Interest of a nadir pointing radar on the European drone, component of Global Precipitation Mission

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The technological limits

Frequency	Antenna diameter	Footprint resolution
14 GHz	3.00 m	4.45 km
35 GHz	1.20 m	4.48 km
95 GHz	0.45 m	4.39 km

Table 1: Antenna size and footprint resolution at the various frequencies for an orbit altitude of 500 km.

Nadir operation allows an increased integration time (by a factor 50, number of across track pixels explored by the PR of the mother). For the same performance the power of the transmitter can be reduced by a factor $\sqrt{50}$ (or 8.5 dB). This combined with the utilisation of pulse compression (PC) allows using a very simple, reliable and cost effective solid state transmitter.

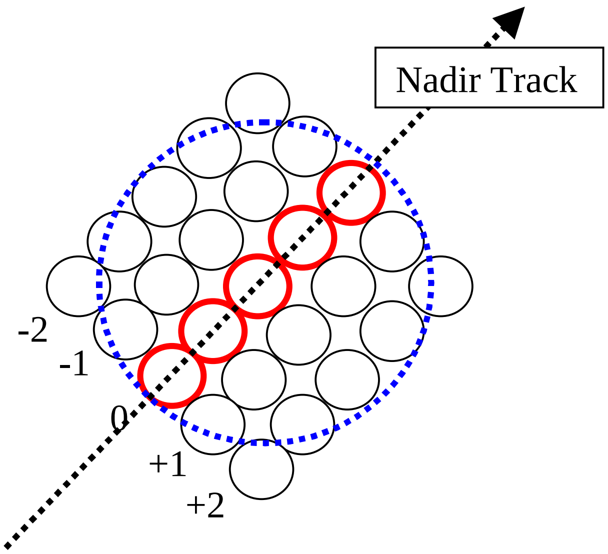
Through a tropical rain 5 km thick, the dynamical range of the 35 GHz radar (considering realistic figures in technological characteristics) is 0.1 to 10 mm/h; that of the 95 GHz radar is 0.1 to 3 mm/h. At mid-latitude where the rain layer is thinner, the performance is more favorable.

Interest of a nadir pointing precipitation radar on E-GPM

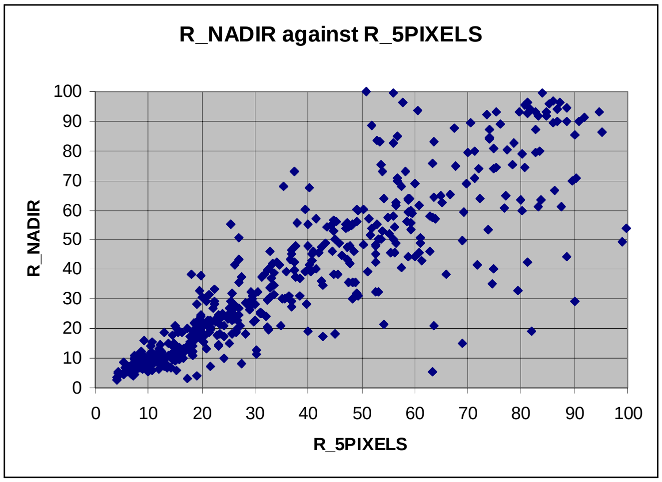
There is two possible use of a nadir pointing rain radar on E-GPM.

