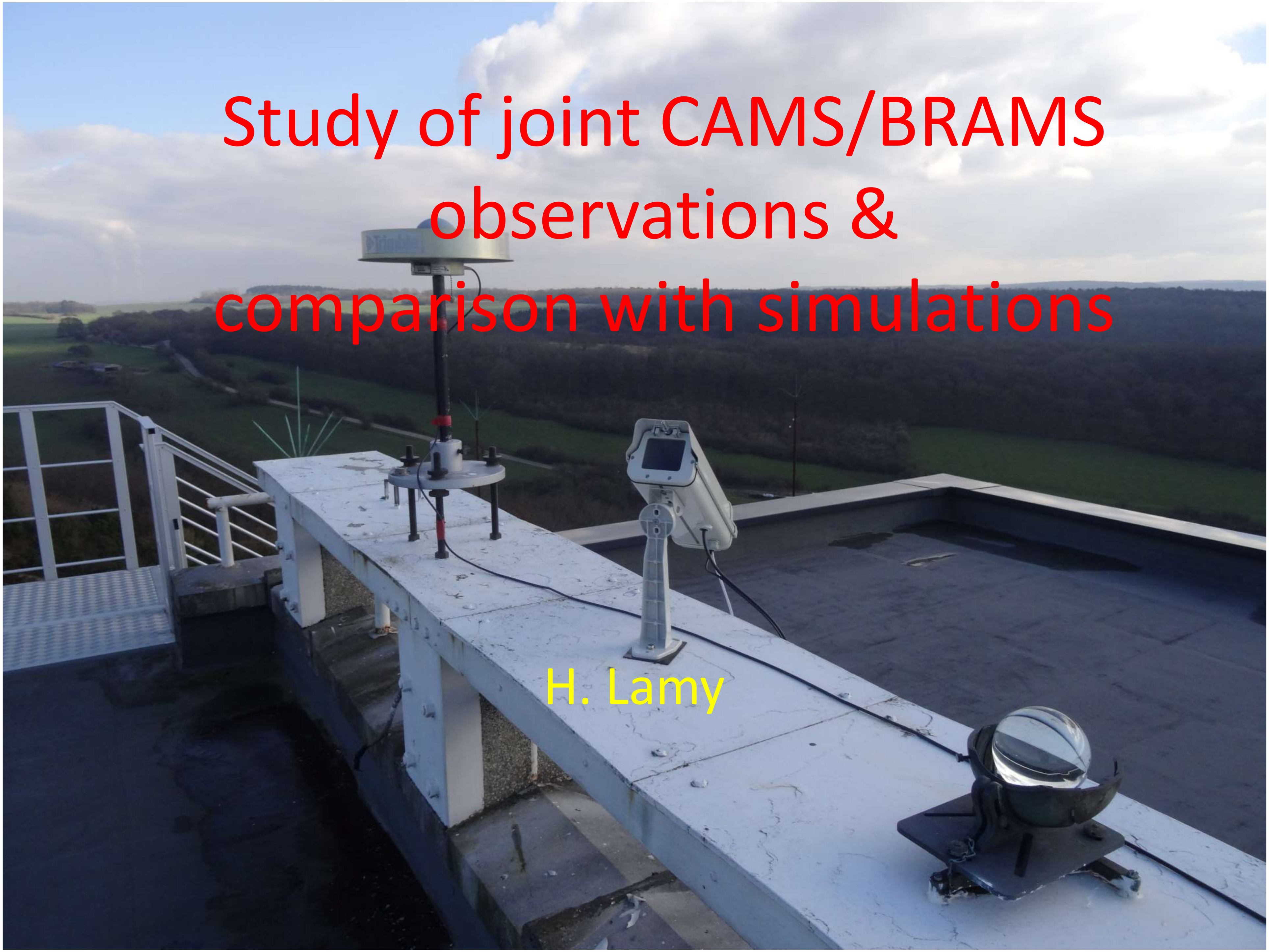
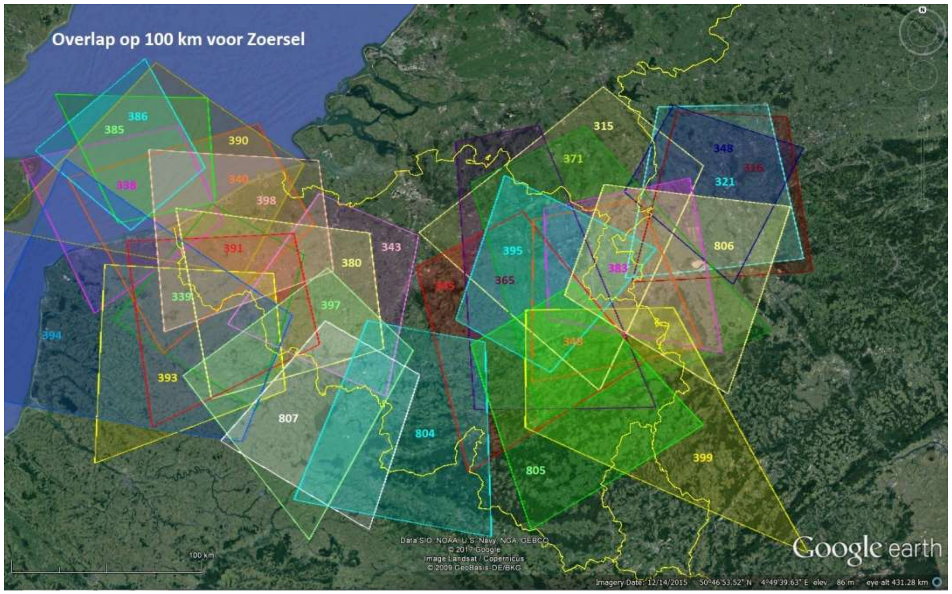
Study of joint CAMS/BRAMS observations & comparison with simulations

