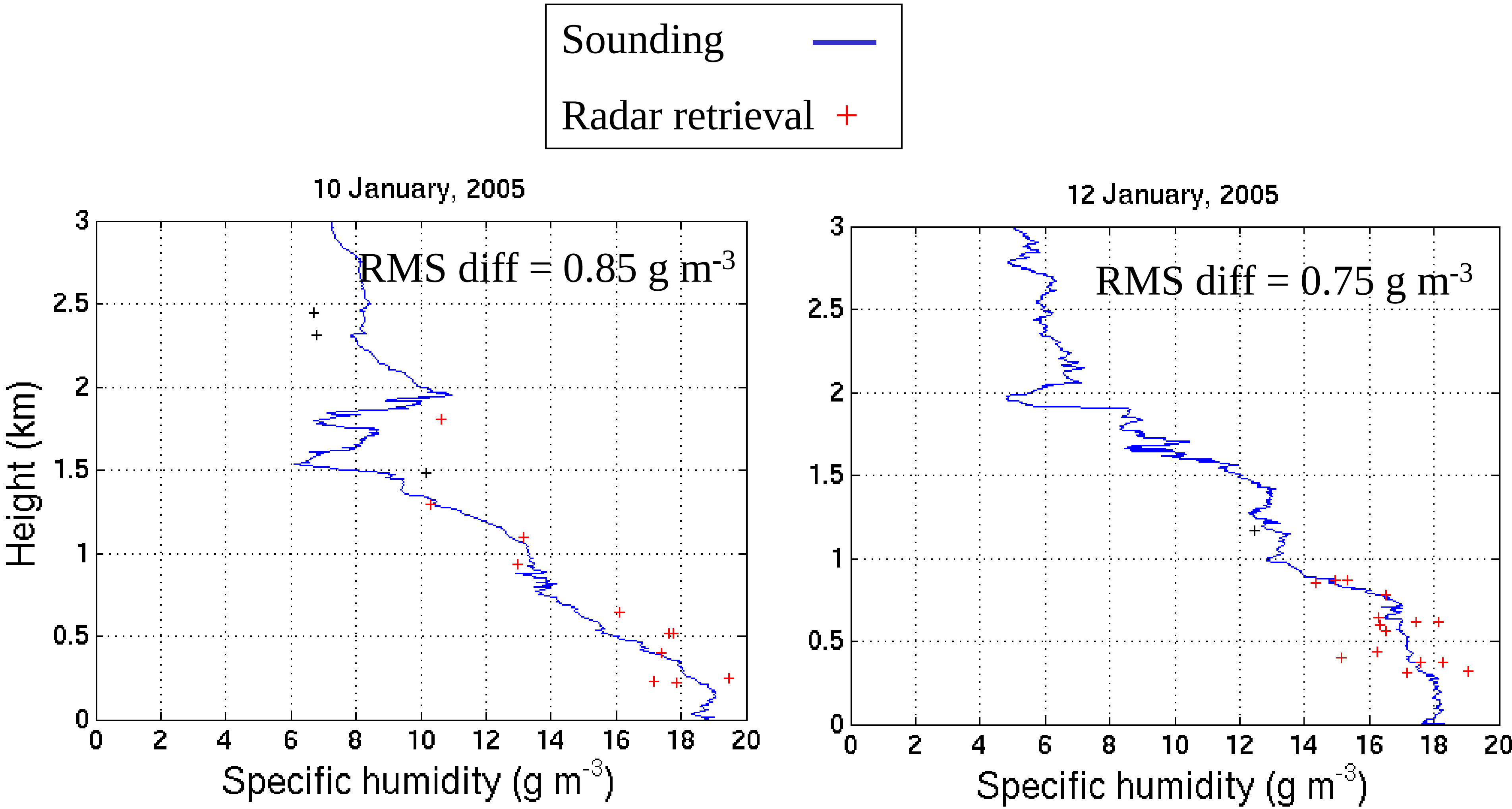
$$SH = 201.40A^3 – 209.60A^2 + 120.55A – 2.25$$

(SH is specific humidity (g m^{-3}) and A is gaseous attenuation (db km^{-1}))