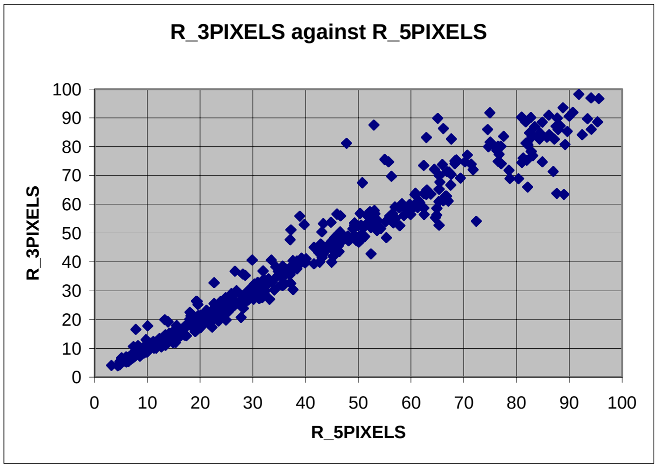
- To "calibrate" the retrieval of the microwave imager following Peter Bauer's approach (developped in the framework of EuroTRMM).
- To derive from the precipitation radar characteristics of the rain layer that may be used as input of the microwave retrieval.

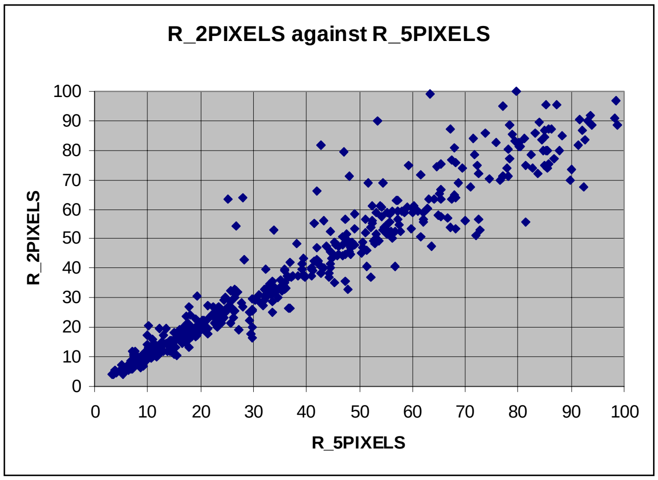
The Nadir Pointing Radar (NPR) for calibration of the microwave imager.



The problem of representativeness of the NPR with respect to the microwave imager.







Representativeness of an NPR that would explore one, two or three tracks with respect to the 25x25 km^2 footprint

The NPR for determination of characteristic parameters of the rain layer

1- Altitude of the melting layer detected as "bright band". (though the bright band is less marked at 35 GHz than at 14 GHz).

2- Determination of N_0^*, the "normalised intercept parameter" of the DSD. N_0^* is a critical parameter of the microwave radiometer inversion, as shown by Viltard (2000). N_0^* may be simply estimated from the "apparent" reflectivity profile $Z_a(h)$ observed by the NPR as:

$$N_0^* = \left[\frac{1}{\alpha} \frac{\{1 - \exp(-0.46\beta.PIA)\}}{I(r_b, r_s)} \right]^{\frac{1}{1-\beta}} \quad (1)$$

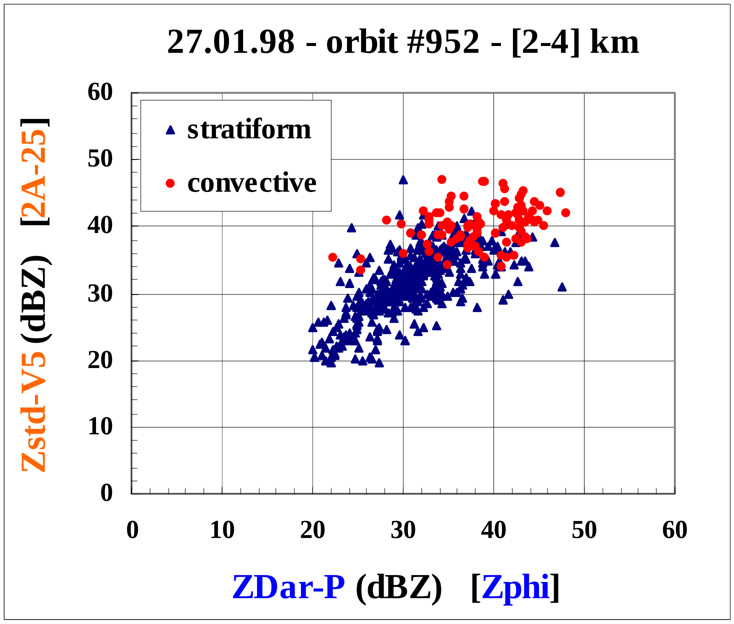
where:

$$I(0, r_s) = 0.46\beta \int_{r_b}^{r_s} Z_a{}^{\beta} ds \quad (2)$$

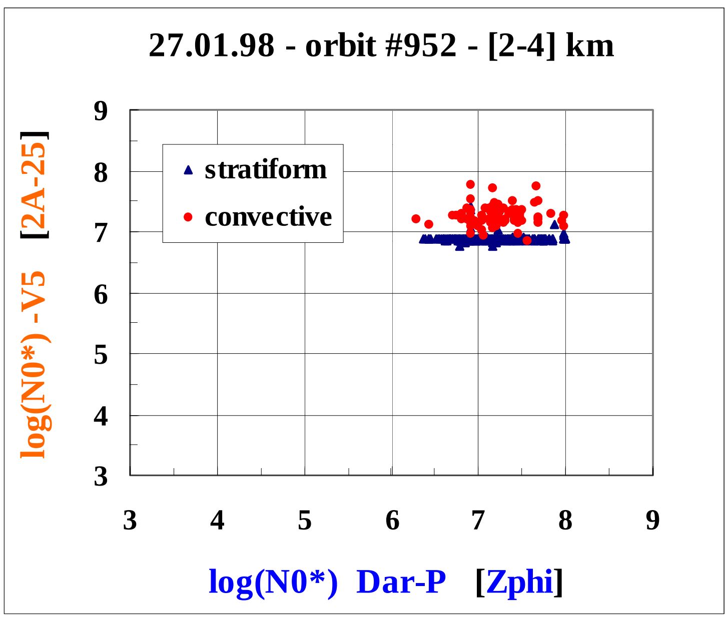
r_b is the radial distance of the bright band from the radar;
r_s is the radial distance of the surface from the radar;

α and β are the cefficient of the relationship between specific attenuation A (dB/km) and equivalent reflectivity Z_e:

$$A = \alpha N_0^{*1-\beta} Z_e{}^{\beta}$$



27.01.98 - orbit #952 - [2-4] km
stratiform
convective
Zstd-V5 (dBZ) [2A-25]
ZDar-P (dBZ) [Zphi]



27.01.98 - orbit #952 - [2-4] km
stratiform
convective
log(N0*) -V5 [2A-25]
log(N0*) Dar-P [Zphi]

