Assessment of RO refractivity under heavy precipitation

Padullés, R.[1], Cardellach, E.[1], Ao, C.O.[2], Wang, K.N.[2], Turk, F.J.[2], de la Torre-Juárez, M.[2]

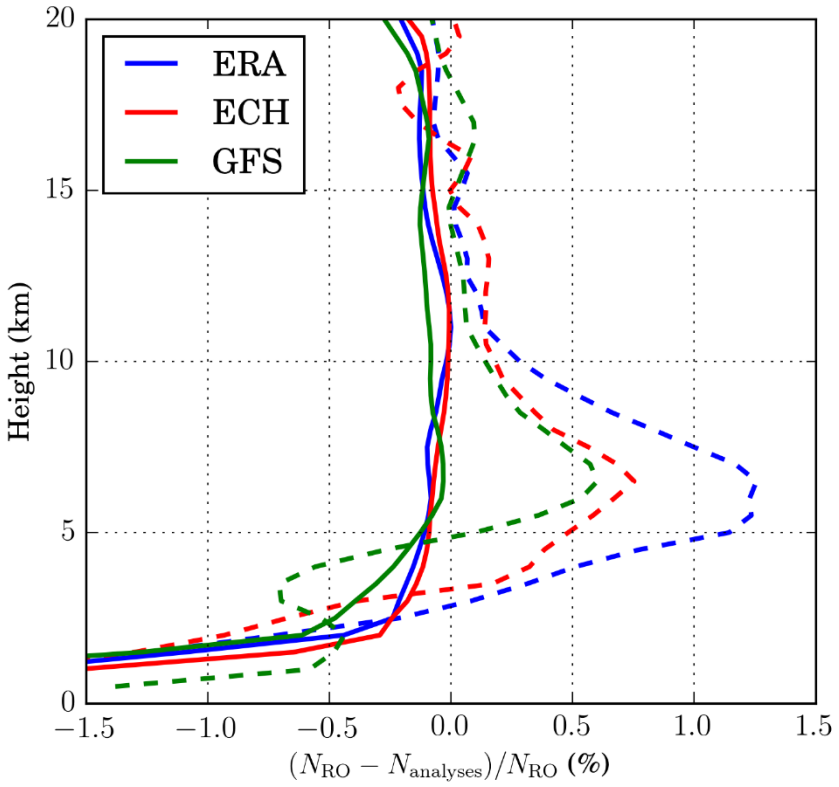
[1] Institut de Ciències de l'Espai, Barcelona, Spain
[2] Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, USA

Positive N-bias

- A bias has been observed when comparing RO refractivity with that of analyses and re-analyses, when heavy precipitation is present

- ECMWF ERA-interim reanalysis [CDAAC eraPrf]
- ECMWF high resolution analysis [CDAAC echPrf]
- NCEP GFS operational analysis [CDAAC gfsPrf]

Solid lines: no rain in the surroundings of RO event
Dashed lines: Heavy precipitation in the surroundings of RO event