Creating vertical profiles



Humidity retrieval results



Ka-band data considerations for humidity retrieval

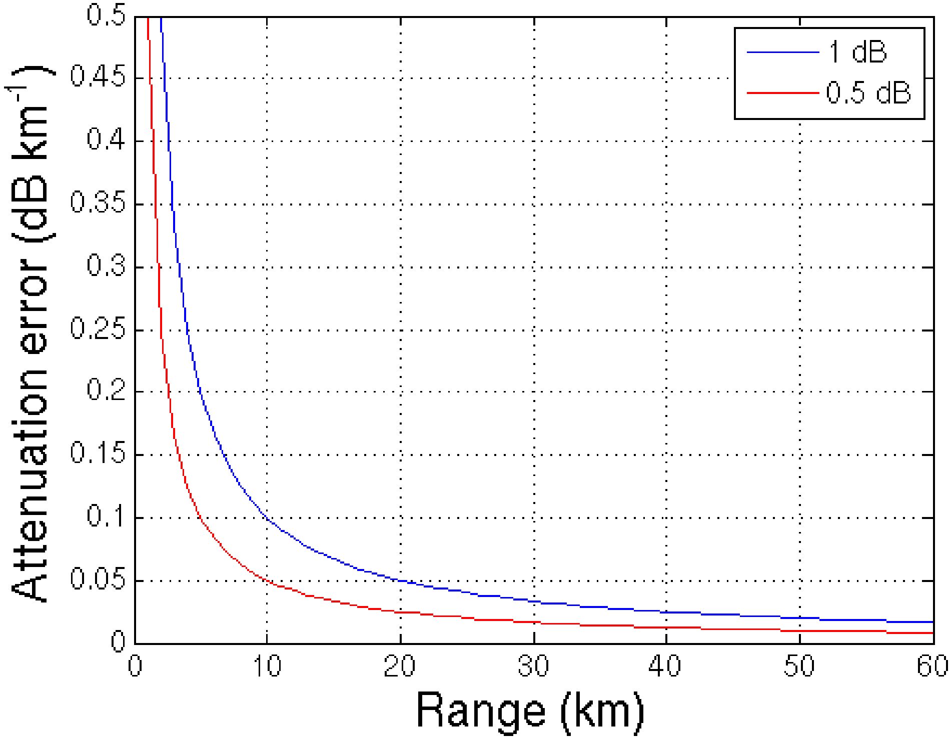
- Corrected Ka-band reflectivity in manner described above
- Avoided periods with documented ghost echoes
- Avoided low SNR ($\lesssim$ 5 dB) at Ka-band
- Allow magnetron to fully warm up
  - Only used data more than one hour after Ka-band radar powered up
- Avoided low elevation angles due to partial blockage ($< 2.5^{o}$)

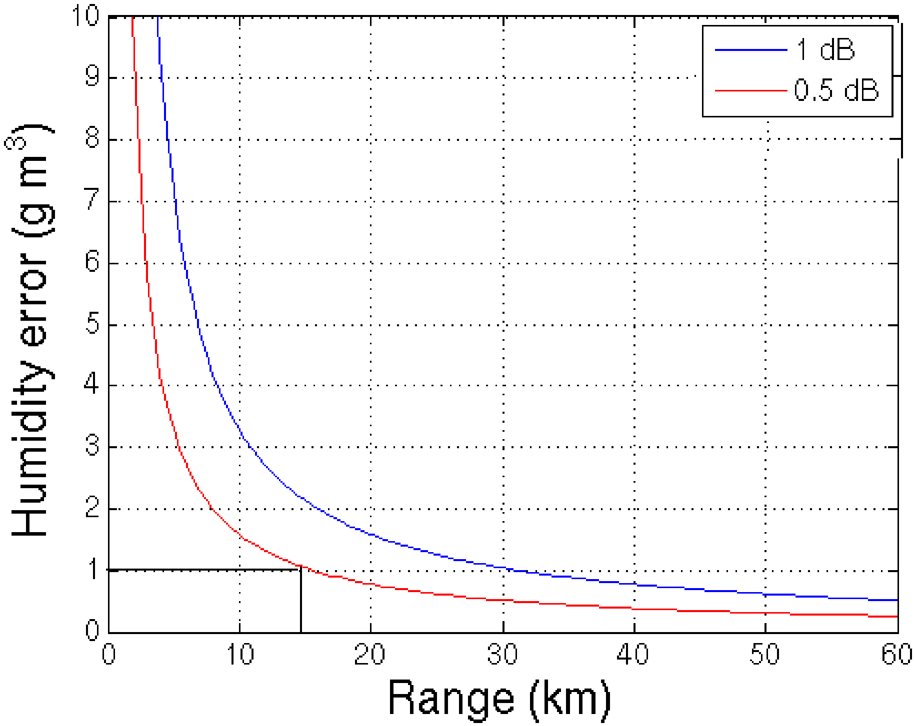
- Next step: Liquid water retrievals based on differential liquid attenuation
- Available for collaborations with RICO PI's

Questions?