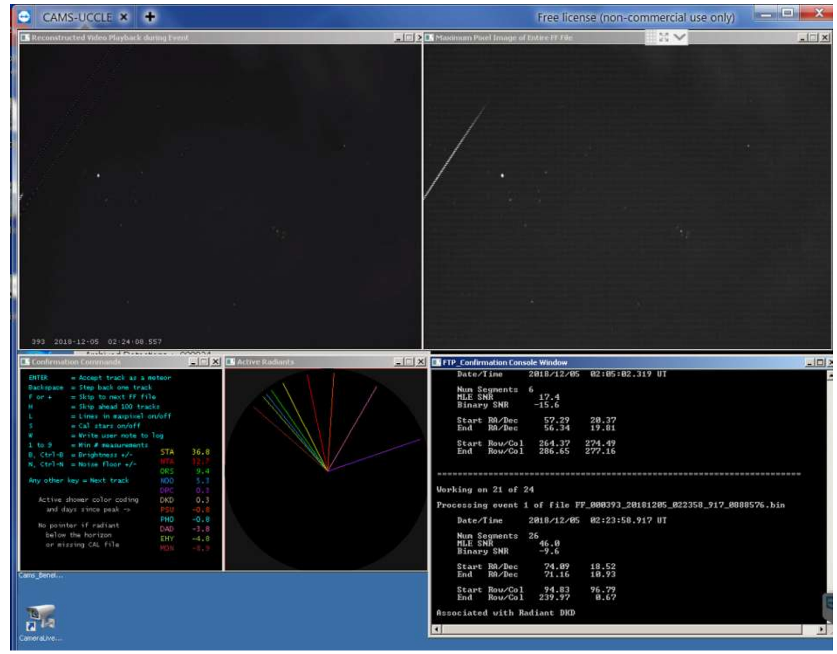
H. Lamy



CAMS observations



Credit : P. Roggemans



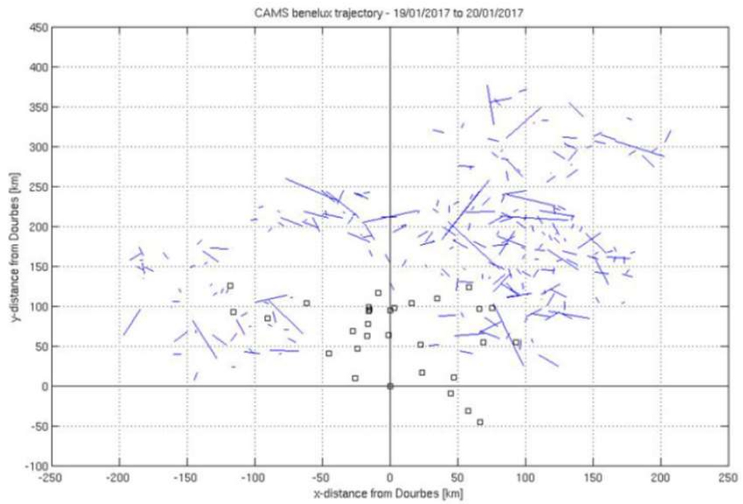
Provide very accurate trajectories, speed and deceleration measurements

$$d_o(t) = d(t=0) + V_\infty t - |a_1|\exp(a_2 t)$$
$$V_o(t) = V_\infty - |a_1 a_2|\exp(a_2 t)$$
$$A_o(t) = -|a_1 a_2^2|\exp(a_2 t)$$

Jenniskens et al (2016)