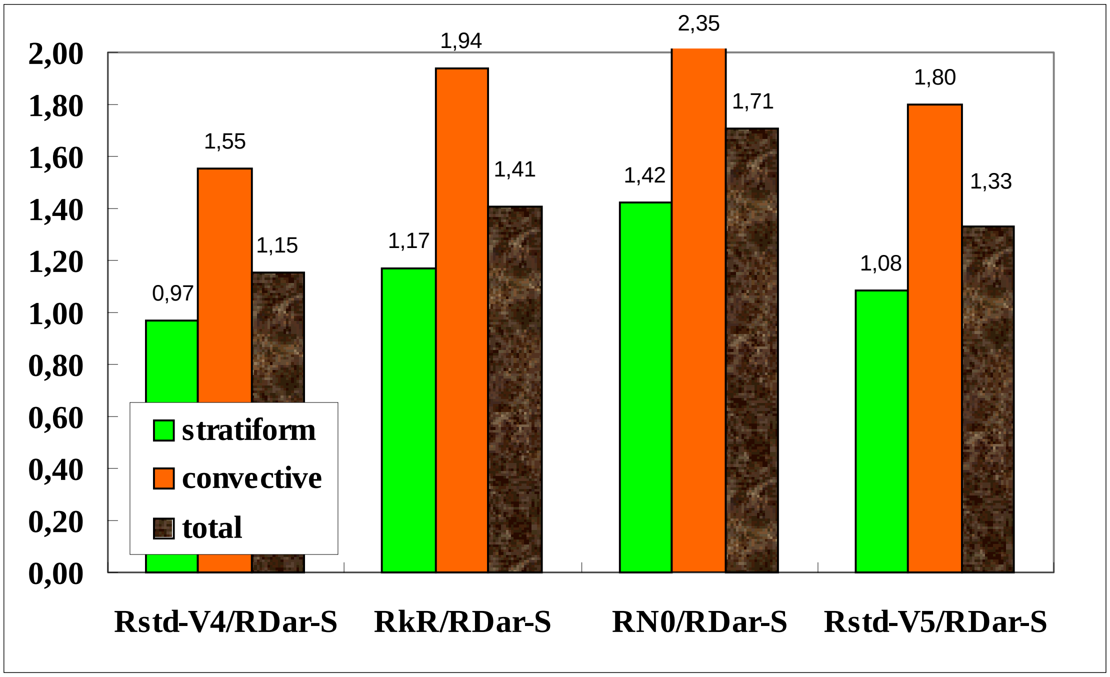


Fig. 21: Ratio of each of the mean *near surface* rain rates from the PR 2A-25 algorithm (version-4 standard $<R_{std\text{-}V4}>$; version-4 alternatives $<R_{kR}>$ and $<R_{N0}>$; and version-5 standard $<R_{std\text{-}V5}>$) to the GV-standard mean *surface* rain rate ($<R_{Dar\text{-}S}>$) from the Darwin-radar. Results are shown for different rain types, as categorized from the PR (cf: Table 7).