Sources of error

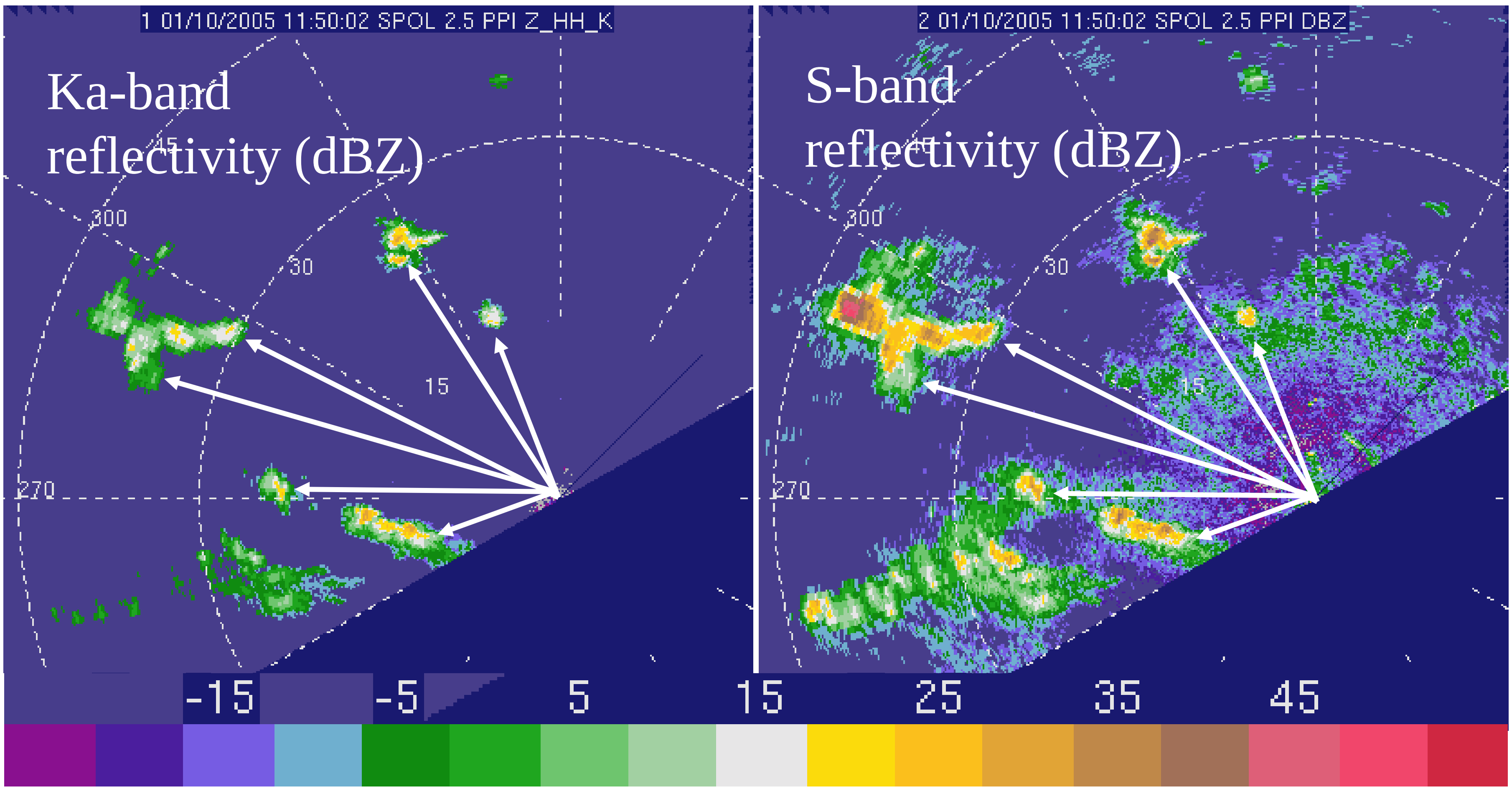
- Radar calibration
  - Errors in reflectivity differences