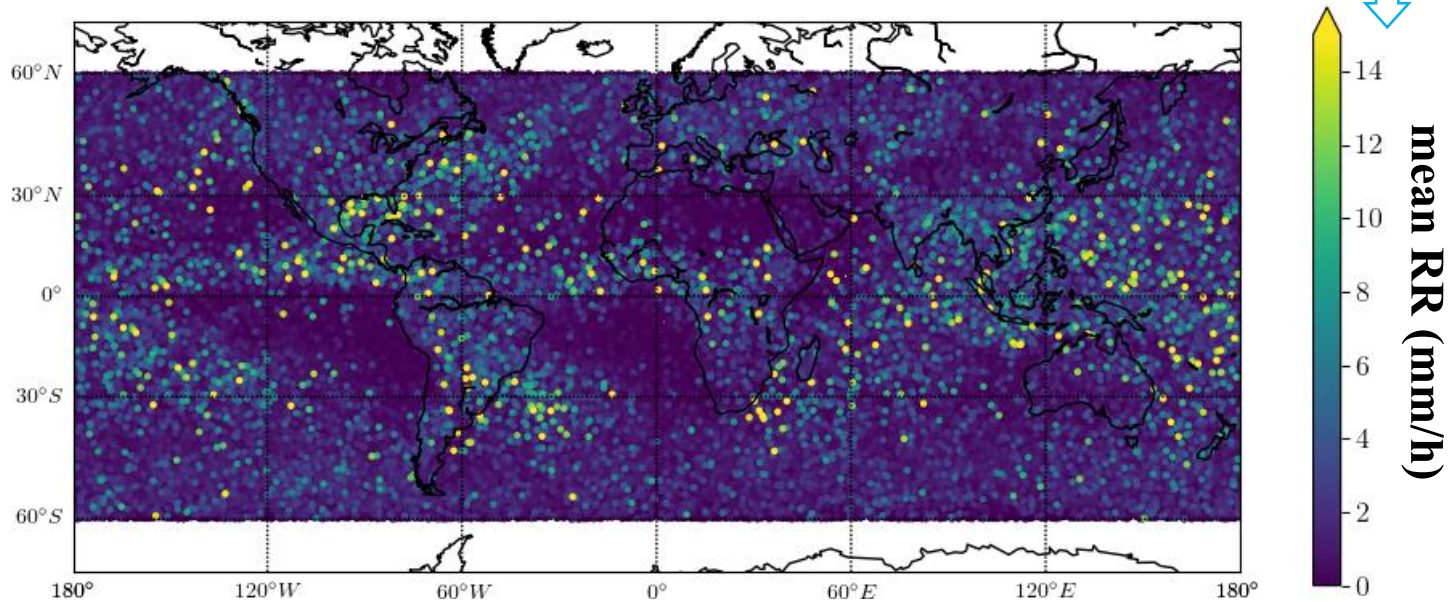


Positive N-bias

- Large scale 2-D co-locations: COSMIC RO + GPM IMERG
- For each RO event, the corresponding (lat, lon, time) IMERG product is checked for precipitation

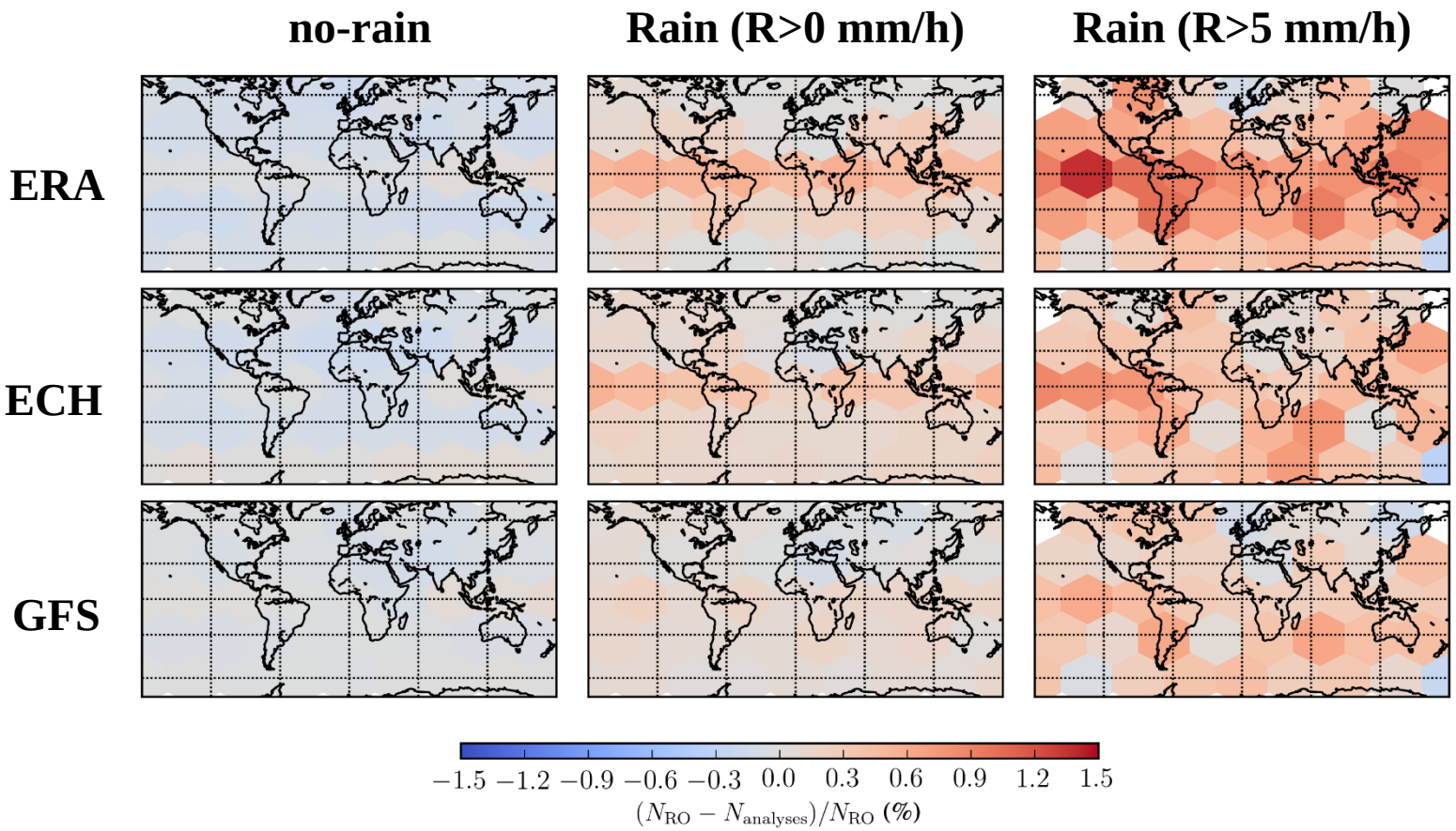
- 259,231 co-located events (30% with rain; 2% heavy rain)
- IMERG Resolution: 0.1ºx0.1ºx30min

Mean RR in a 1º squared around RO point



Positive N-bias

- Regional difference in the N-bias?



