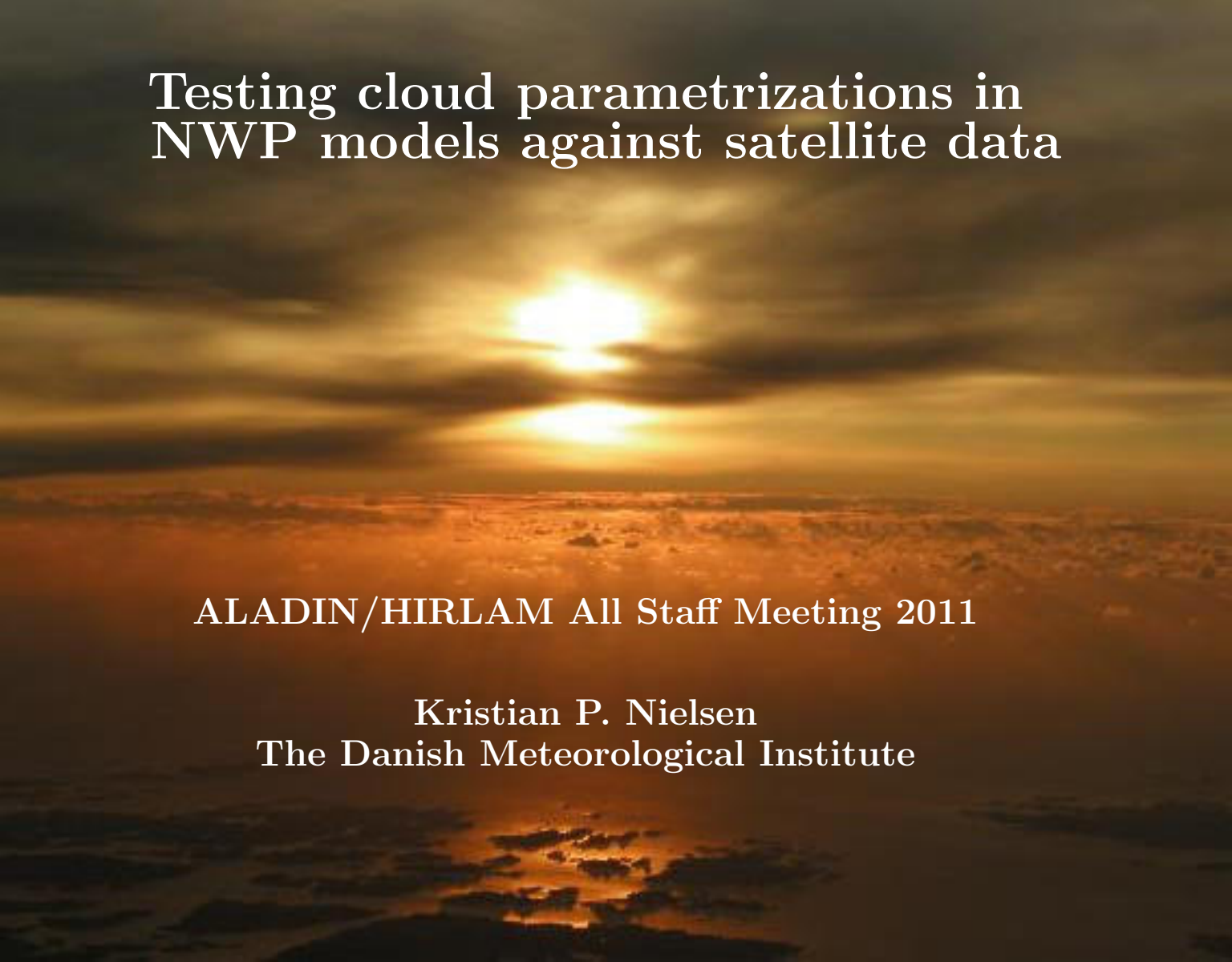
Testing cloud parametrizations in NWP models against satellite data



ALADIN/HIRLAM All Staff Meeting 2011

Kristian P. Nielsen
The Danish Meteorological Institute

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- Rainer Hollman, DWD/CMSAF.
- CloudSat Data Processing Center.
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- Michael Scharling, DMI.
- Kai Sattler, DMI.

MINISTRY OF
CLIMATE AND ENERGY

Overview

- Cloud cover vs cloud physical properties;
- Testing 2-D cloud physical properties;
- Testing 3-D cloud physical properties;
- Impact of $r_{e,ice}$-parametrizations;
- Concluding remarks.

MINISTRY OF CLIMATE AND ENERGY

Classical vs physical cloud description

- Classical clouds:
  - Cloud cover in octas;
  - Low, medium, and high clouds;
  - Cloud types.

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  - Integrated cloud water [kg m^{-2}];
  - Average effective cloud drop size, r_e, [μm];
  - Cloud top temperature [K];
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MINISTRY OF CLIMATE AND ENERGY