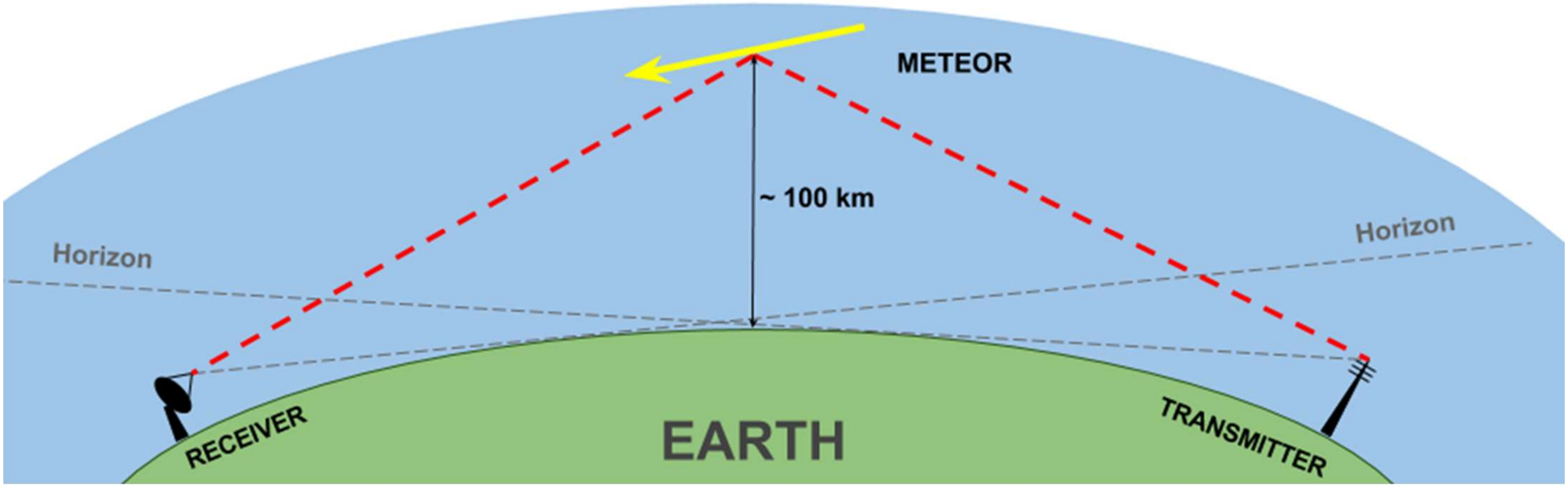
CAMS observations

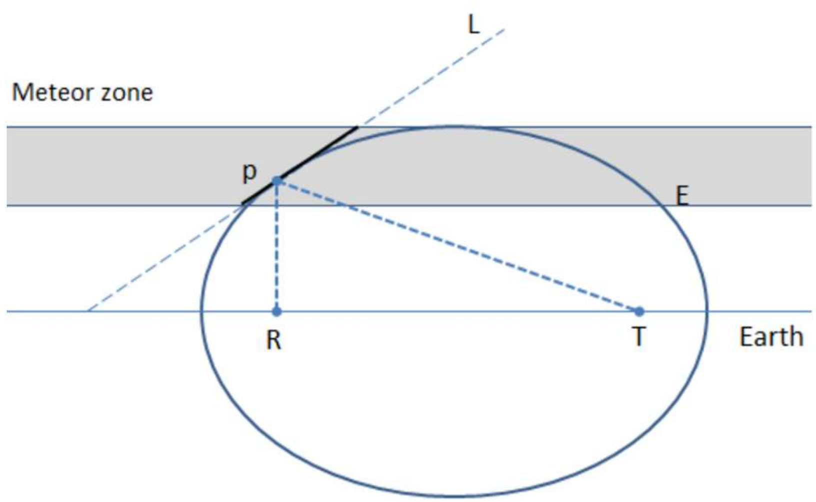
- Night from 19 to 20 January : 245 trajectories



- Trajectory 240 :
  - $V_\infty = 66.33 \pm 0.15$ km/s
  - $a_1 = 0.017 \pm 0.01$ km/s
  - $a_2 = 0.398 \pm 0.08$ s^{-1}
  - Lat, Long, H of begin and end points of CAMS trajectory
  - Begin time of observation of CAMS trajectory