Positive N-bias

- RO refractivity → inversion from observed bending angle
- (Re)analyses refractivity → combination of *P*, *T*, *e*

$$N = 77.6\frac{P}{T} + 3.73 \times 10^5 \frac{e}{T^2} - 40.3 \times 10^6 \frac{n_e}{f^2} + O\left(\frac{1}{f^3}\right) + 1.4W_w + 0.6W_i$$

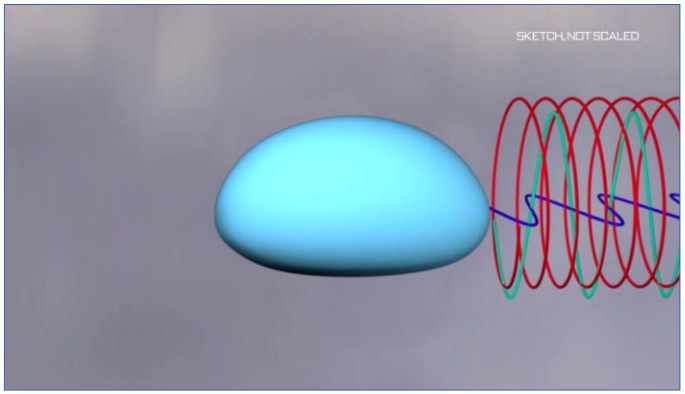
- The question is: **which is the cause of the bias?**

  Possible Answers:

  - $W_{w,i}$ trems are not taken into account in the inversion process [Zou et al. 2012, JAS][Yang and Zou 2012, JGR]
  - Models / (re)analyses do not perform well when heavy precipitation is present [Hersbach et al. 2015, QRJMS]

Positive N-bias

- Hypothesis: If $W_{w,i}$ terms should not be neglected in the inversion process, removing its contribution from the excess phase should result in a noticeable difference in the retrieval when it is compared with the original one



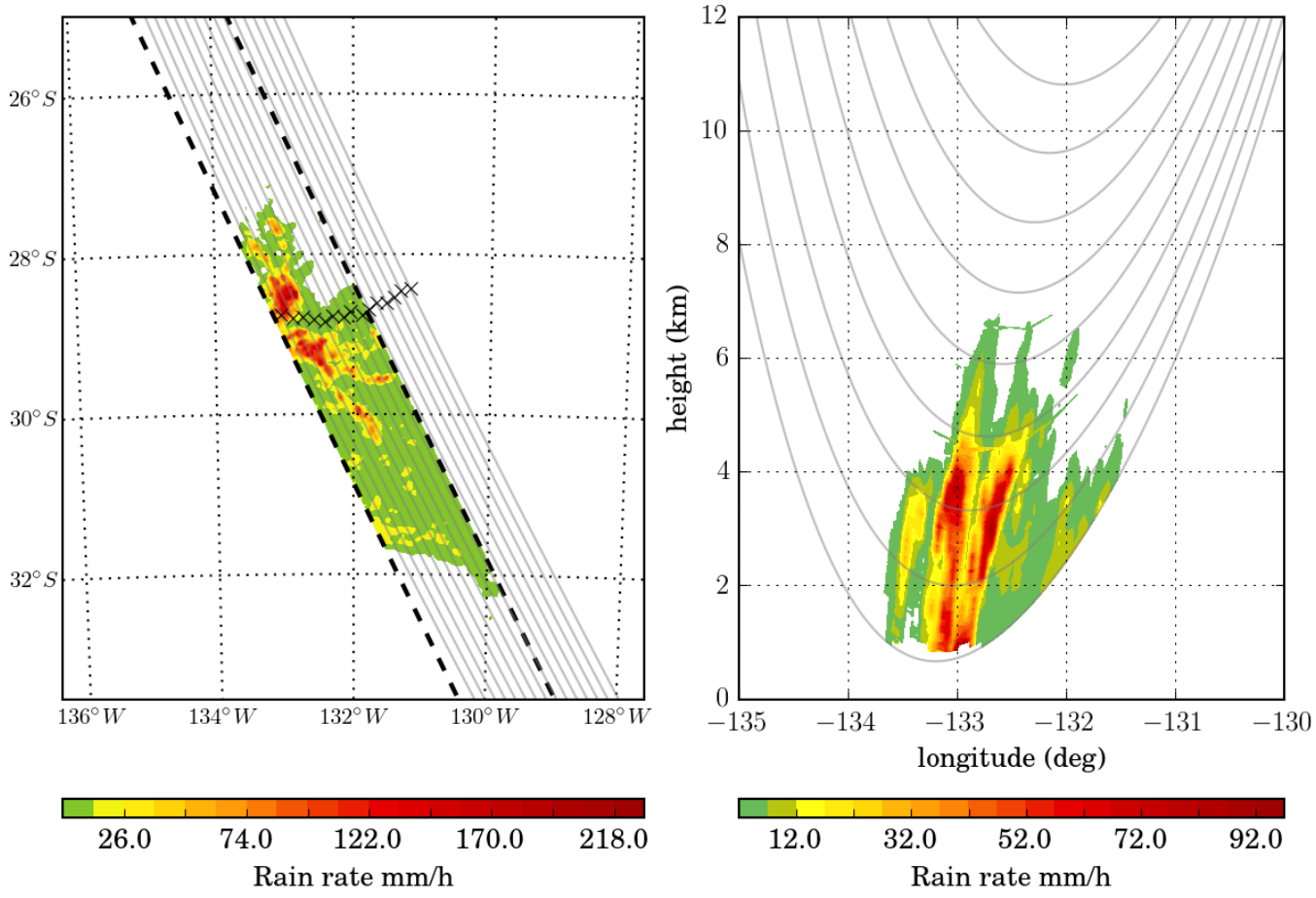
$$\Phi_{rain} = \frac{2\pi}{k_0} \int \Re\{\frac{S_{\mathrm{hh}} + S_{\mathrm{vv}}}{2}\} N(D)\mathrm{d}D$$