Classical vs physical cloud description

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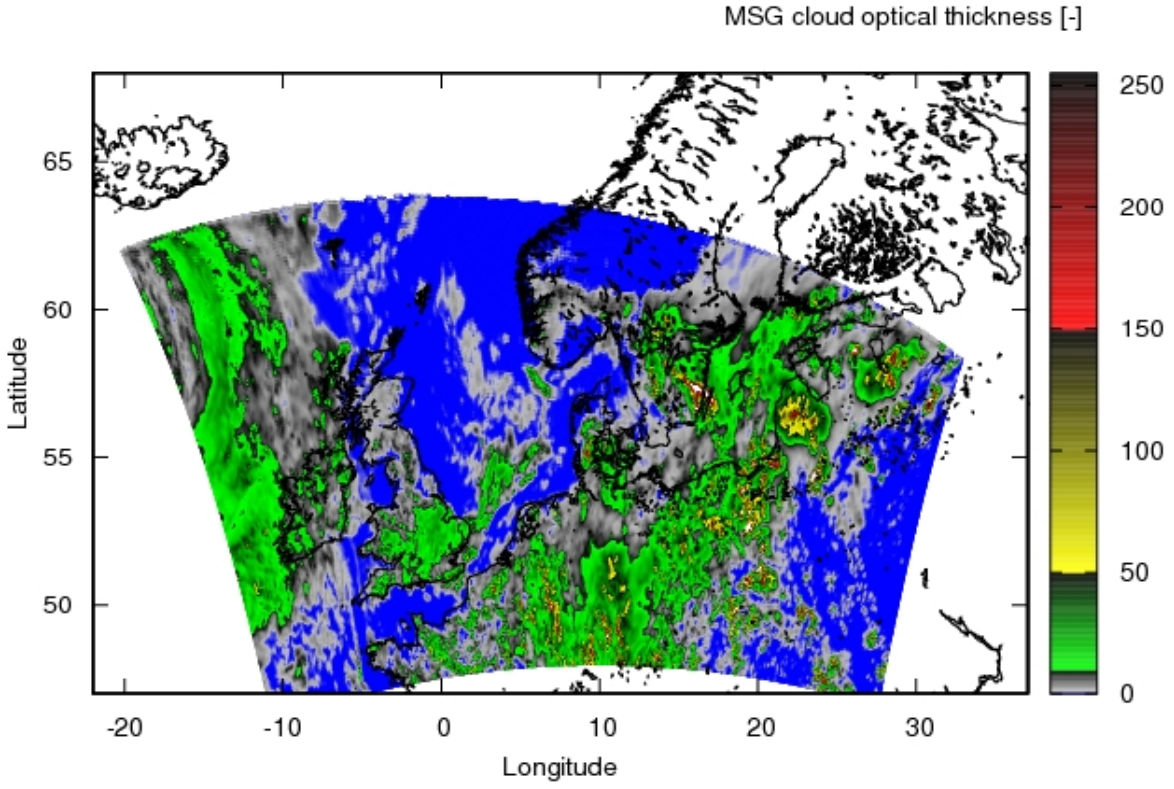
  - Average effective cloud drop size, r_e, [μm];
  - Cloud top temperature [K];
  - Cloud bottom temperature [K].
- **3-D physical cloud properties:**
  - Cloud water concentration [g m^{-3}];
  - Ice phase fraction [-];
  - Effective cloud particle size, $r_{e,wat}/r_{e,ice}$, [μm];
  - Detailed size distribution of cloud particles;
  - Detailed shape distribution of cloud particles.

Why use the physical cloud description?

"The reanalysis models simulate the radiative fluxes well *if/when* the cloud fraction is simulated correctly"

Quote from Walsh *et al.*, J. Climate, 2009; 22: 2316.