BRAMS observations : specularity condition

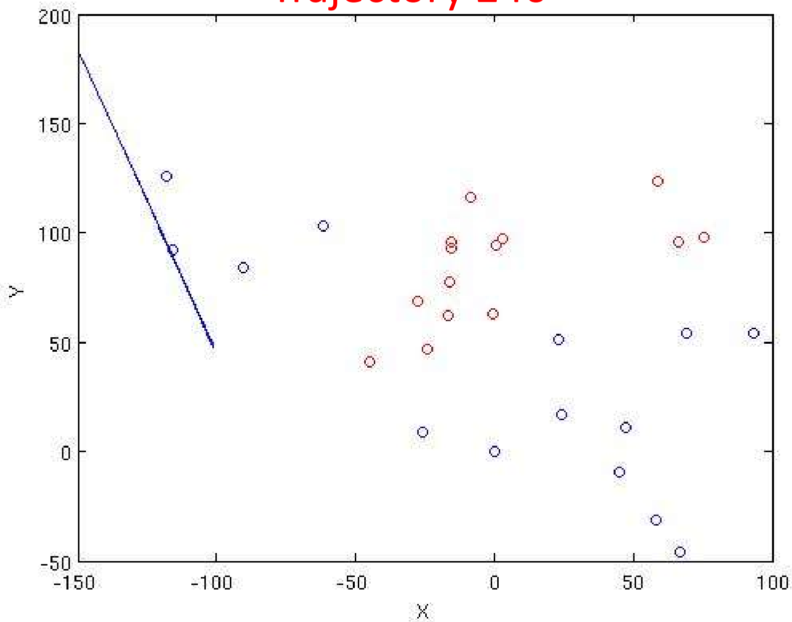


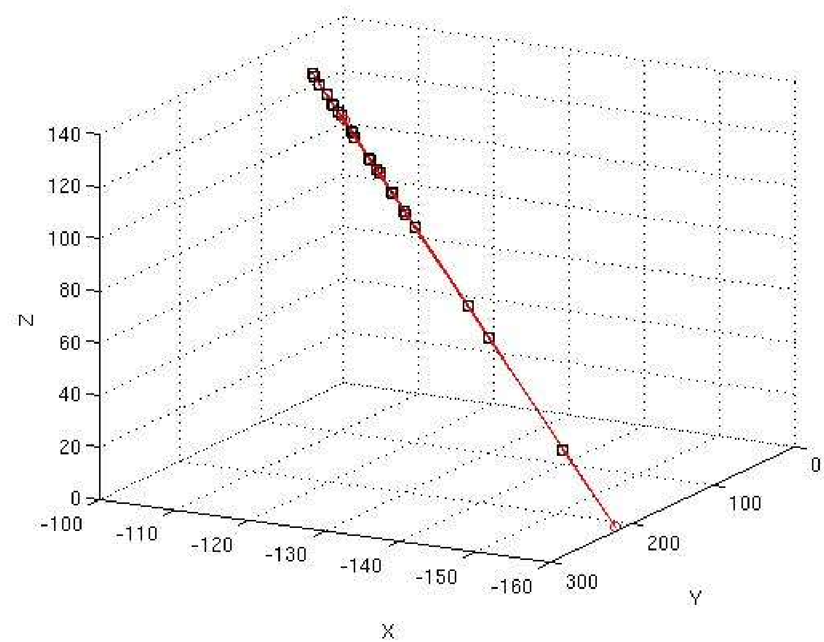


CAMS/BRAMS 1st comparison

Night from 19 to 20/01/2017 : 245 trajectories

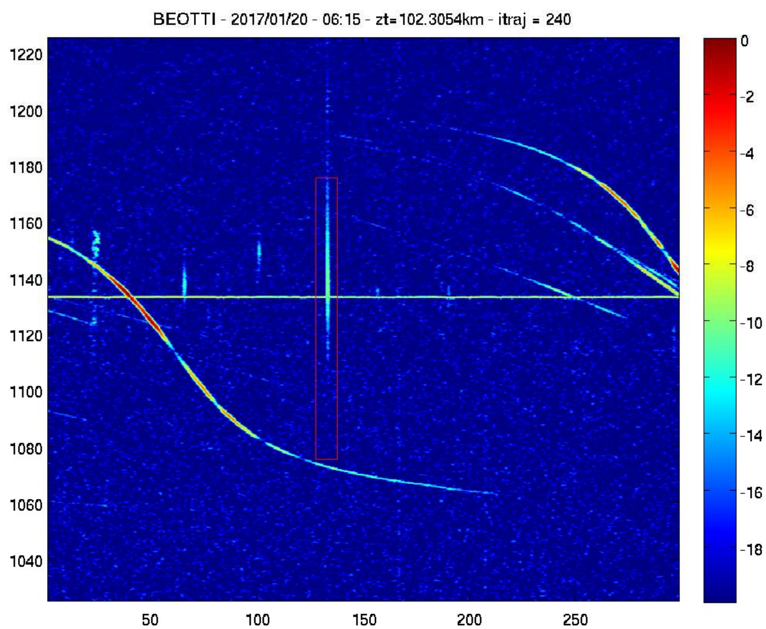
Trajectory 240



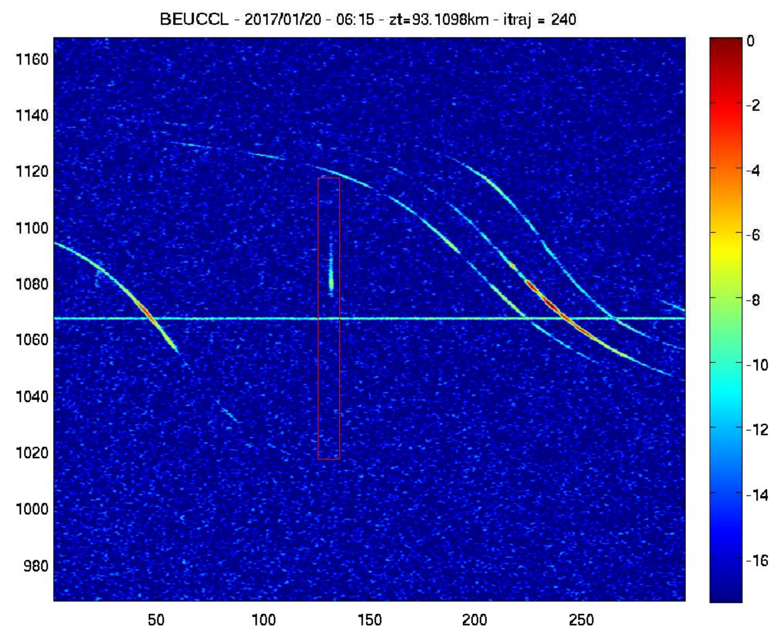


Not all stations were working nominally !