$S_{hh,vv}$: co-polar components of scattering amplitude matrix for raindrops at L-band

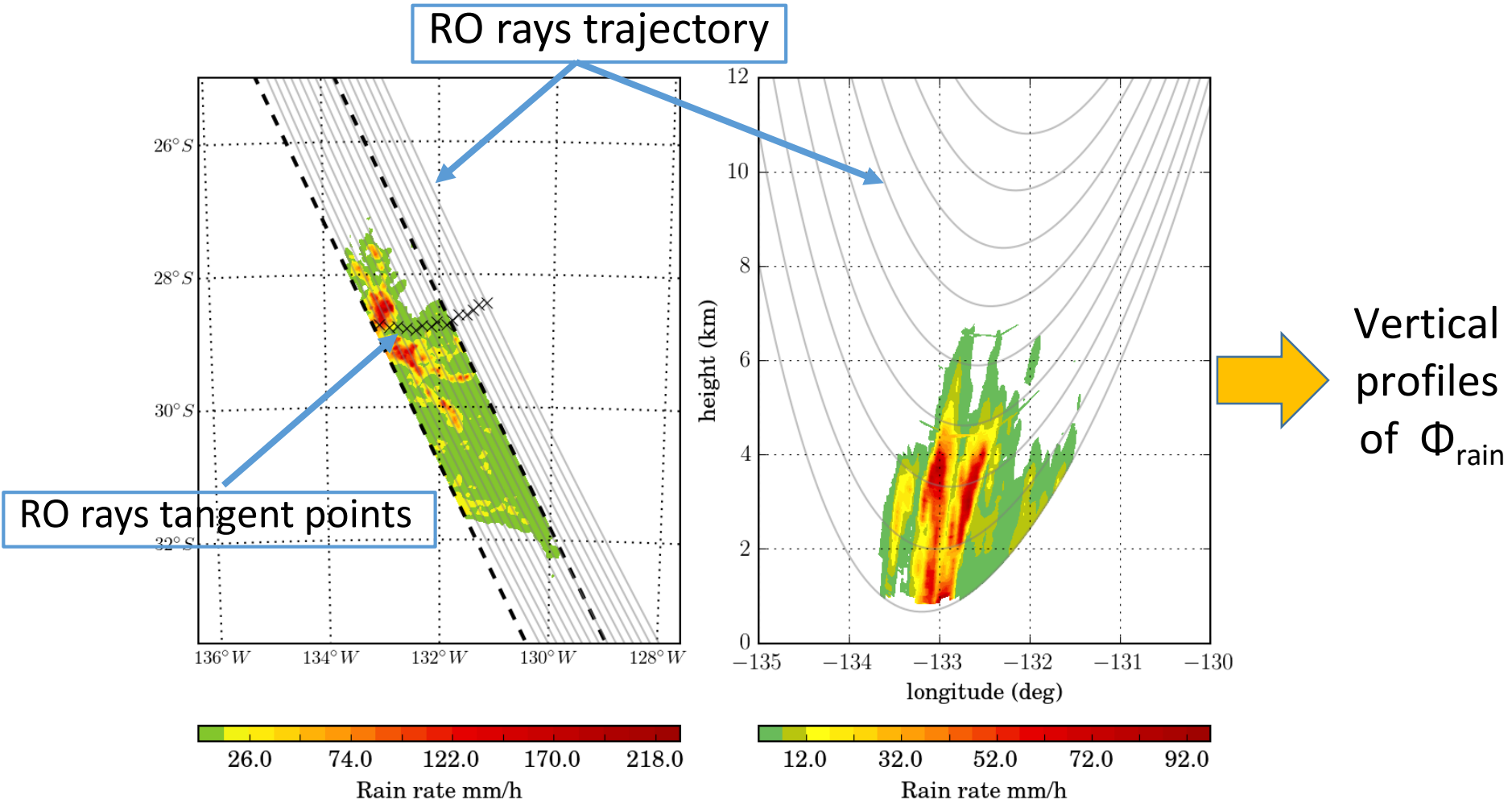
N(D): drop size distribution

- Simulations of S with T-matrix; realistic N(D) from co-located RO-TRMM observations