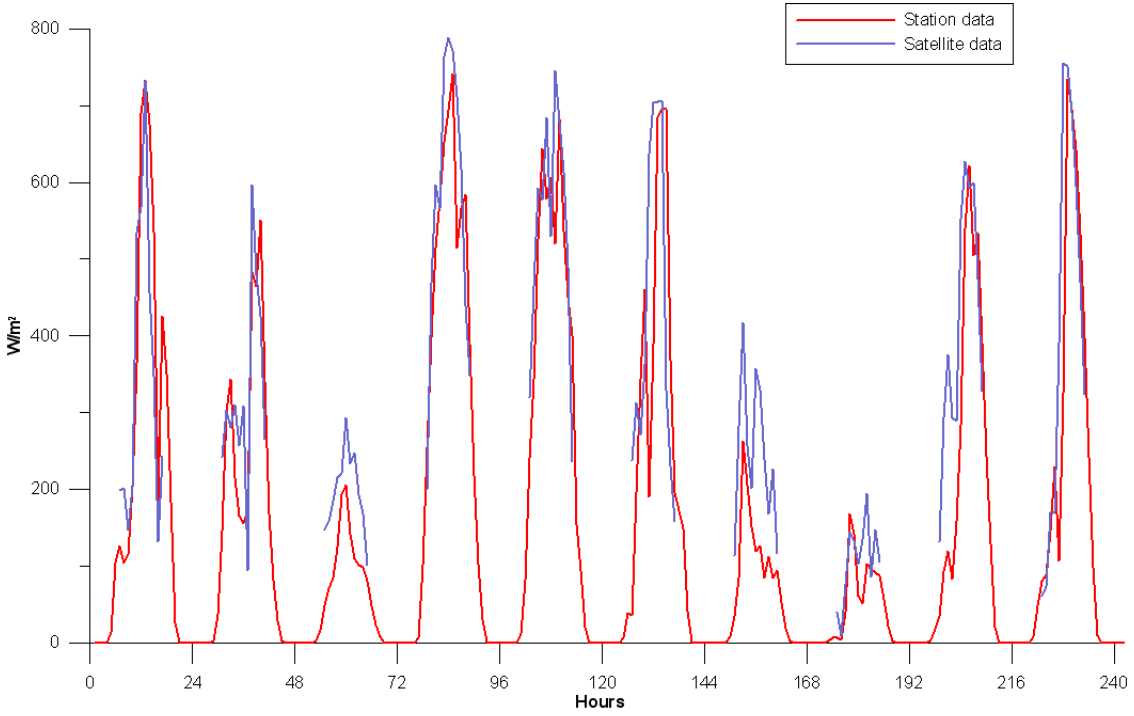
MSG 2-D VIS cloud optical thickness



2010-07-23 15:00

$$\tau_{vis} = \frac{3CWP}{2r_e\rho_l} \quad (1)$$

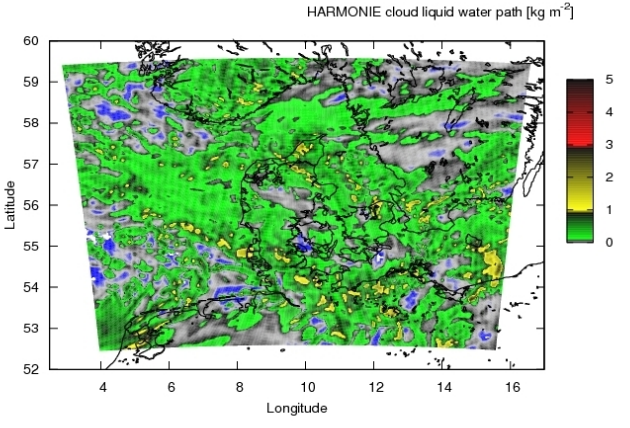
SW transmittance from MSG COT

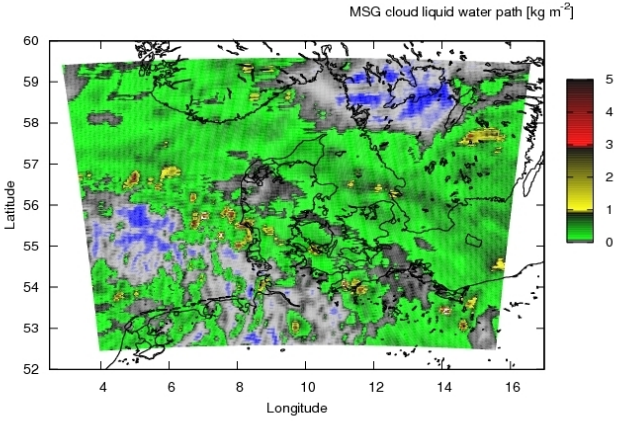


Combined with SW calculations of Savijärvi (1990), and compared with measurements by Michael Scharling. Preliminary results!

MINISTRY OF CLIMATE AND ENERGY

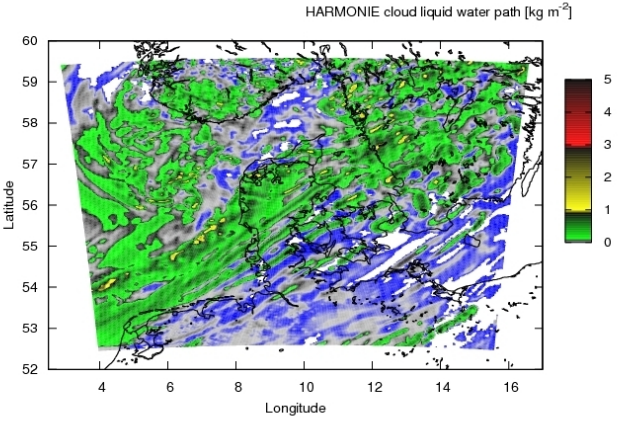
Comparing HARMONIE with 2D cloud MSG cloud water path

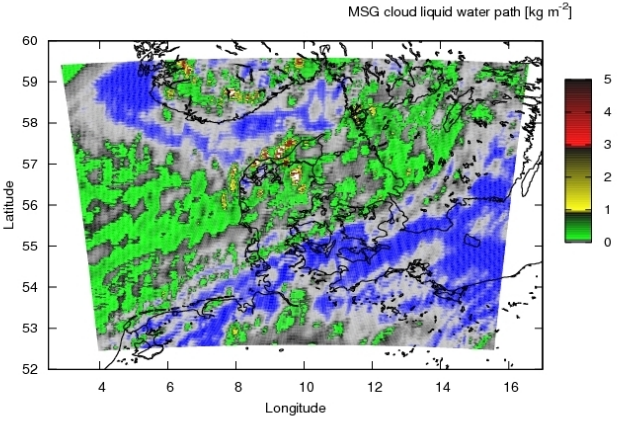




2009-09-03 00:00 +11h forecast

Comparing HARMONIE with 2D cloud MSG cloud water path





2009-09-04 00:00 +15h forecast

Parametrizations of $r_{e,ice}$

Ou & Liou (1995)

$$r_{e,ice,HIRLAM} = 163.15 + 6.21T_C + 0.0985T_C^2 + 0.0006T_C^3, \quad T_C = T - 273.15 \qquad (2)$$

Sun & Rikus (1999); Sun (2001)

$$r_{e,ice,IFS} = 3\sqrt{\frac{3}{8}}(1.2351+0.0105T_C)(45.8966IWC^{0.2214}+0.7957IWC^{0.2535}(T-83.15)) \quad (3)$$

and many others . . .

