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A Device to Measure the Influence of Spatially Inhomogeneous Cirrus on Atmospheric Radiation

Leipzig Institute for Meteorology

MAX-PLANCK-INSTITUT FÜR CHEMIE

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1. AIRTOSS - Project

- study of effects of microphysical inhomogeneity of the cloud on their radiative energy budget and remote sensing results
- deviation of retrieved microphysical parameters and in situ data depends on 3D effects within the Cirrus

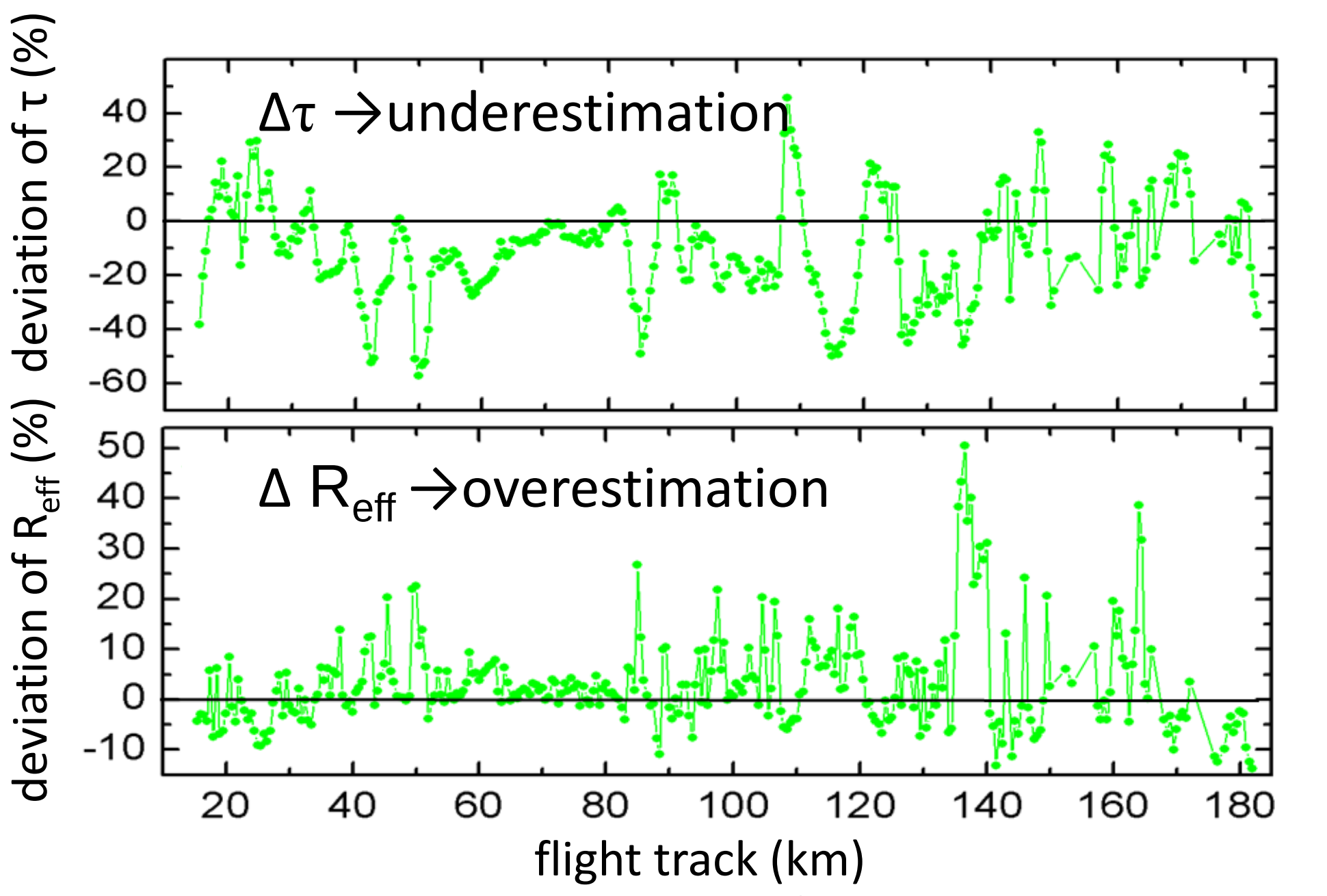

Fig. 1: Airborne measurements (optical thickness τ, effective radius R_{eff}) from an spatially inhomogeneous Cirrus compared to a 3D modelled Cirrus [2]