CAMS/BRAMS 1st comparison

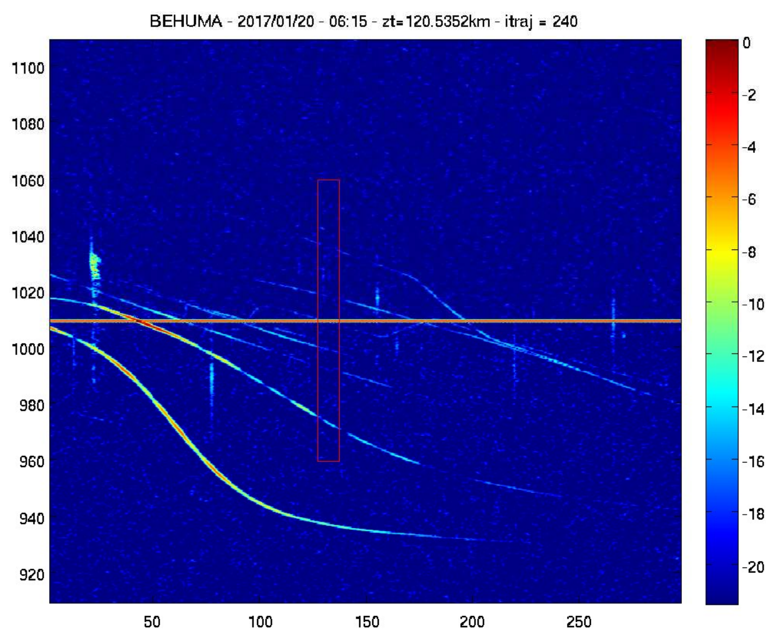


Zt =102.3 km

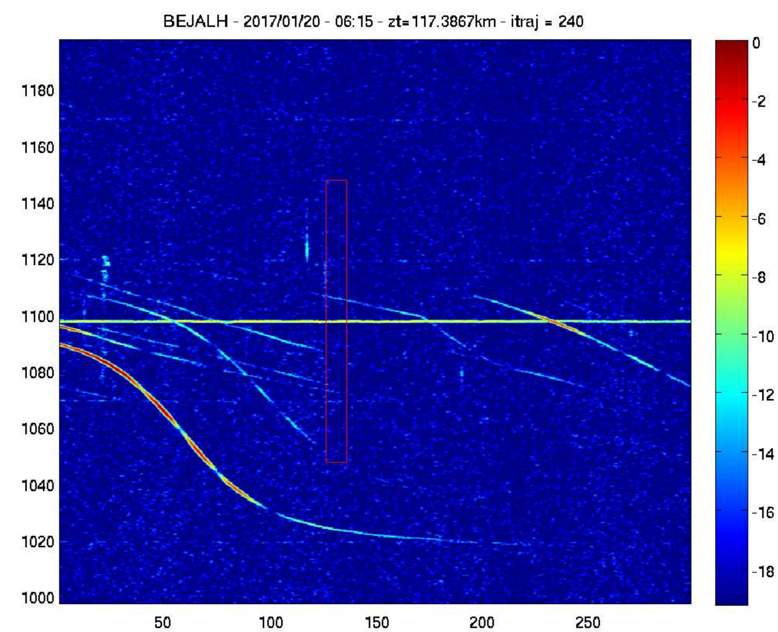


Zt =93.1 km

CAMS/BRAMS 1st comparison

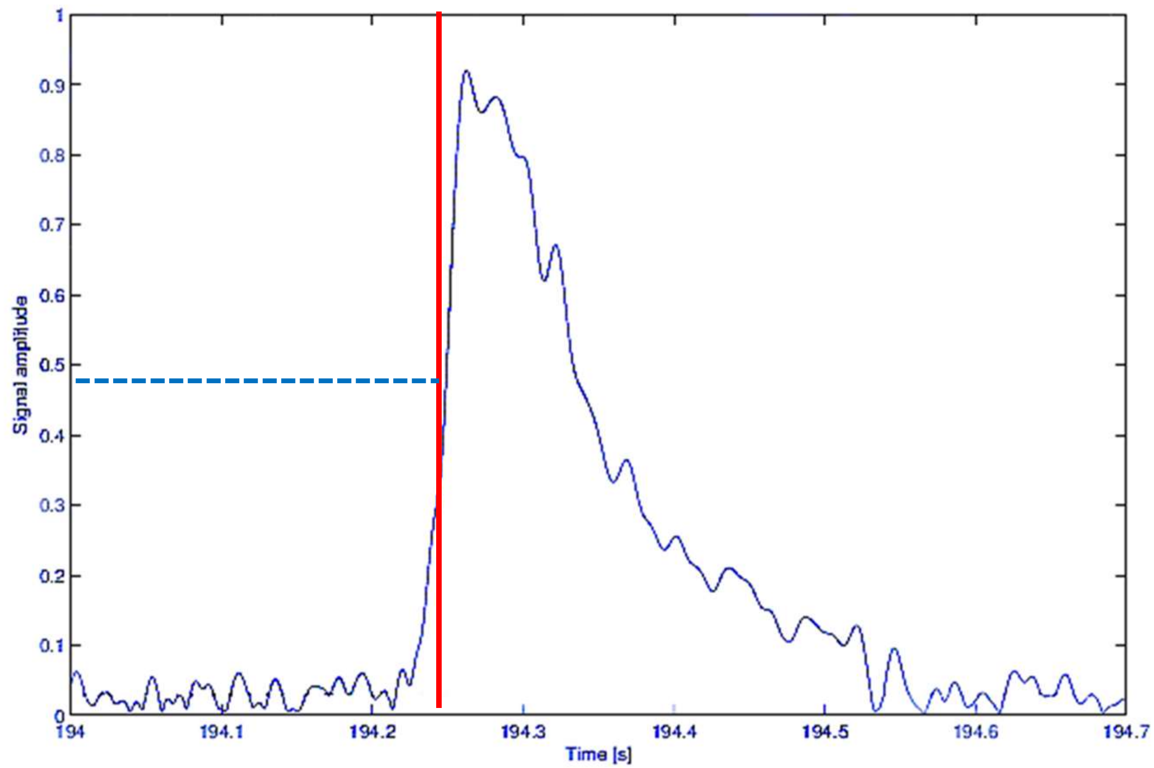