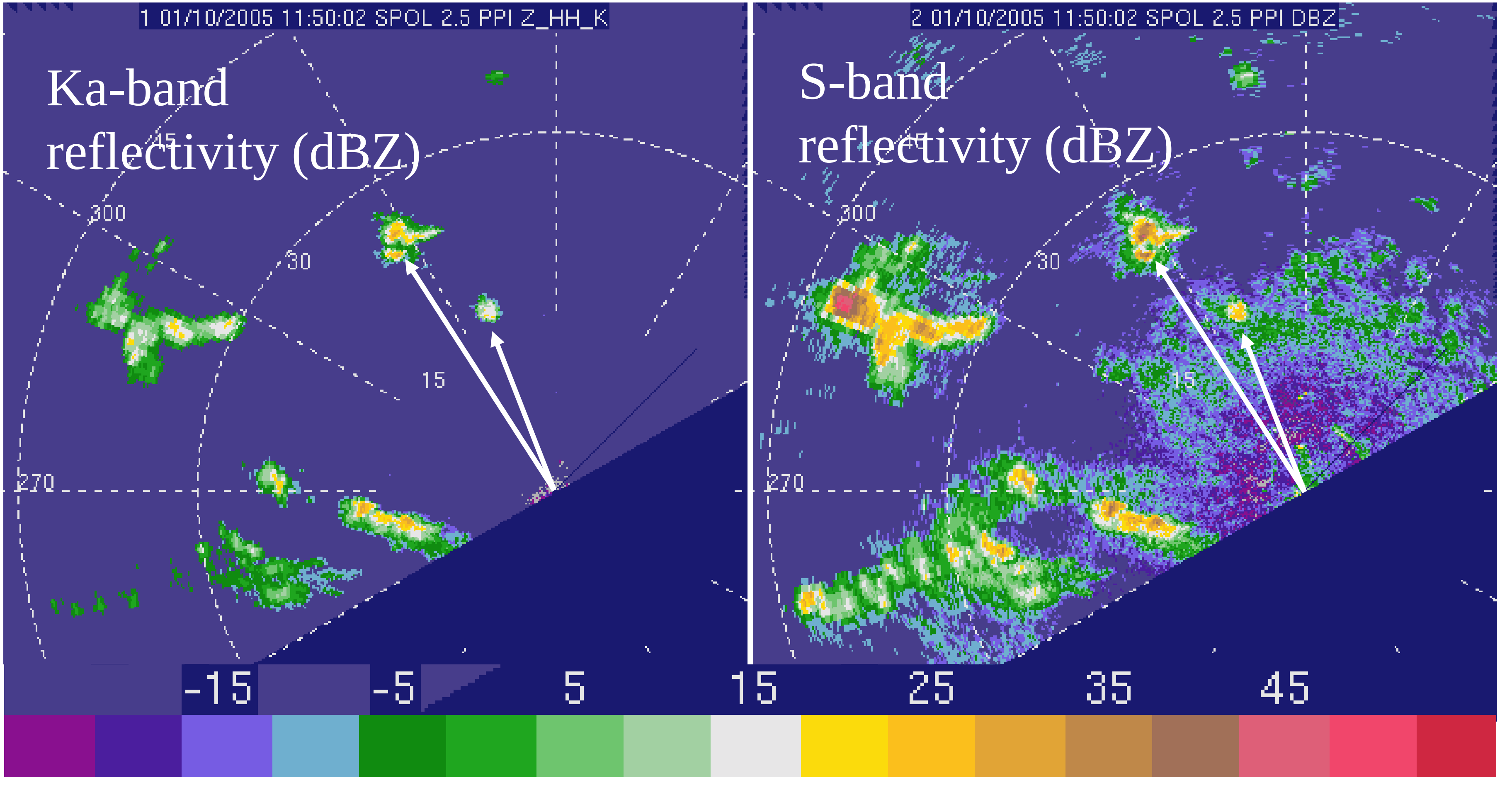


Errors in attenuation and humidity resulting from errors in dBZ differences (S – Ka)