airborne microphysical measurements

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modelling of Cirrus fields

AIRcraft **TO**wed **S**ensor **S**huttle

simultaneous measurements above and beneath the Cirrus

airborne radiation measurements

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radiative transfer model

2. Instruments

right wing: AIRTOSS
left wing: wing pod
fuselage: spectrometer, PC, …

Airtoss is let down on a 4000 m long towing cable

two field campaigns in spring and autumn 2013 above the North Sea

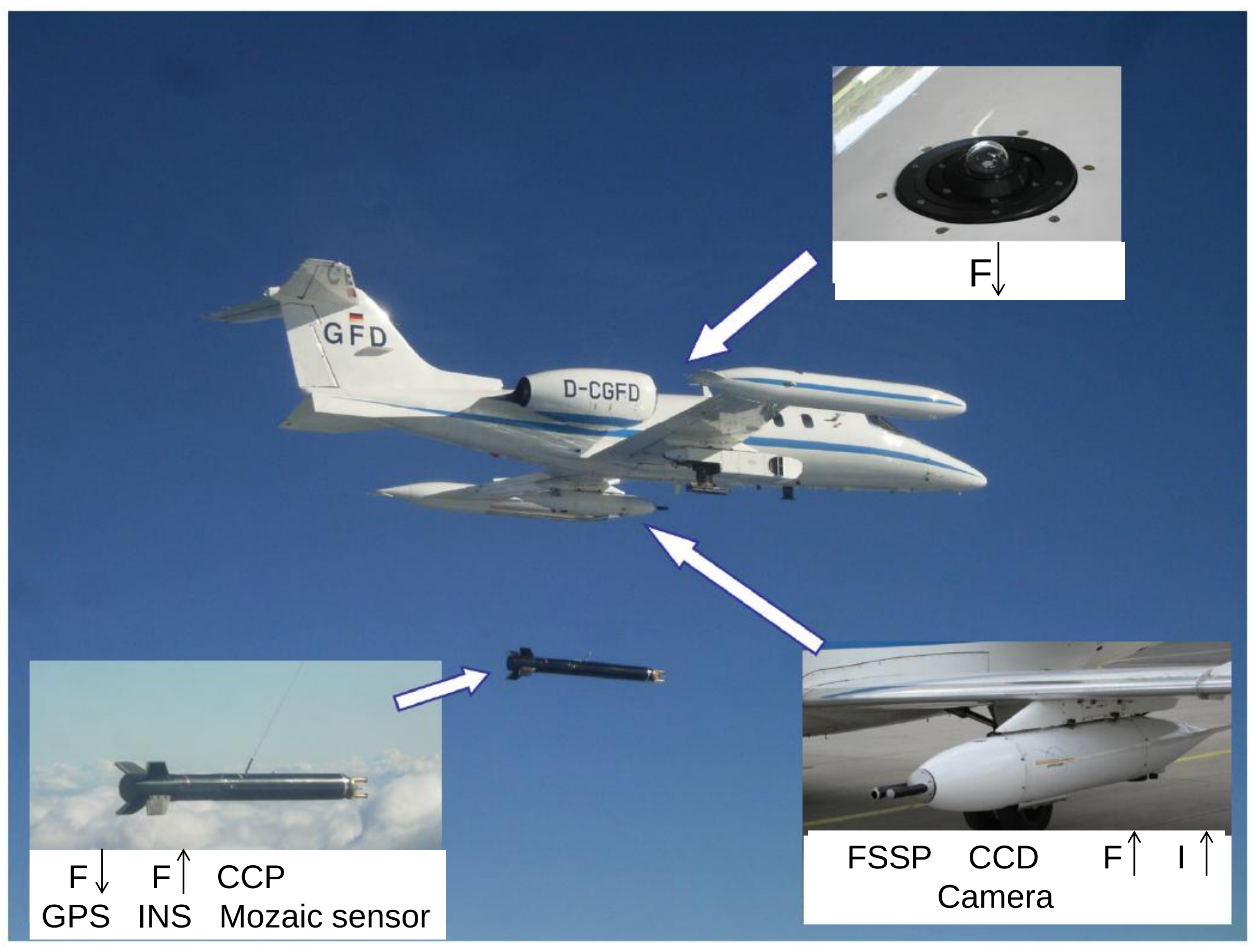