3 Dimensional co-location example

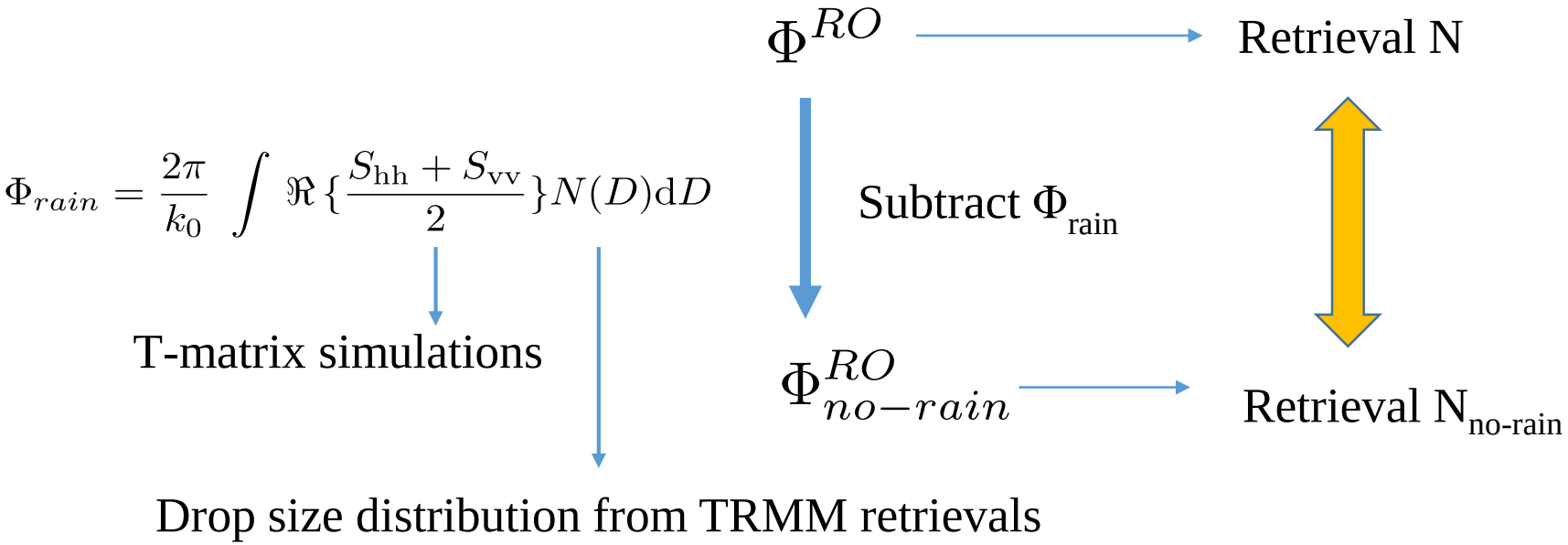


3 Dimensional co-location example



Rain – no rain comparison

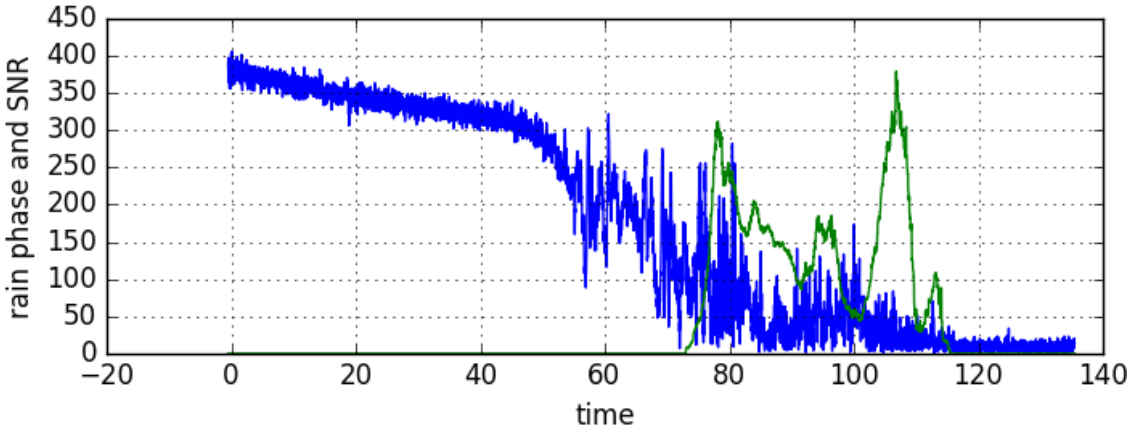
- Once the excess phase (Φ_{rain}) due to rain is computed, it can be removed from the RO observed one, so that the remaining profile becomes non-rain affected