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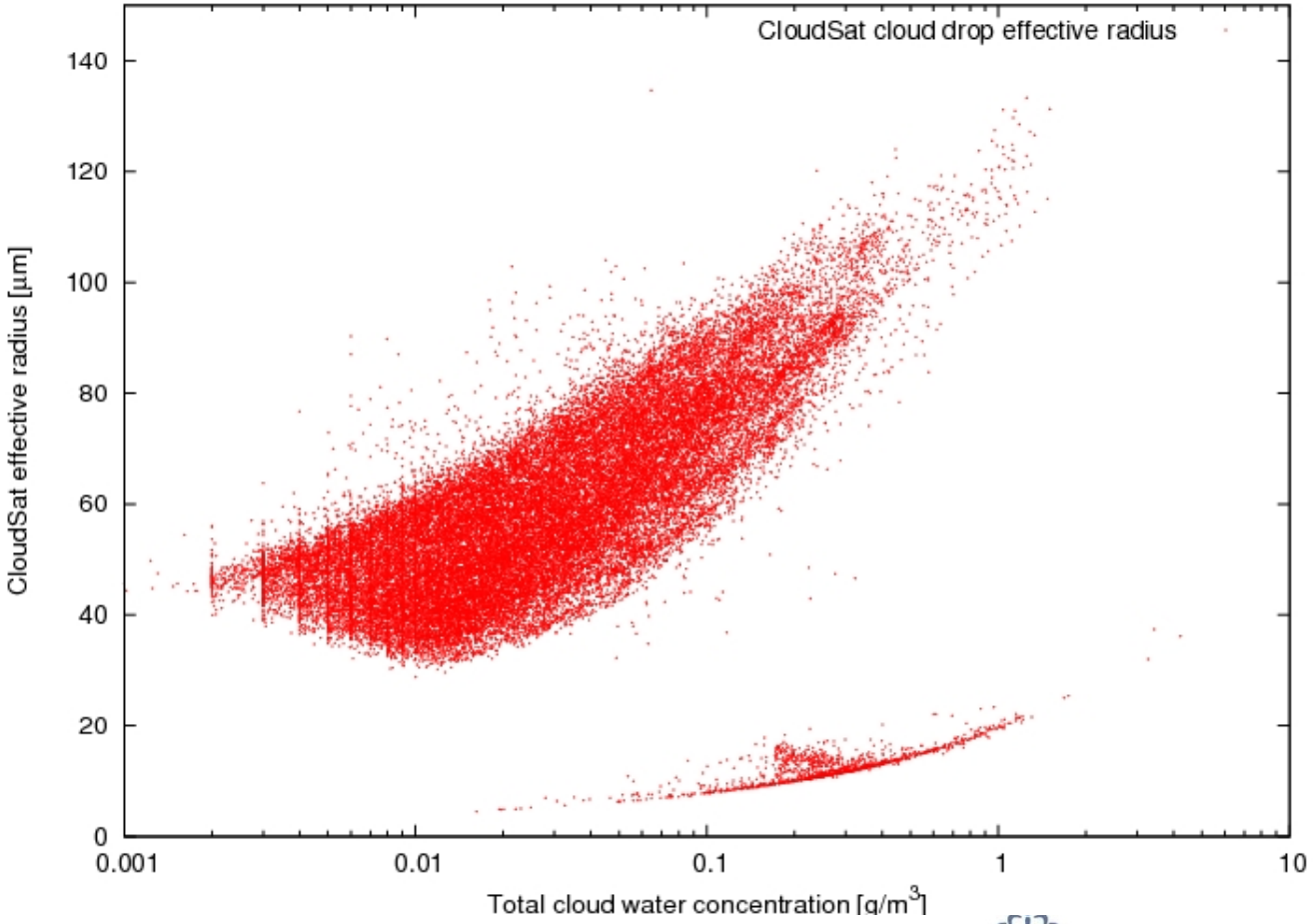
CloudSat 3D $r_e(IWC)$



Data from the CloudSat data processing center.
Stephens *et al.* (2008); Wood (2008); Protat *et al.* (2010).

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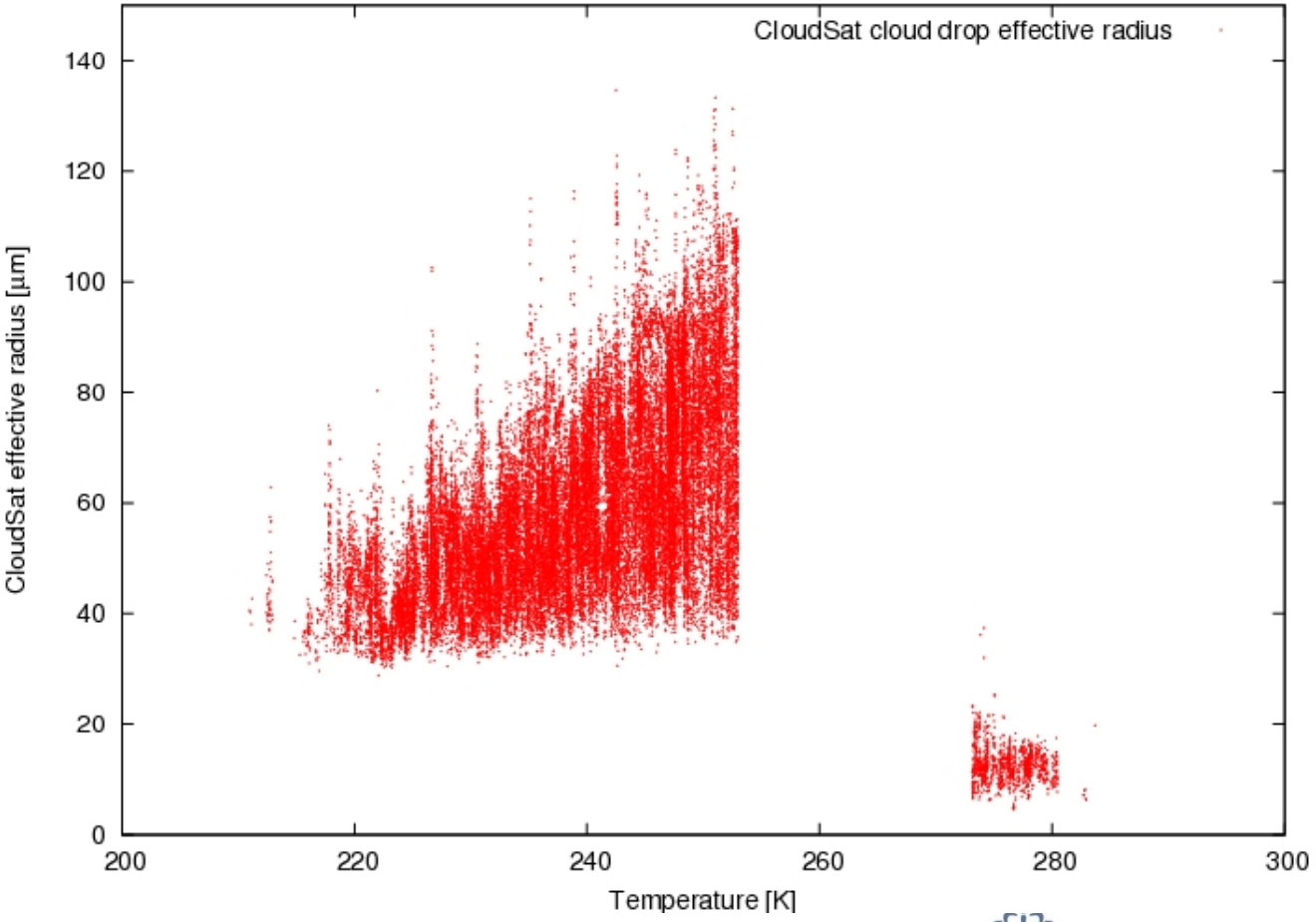
CloudSat 3D $r_e(T)$