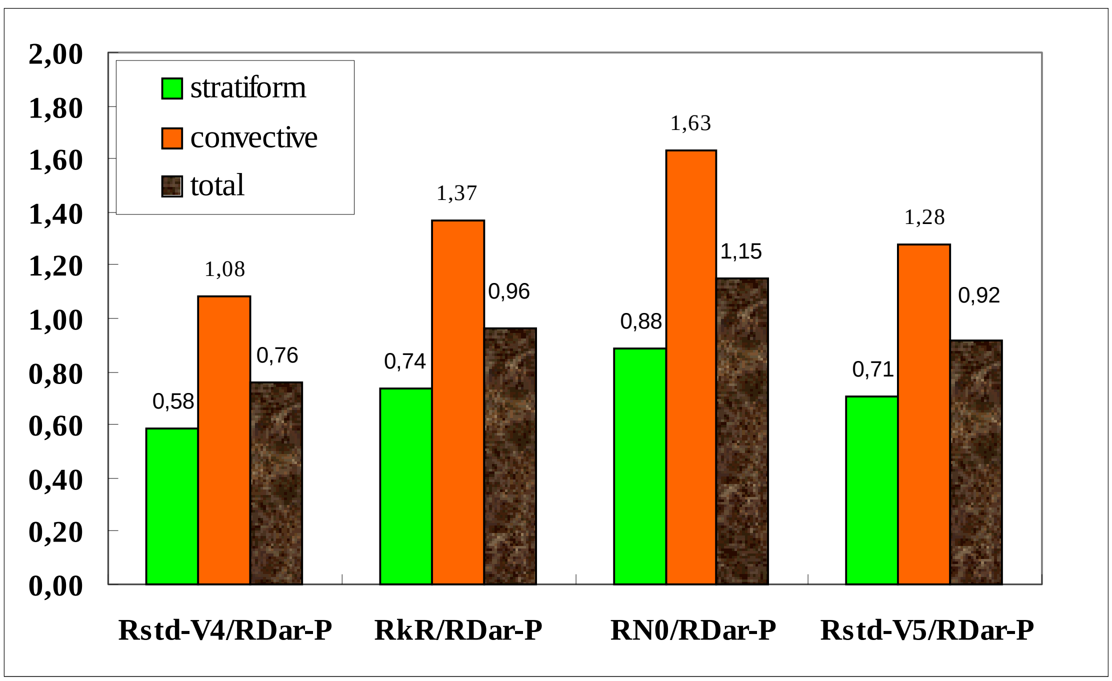
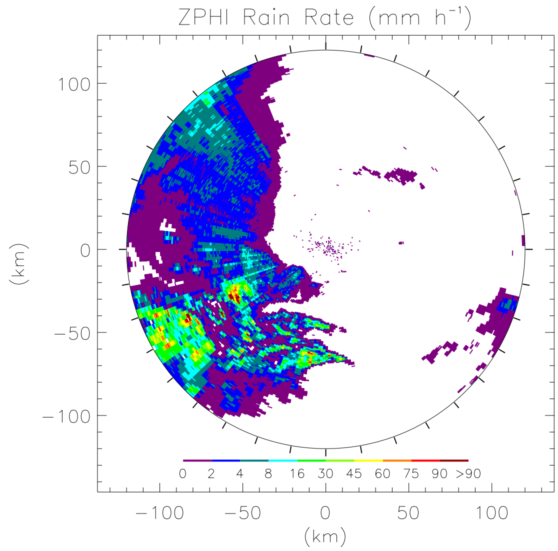
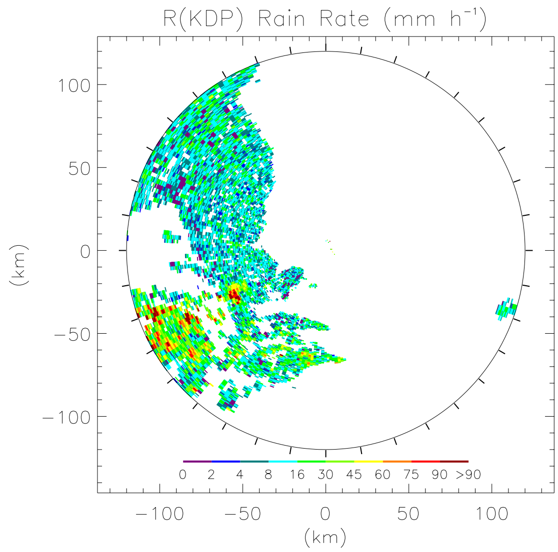
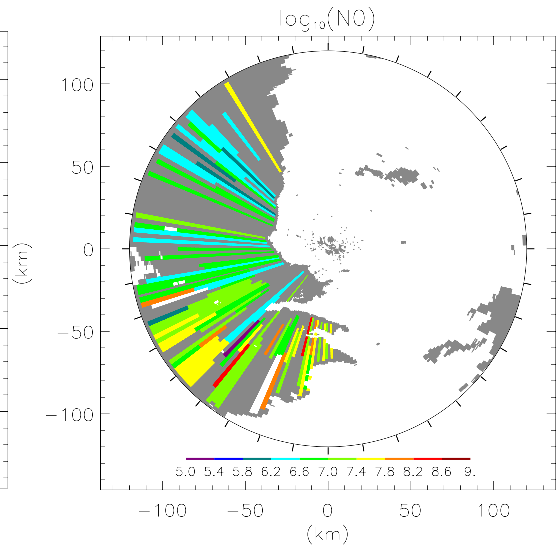


Fig. 24: Same as Fig. 21, but involving rain rates for data points within the [2-4] km altitude range, and « reference » Darwin-radar rain rates (<$R_{Dar\text{-}P}$>) from the Z-Phi polarimetric algorithm instead of GV-standard algorithm. Results are shown for different rain types, as categorized from the PR (cf: Table 8).