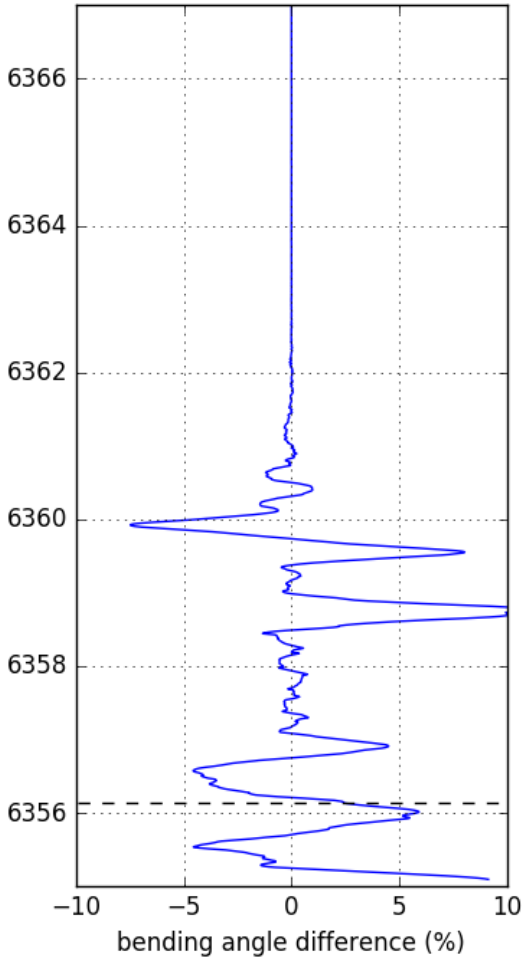


Rain -- no rain comparison

BA difference

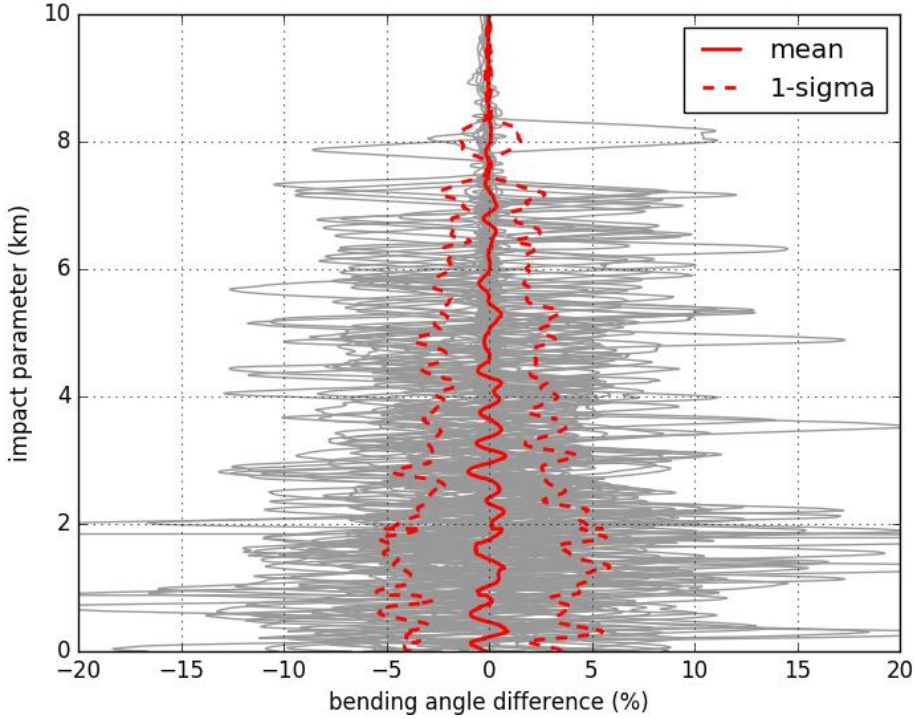
- C001.2008.345.00.43.G03