Data from the CloudSat data processing center.
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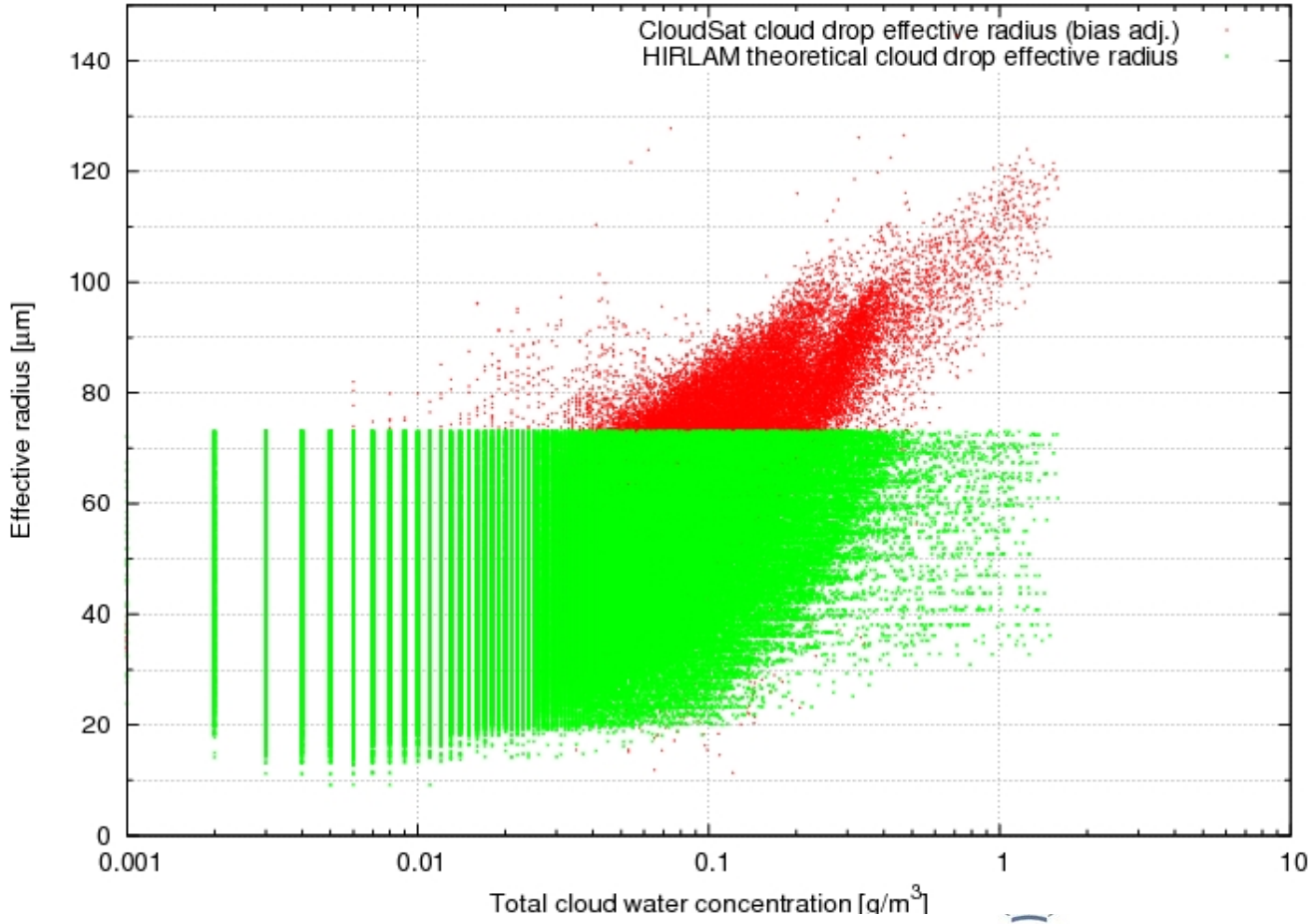
HIRLAM $r_{e,ice}$ vs CloudSat $r_{e,ice}$