Fig. 2: Instrumented Learjet and Airtoss (adapted from [1])

Tab. 1: Instrumentation list for the AIRTOSS campaigns in 2013

	Leipzig	Mainz
Airtoss	2 irradiance sensors GPS and position (INS) sensor p,T,RH – sensor	Cloud Combination Probe CCP
Wing Pod	radiance and irradiance sensor CCD Camera	Forward Scattering Spectrometer Probe FSSP
Fuselage	Irradiance sensor	QCL, Ozone Monitor, DENCHAR Package, NDIR

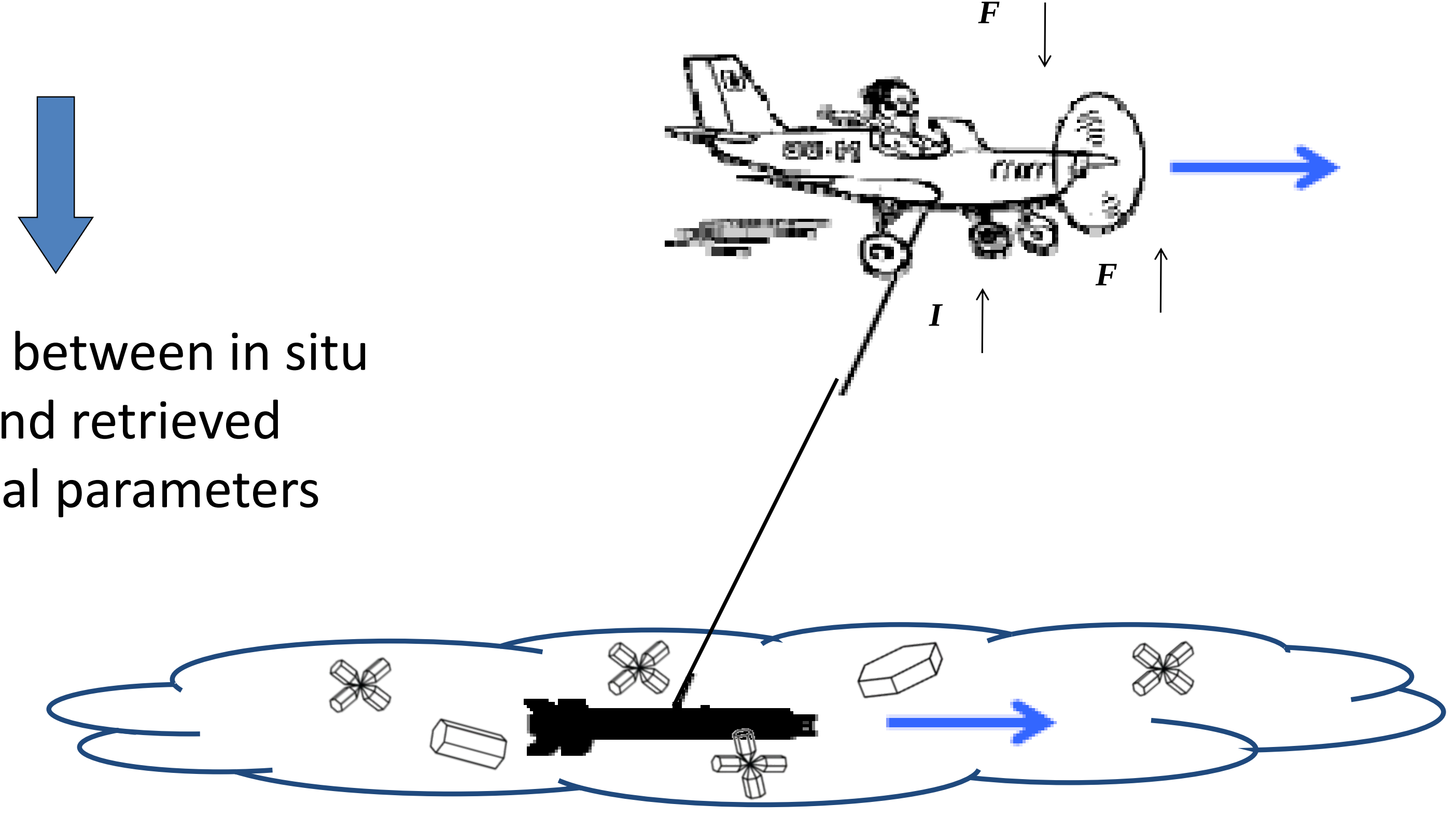
QCL: Quantum Cascade Laser, NDIR: Nondispersive Infrared Sensor
DENCHAR: Development and Evaluation of Novel Compact Hygrometer for Airborne Research