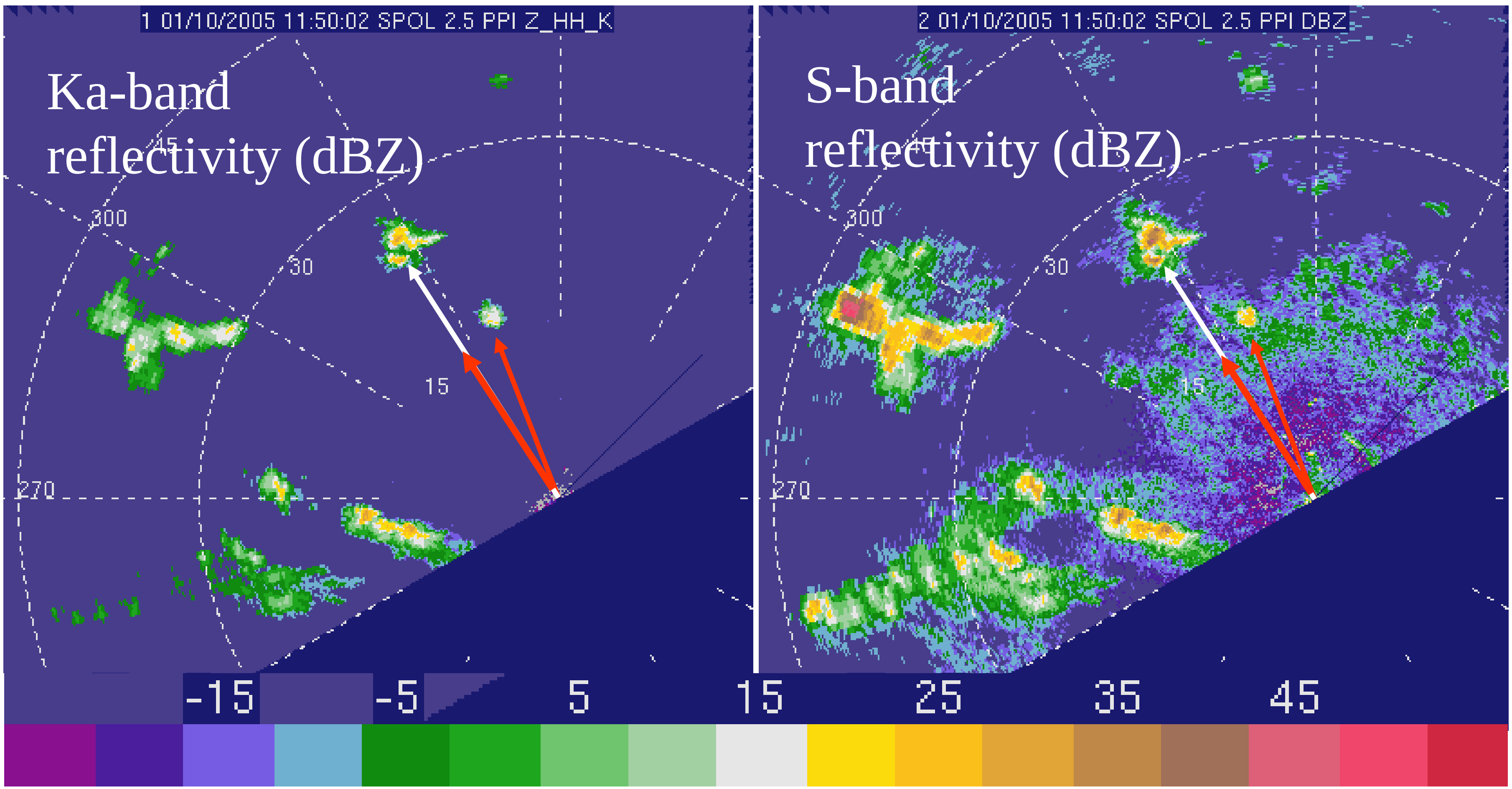
Method: potential primary rays



Method: creating secondary rays method 1