Ou & Liou *et al.* (1995); Wyser *et al.* (1999). (n = 199371)

MINISTRY OF CLIMATE AND ENERGY

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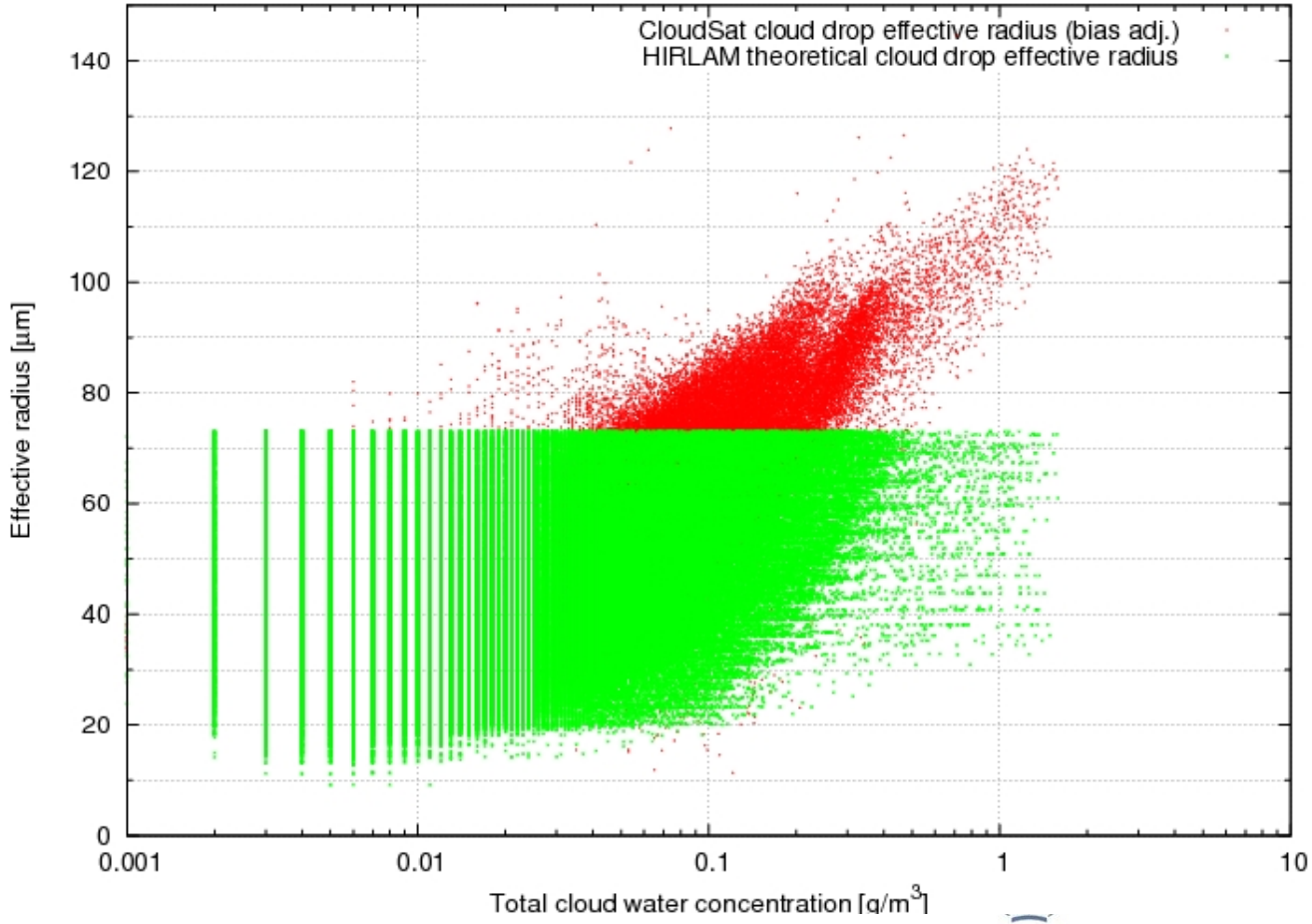
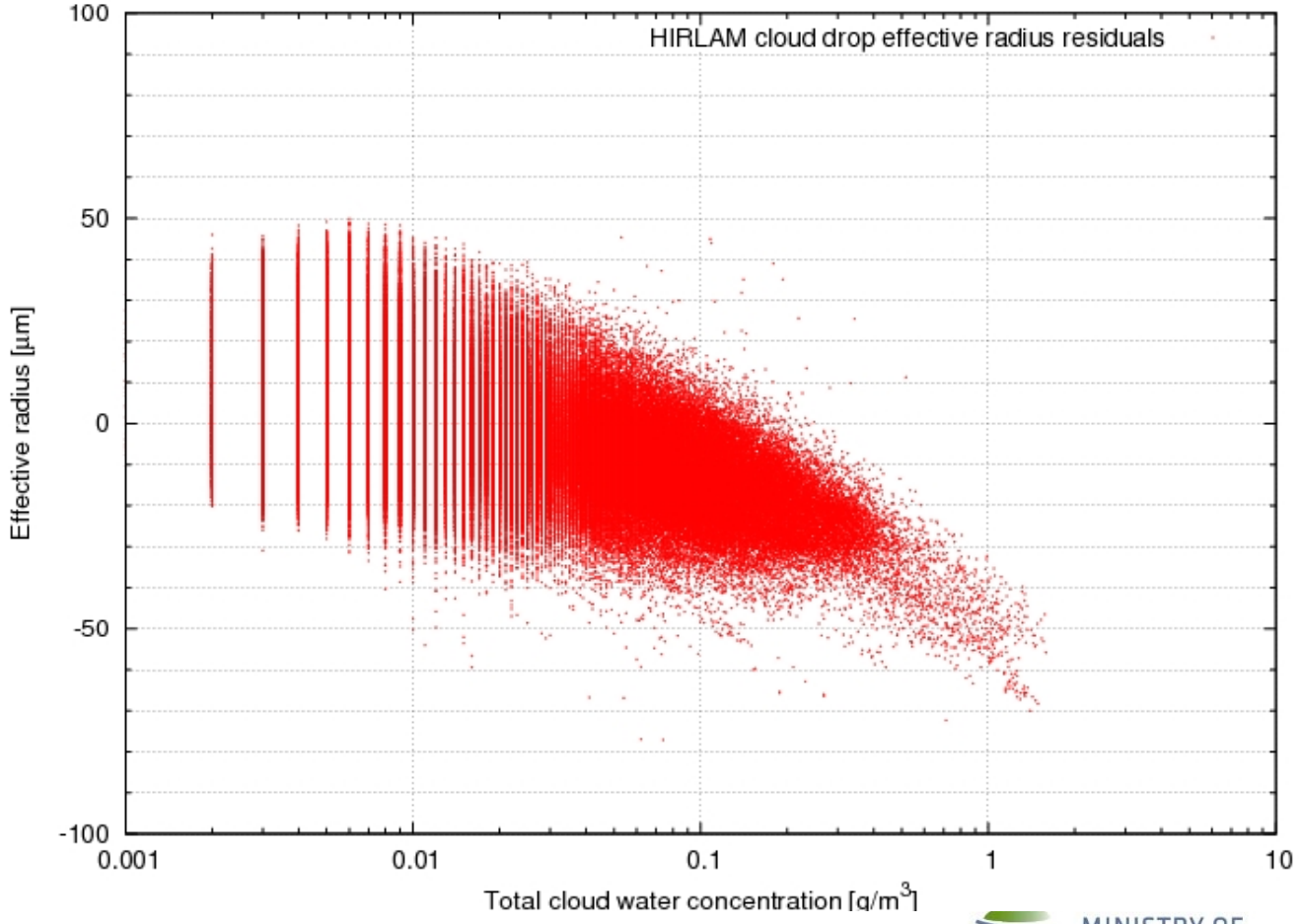