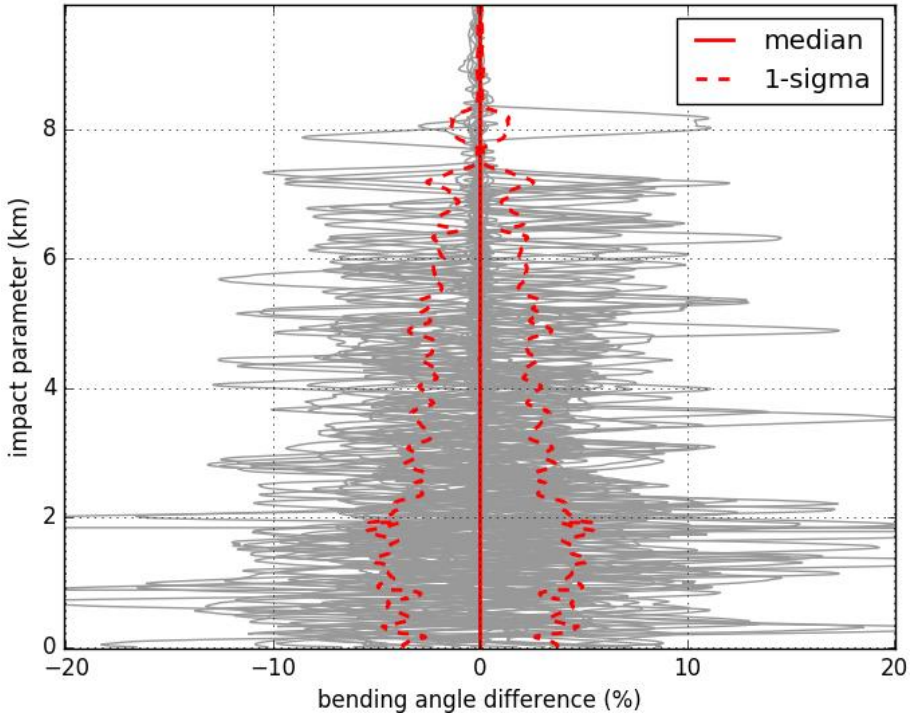




Rain – no rain comparison

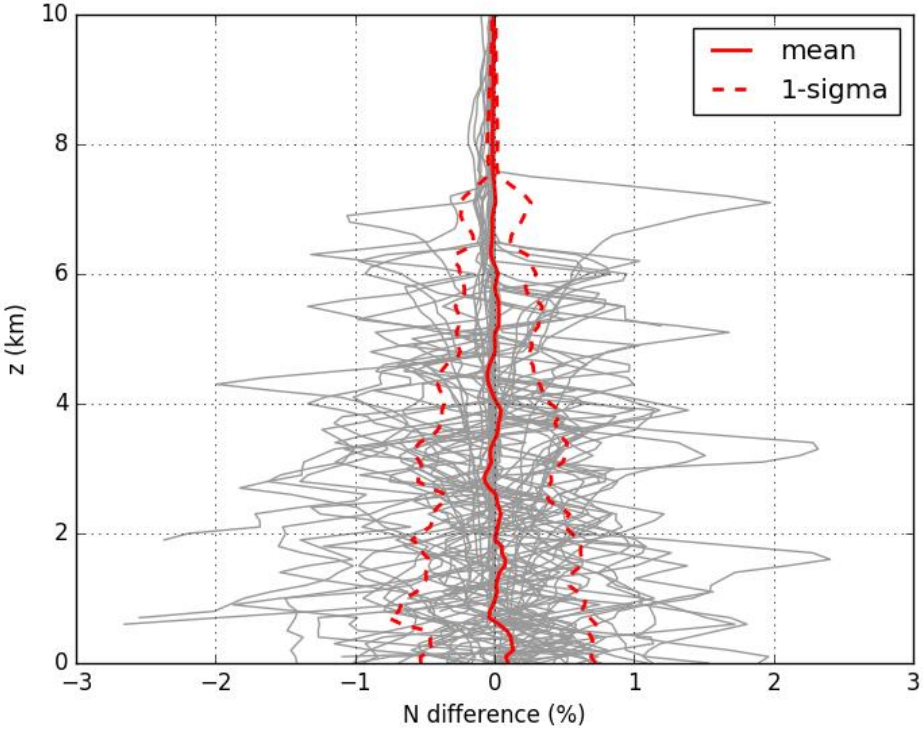
- Bending angle difference (No rain - rain)