Method: creating secondary rays method 1



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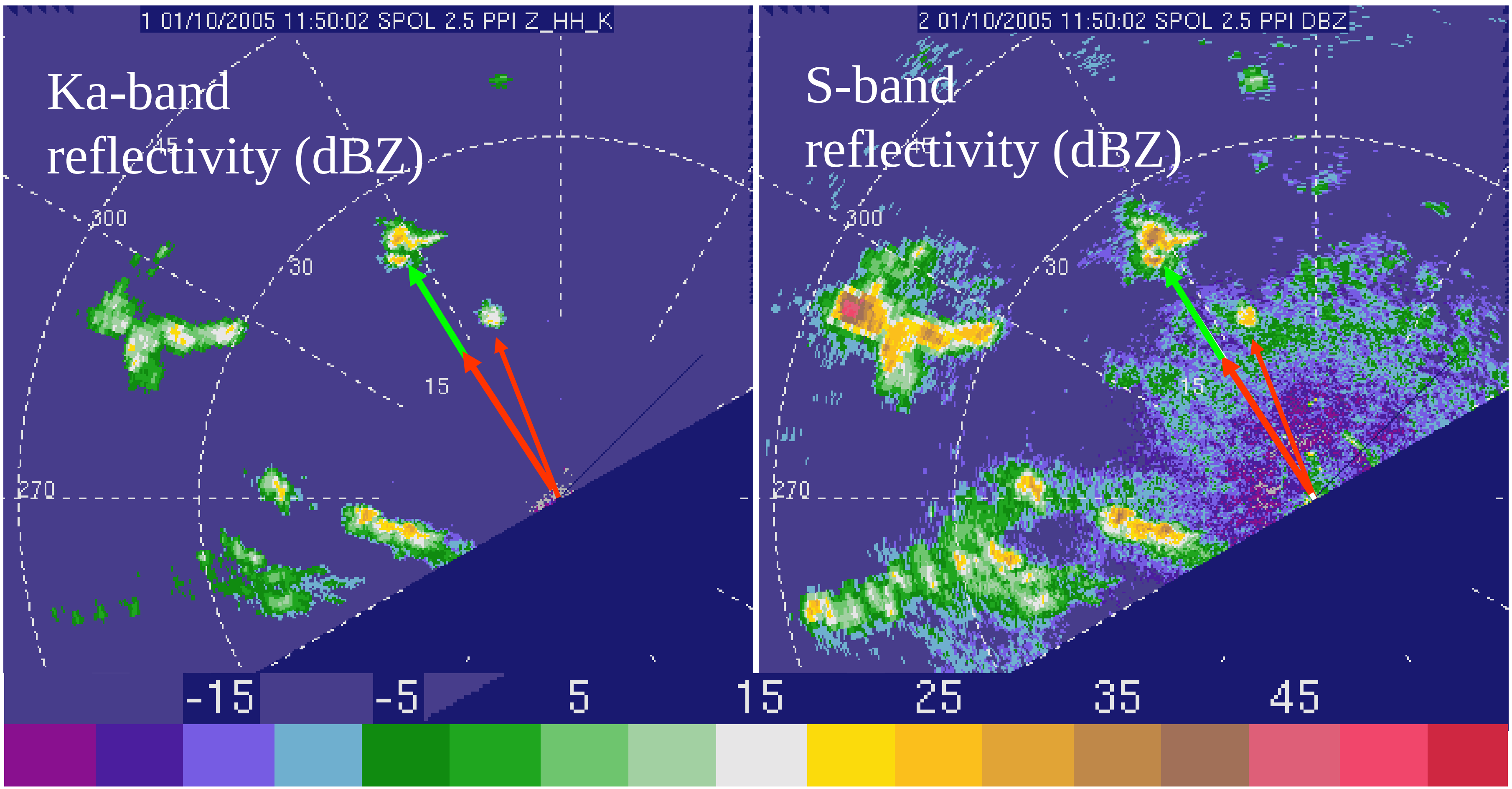
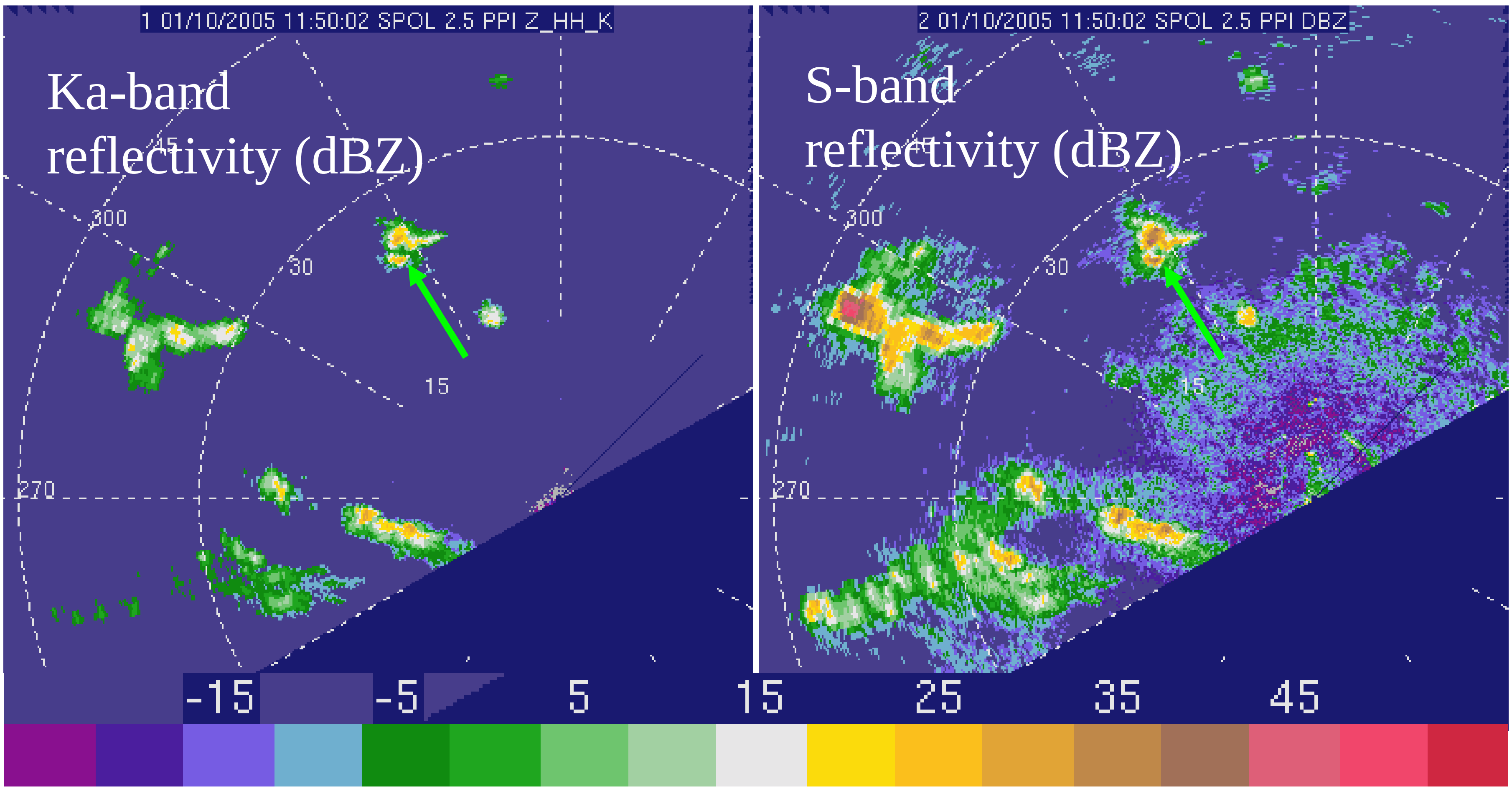
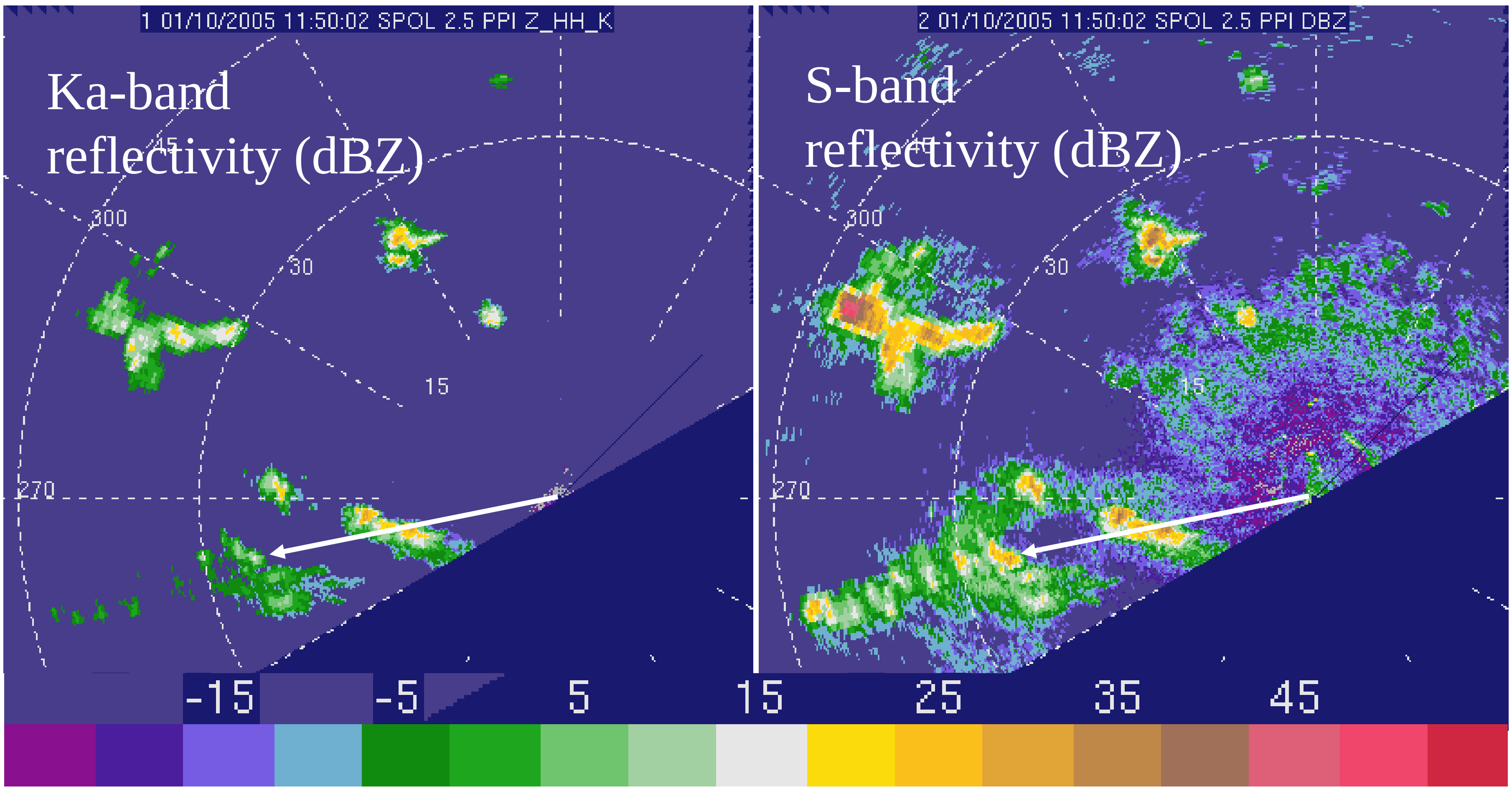