3. Strategy for Remote Sensing

- AIRTOSS is dipped from above into the cloud to obtain in situ microphysical measurements
- reflected radiance measurements collected on the Learjet simultaneously

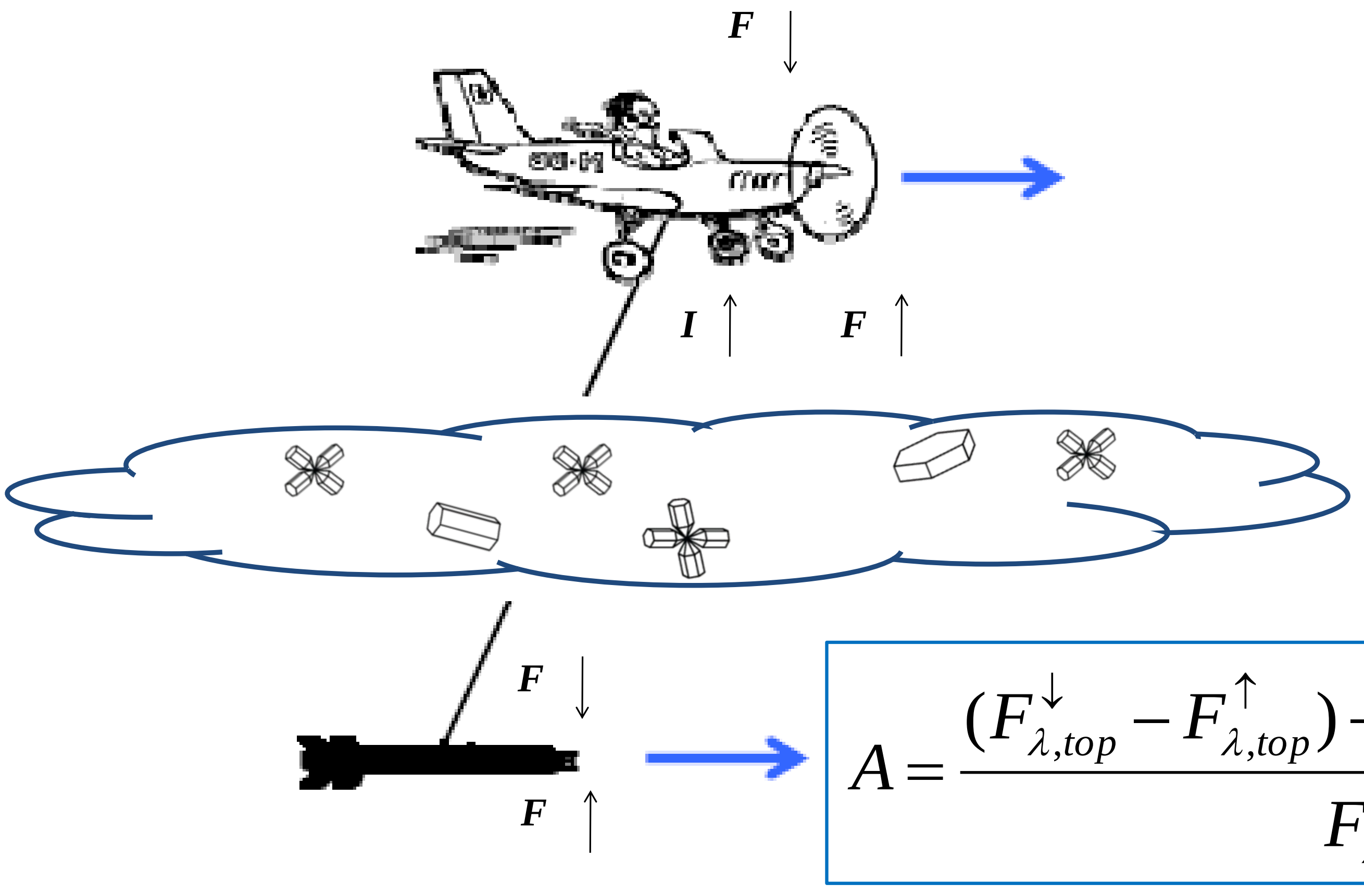
Nakajima & King → optical thickness τ
effective radius R_{eff}