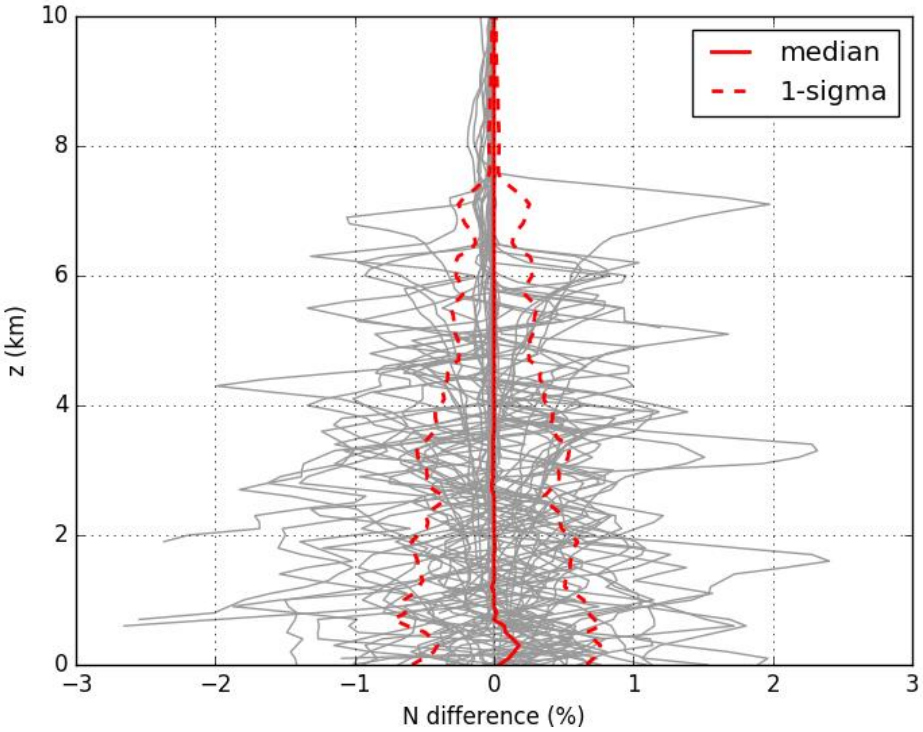




Rain – no rain comparison

- Refractivity difference (No rain - rain)



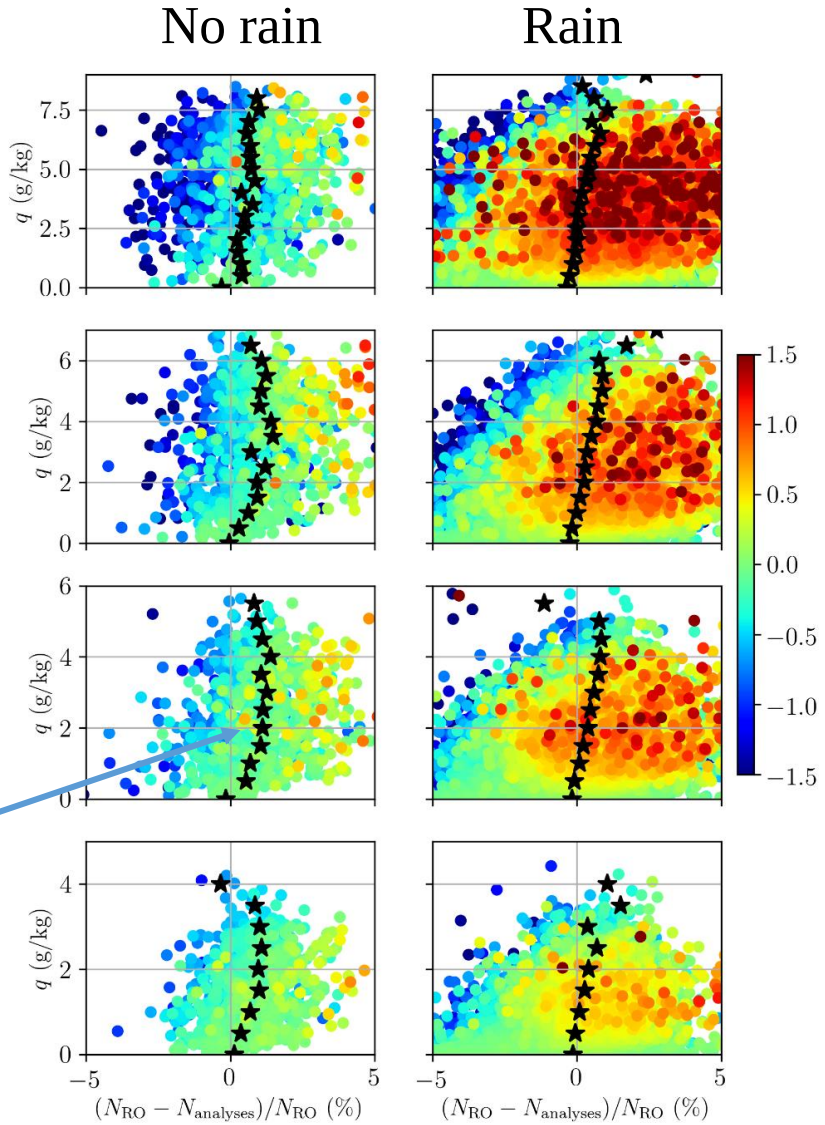


Conclusion

- A bias has been observed when comparing RO refractivity retrievals with that of analyses and re-analyses, when heavy precipitation is present
- The results of our studies point toward a worse performance of the models when precipitation is present (e.g. high q conditions), causing the observed bias
- This is consistent with the known problems of models in representing precipitation (Convective Parameterization,etc)
- Joint retrieval of precipitation and RO thermodynamic products (Pol-RO) could be useful in advance solving this problem

Models and (re)analyses performance

- The bias has a certain dependence on the specific humidity, regardless of rain
- Heavy precipitation is usually linked to high specific humidity
- The bias is positive when the model is biased wet



Mean <N_{obs}-N_{analy}> as a function of q