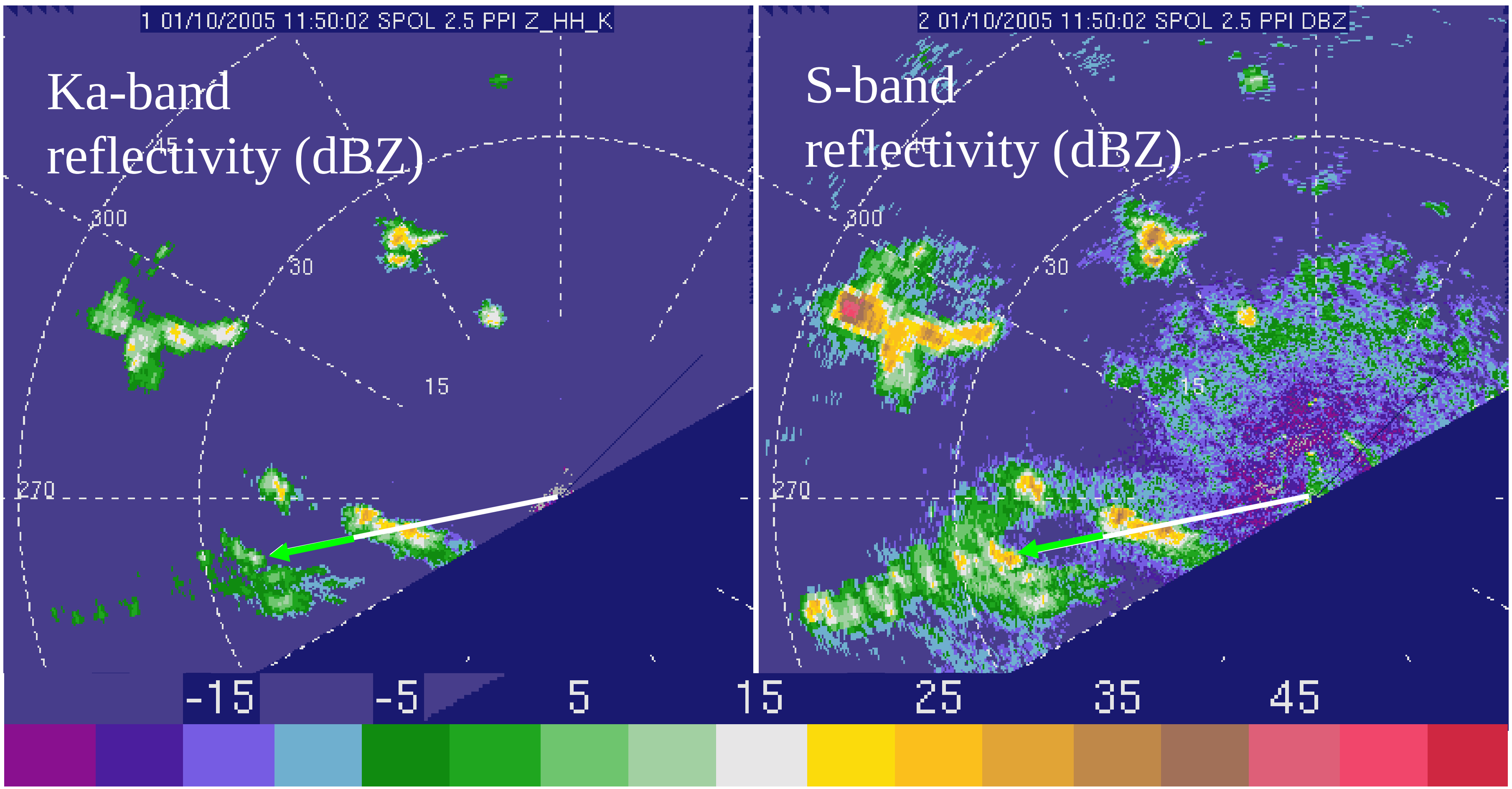
Method: creating secondary rays method 1



Method: creating secondary rays method 2 (not implemented yet)



Method: creating secondary rays method 2 (not implemented yet)



Method: creating secondary rays method 2 (not implemented yet)