Ou & Liou *et al.* (1995); Wyser *et al.* (1999). (n = 199371)

MINISTRY OF CLIMATE AND ENERGY

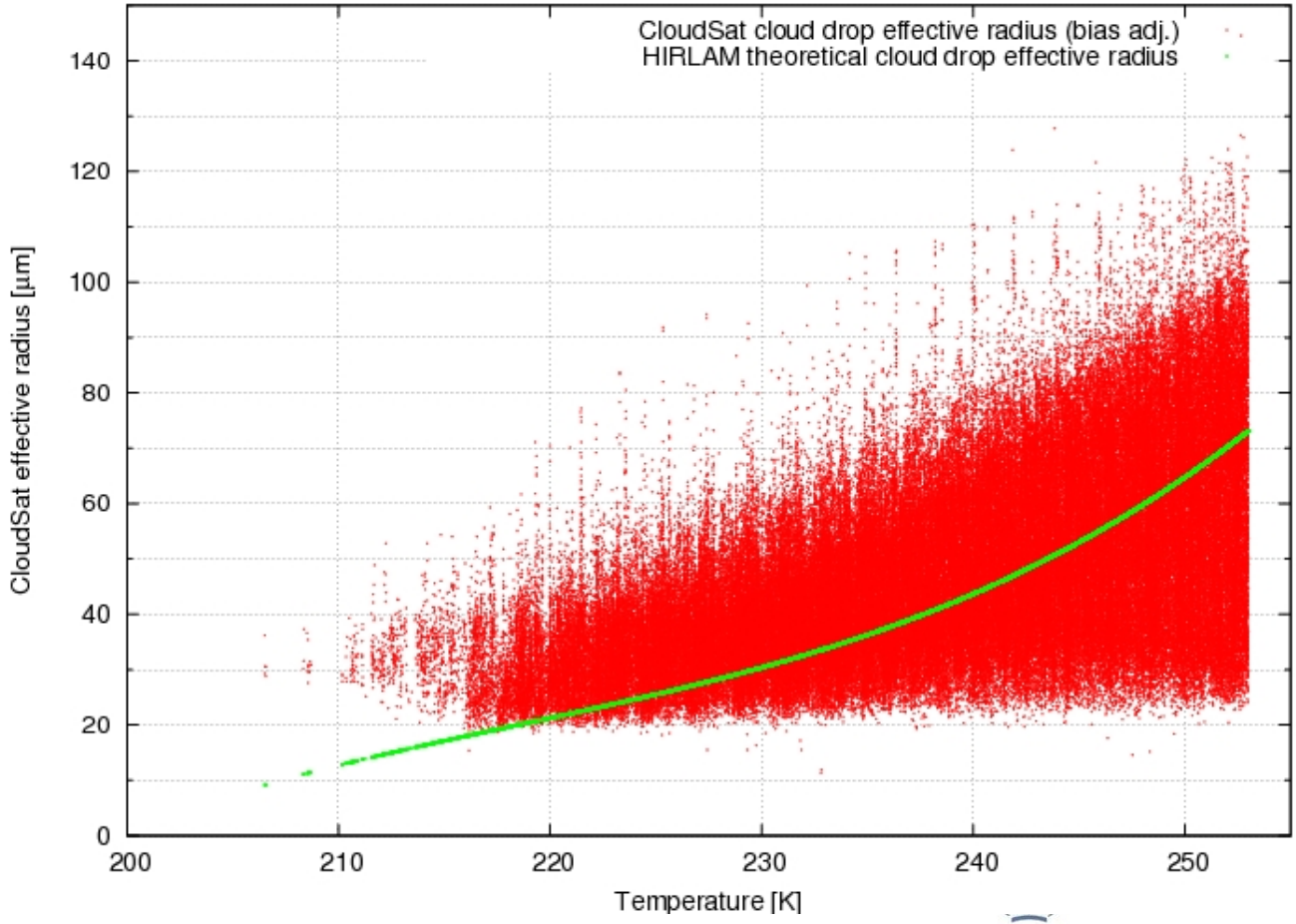
HIRLAM $r_{e,ice}$ vs CloudSat $r_{e,ice}$, residuals