comparison between in situ measured and retrieved microphysical parameters



4. Strategy for Energy Budget

- collocated measurements by the Learjet and AIRTOSS above and beneath the Cirrus



$$T = \frac{F^{\downarrow}_{\lambda,\mathrm{base}}}{F^{\downarrow}_{\lambda,\mathrm{top}}}$$

$$R = \frac{F^{\uparrow}_{\lambda,\mathrm{top}}}{F^{\downarrow}_{\lambda,\mathrm{top}}}$$

$$A = \frac{(F^{\downarrow}_{\lambda,top} - F^{\uparrow}_{\lambda,top}) - (F^{\downarrow}_{\lambda,base} - F^{\uparrow}_{\lambda,base})}{F^{\downarrow}_{\lambda,top}}$$

- spectral nadir – radiances and up- and downward irradiances will be measured

→ spectral transmissivity T, absorptivity A and reflectivity R

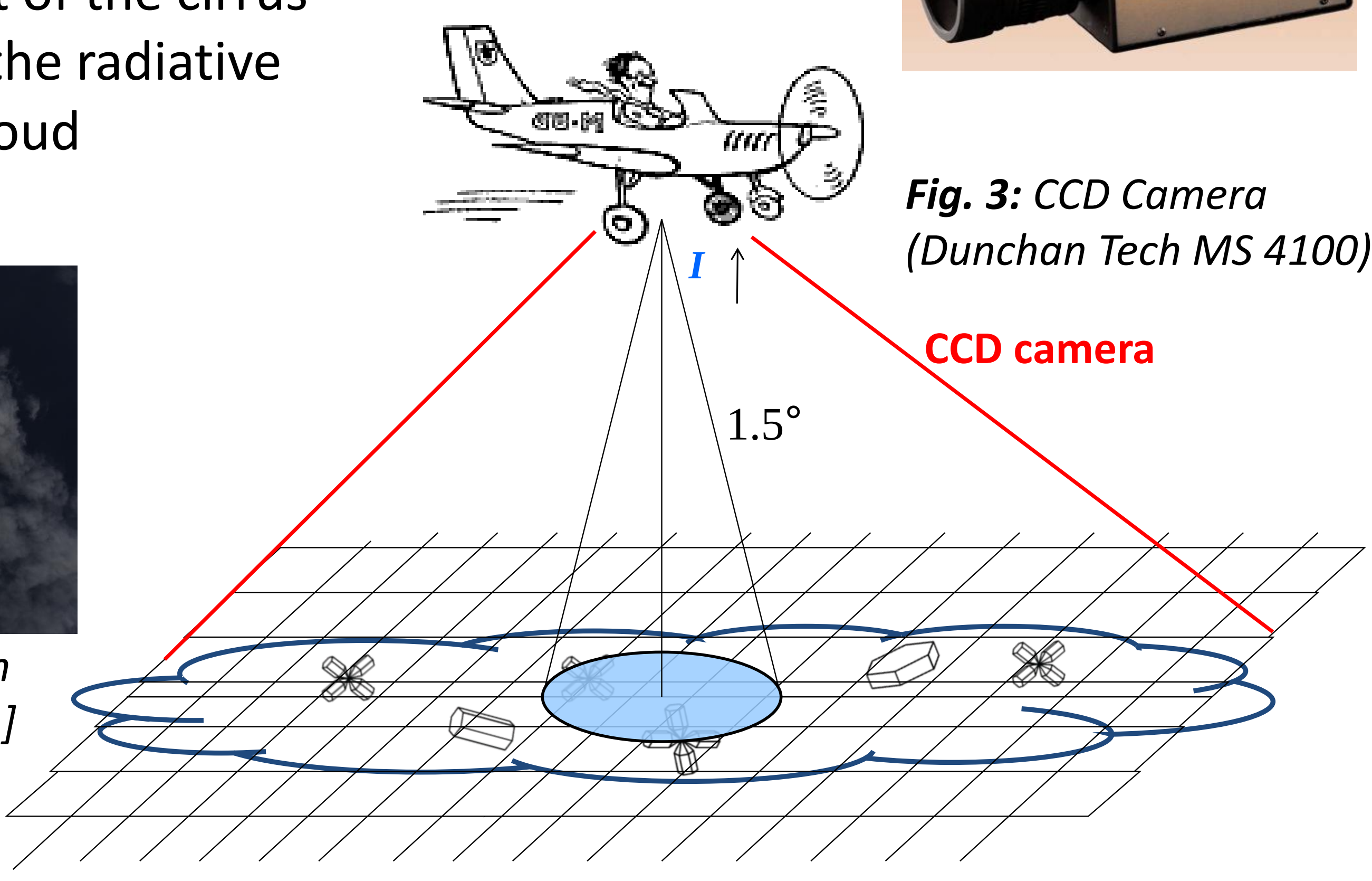
5. Cirrus inhomogeneity

- multispectral CCD Camera (Dunchan Tech MS 4100) looks downward onto the cloud field (550 nm, 670 nm, 800 nm)
- collects images from above the Cirrus cloud surface
- the data will be transformed into radiances and combined with the radiative data
- to obtain the effect of the cirrus inhomogeneity on the radiative properties of the cloud