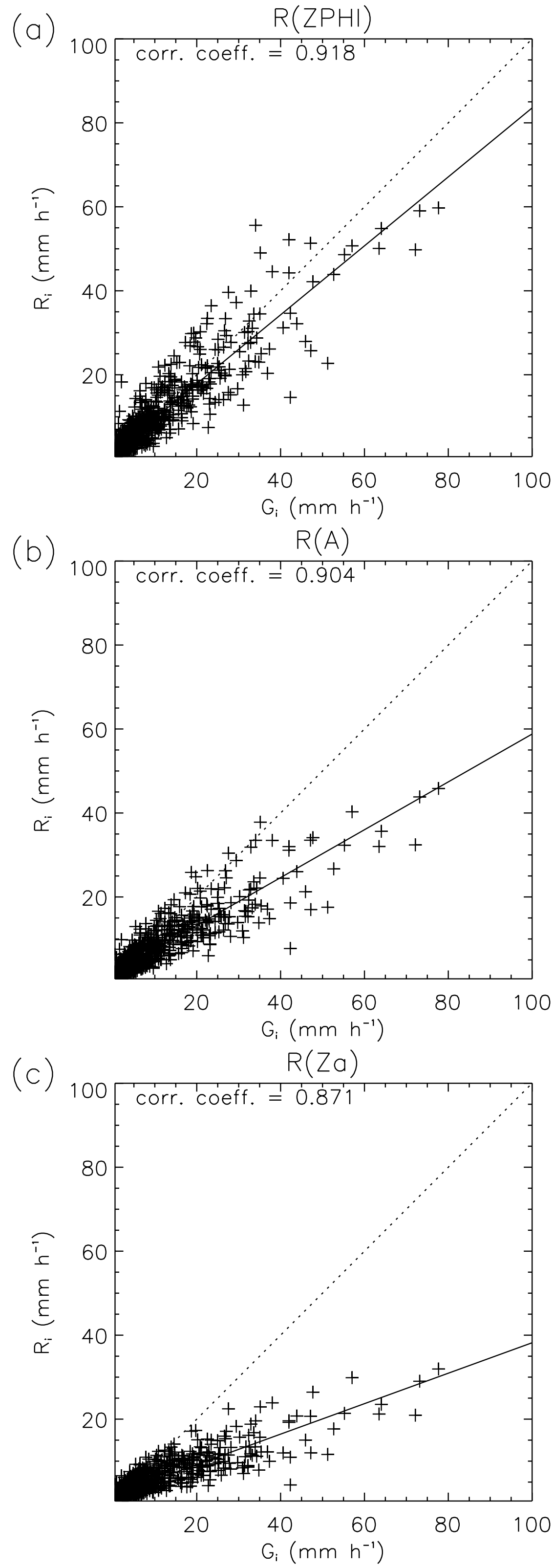
Illustration of the products of the Darwin Polarimetric radar with ZPHI







Performance of the Darwin polarimetric radar with ZPHI


(a)
R(ZPHI)
corr. coeff. = 0.918
R_i (mm h^{-1})
G_i (mm h^{-1})
(b)
R(A)
corr. coeff. = 0.904
R_i (mm h^{-1})
G_i (mm h^{-1})
(c)
R(Za)
corr. coeff. = 0.871
R_i (mm h^{-1})
G_i (mm h^{-1})

Conclusion

The inclusion of an NPR in E-GPM would explore a new technology that could make E-GPM a precursor of future operational satellites dedicated to measurement of precipitation.

The 14 GHz frequency for the radar seems excluded because of antenna size. Frequency 35 GHz seems the best compromise between antenna size and dynamical coverage in rain rate.

For calibration of the radiometric retrieval by the radar, it would be useful that the NPR explores two tracks 8 km apart about nadir, rather than a single track at nadir.

For N_0^* derivation, the possibility of a 35 GHz radar should be extended with respect to a 14 GHz one, and should cover the stratiform rain.