Zt = 120.5 km



Zt = 117.4 km

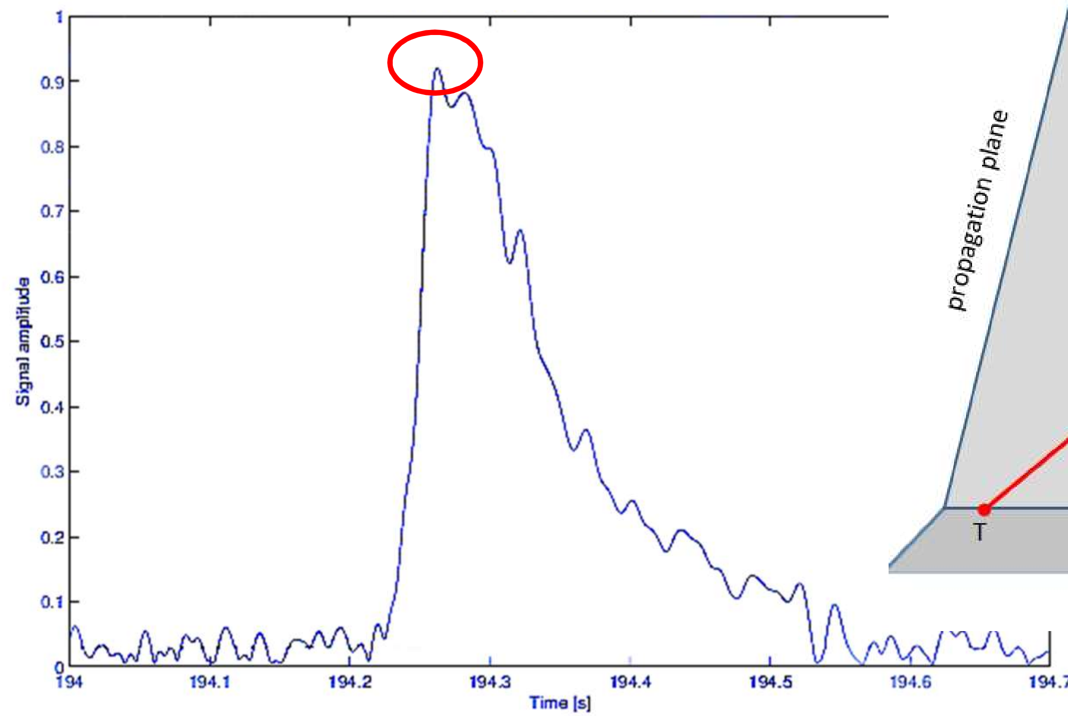
CAMS/BRAMS more accurate comparison

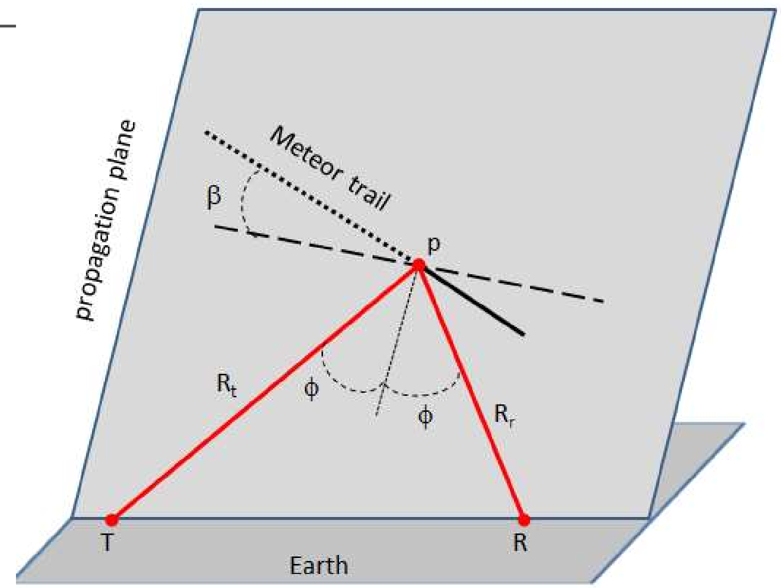


TBD

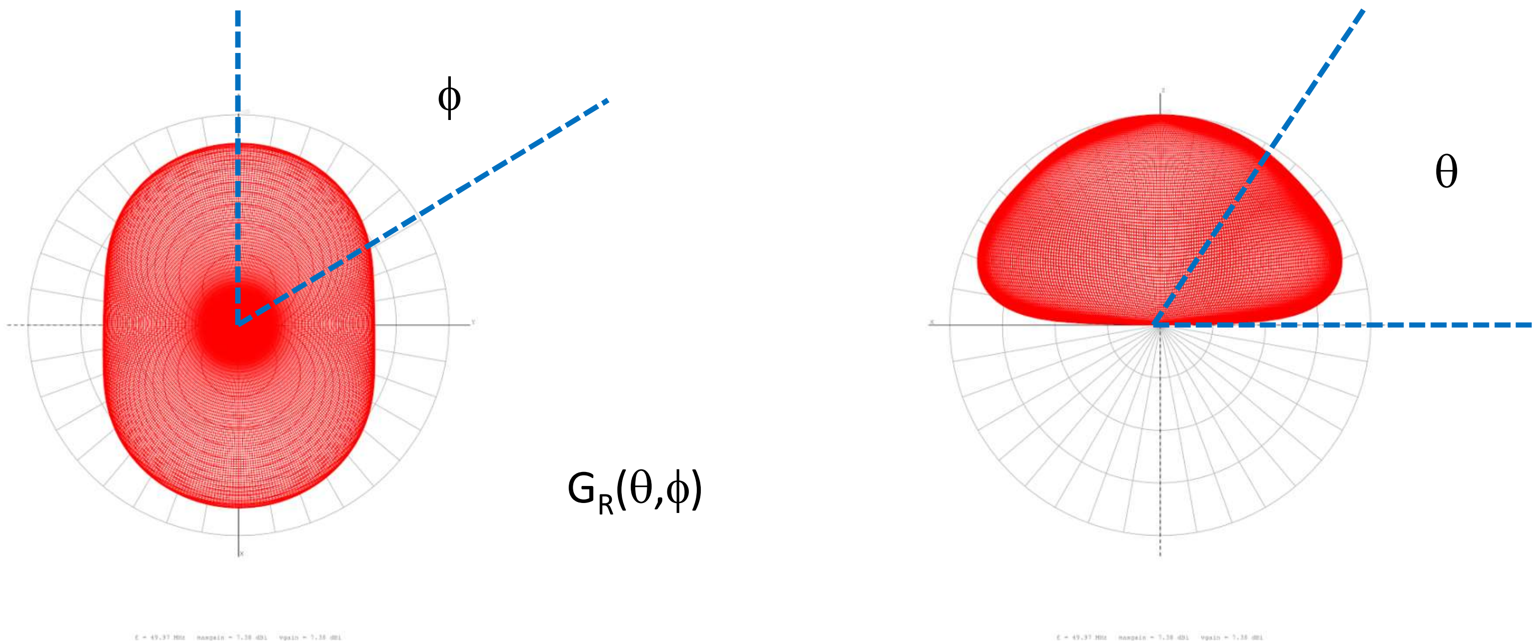
Determination of peak power

$$P_{\text{peak-under}} = \frac{P_T G_T G_R \lambda^3 r_e^2 \alpha^2 \sin^2\gamma}{16\pi^2 R_T R_R (R_T + R_R)(1 - \sin^2\phi\cos^2\beta)},$$