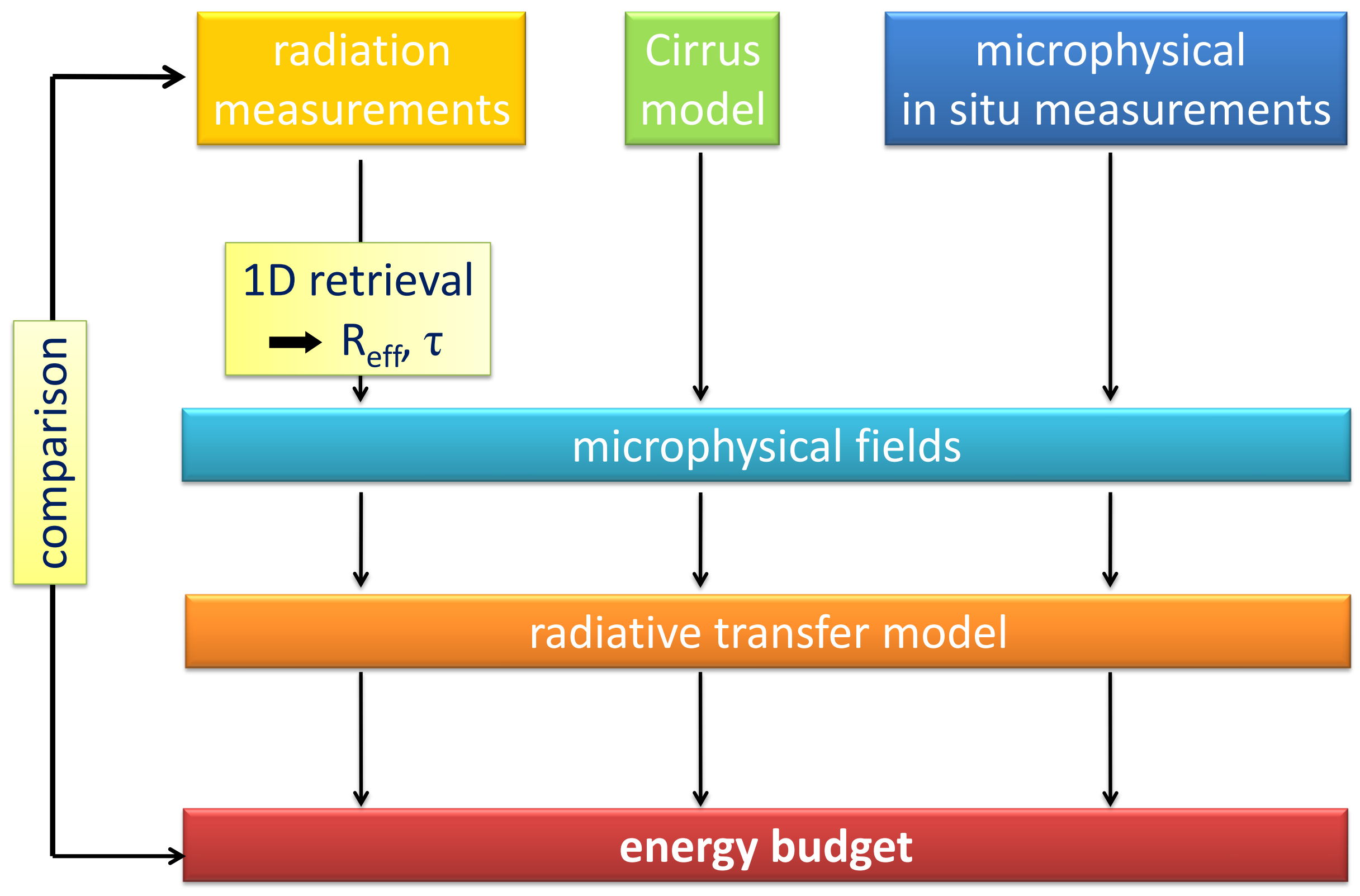
***Fig. 3:** Inhomogeneous Cirrus field*

***Fig. 3:** CCD Camera (Dunchan Tech MS 4100)*

***Fig. 4:** Cloud image from a CCD camera [A.Ehrlich]*



6. Evaluation



radiation measurements

Cirrus model

microphysical in situ measurements

1D retrieval
→ R_{eff}, τ

comparison

microphysical fields

radiative transfer model

energy budget

RTM with varying ice crystal shapes
+
as 1D – and 3D – model

References:
[1] Frey, W. et al., 2009: A new airborne tandem platform for collocated measurements of microphysical cloud and radiation properties, Atmos. Meas. Tech., 2, 147–158.
[2] Eichler, H. et al., 2009: Influence of Ice Crystal Habit and Cirrus Spatial Inhomogeneities on the Retrieval of Cirrus Optical Thickness and Effective Radius, PhD Thesis, University of Mainz.

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