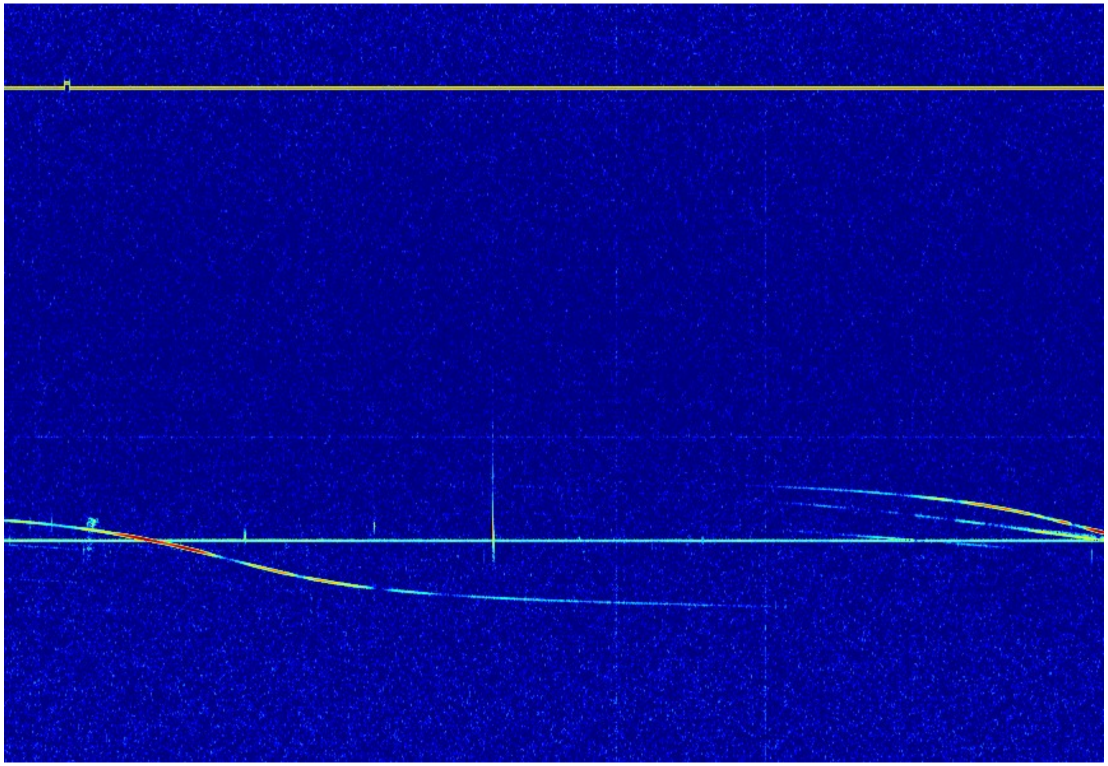
Determination of peak power



Credit : A. Martinez Picar

Determination of peak power

« Calibrated » value by determining the amplitude of the calibrator signal



→ $P_{peak\text{-}under}$ in Watts

Limitations

- Mc Kinley's formula is strictly valid for underdense meteor echoes. Quid for overdense ones or even those with intermediate electron line densities?
- Most antennas were tilted at that time, which means that their gain GR(θ,ϕ) is not very well constrained in the direction to the reflection point.
- For the polarisation factor, we can tentatively take ½ (assuming we emit a circularly polarised wave, which is not exactly the case)
- We have also to check the stability of the calibrator over time
- Not all stations were working nominally at that time (problems with receiver, no calibrator everywhere, mismatch of antennas, etc…)

Electron line densities

$$P_{peak\text{-}under} = \frac{P_{\mathrm{T}} G_{\mathrm{T}} G_{\mathrm{R}} \lambda^3 r_e^2 \alpha^2 \sin^2 \gamma}{16\pi^2 R_{\mathrm{T}} R_{\mathrm{R}} (R_{\mathrm{T}} + R_{\mathrm{R}})(1 - \sin^2 \phi \cos^2 \beta)},$$

➡ We obtain the linear electron line density α in different points along the meteoroid path

Comparison with simulations

First, with a relatively simple model such as the one from Vondrak et al (2008). Matlab code available from VKI

$$\frac{dV}{dt} = -\Gamma V^2 \frac{3\rho_a}{4\rho_m R} + \rho_m g$$

$$\frac{1}{2}\pi R^2 V^3 \rho_a \Lambda = 4\pi R^2 \varepsilon\sigma (T^4 - T_{env}^4) + \frac{4}{3}\pi R^3 \rho_m C \frac{dT}{dt} + L\frac{dm}{dt}$$

$$\frac{dz}{dt} = -V\cos(\chi)$$

$$\frac{dm_i^A}{dt} = \gamma\, p_i S \sqrt{\frac{\mu_i}{2\pi k_B T}}$$

$$\frac{dm^A}{dt} = \sum_i \frac{dm_i^A}{dt}$$

- V and χ given by CAMS
- ρ_m assumed with typical values (unless other information available)
- Only unknown remains the mass

Comparison with simulations

$$q = -\frac{\beta}{\mu V}\frac{dm}{dt}$$

q is the ionisation rate (in e-/m^3)

General idea :

- Run the model for several « reasonable » values of the initial mass. Each model produces a profile of q as a function of the distance along the meteoroid path
- Pick up the value of the mass that minimizes (in least square sense) the difference between simulated values and values obtained from BRAMS data
- For that, establish link between q and α

What is next?

1. Correct the existing codes to analyze BRAMS/CAMS data and make them robust
2. Run the Matlab codes for the Vondrak model and pick up the best solution
3. Publish the results
4. Try to make comparisons with more sophisticated models developed by VKI
5. Explore other possibilites to decrease the aforementioned limitations