Ou & Liou *et al.* (1995); Wyser *et al.* (1999). (n = 199371)

MINISTRY OF CLIMATE AND ENERGY

HIRLAM $r_{e,ice}$ vs CloudSat $r_{e,ice}$



Ou & Liou *et al.* **(1995); Wyser** *et al.* **(1999). (n = 199371)**

MINISTRY OF CLIMATE AND ENERGY

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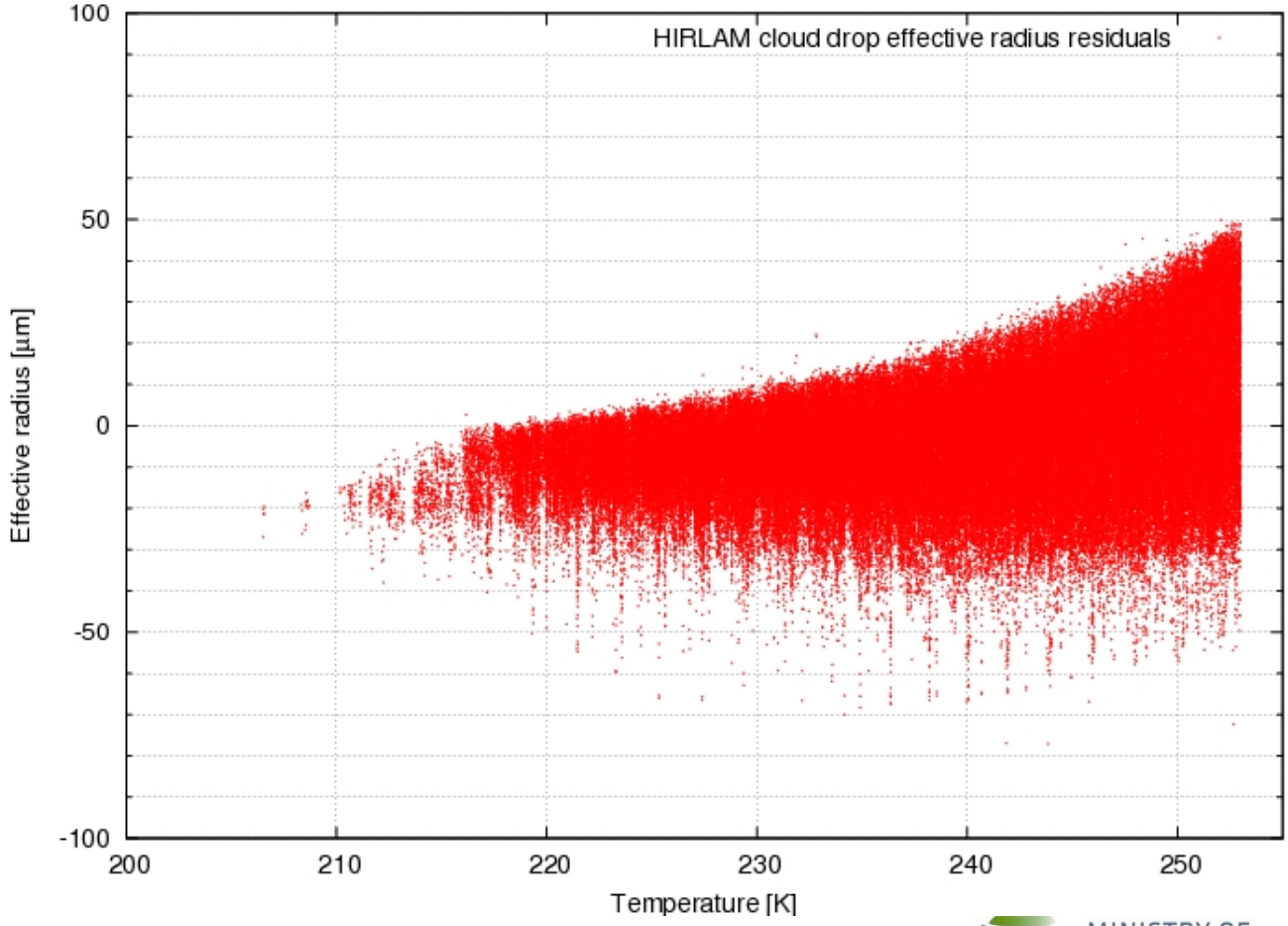
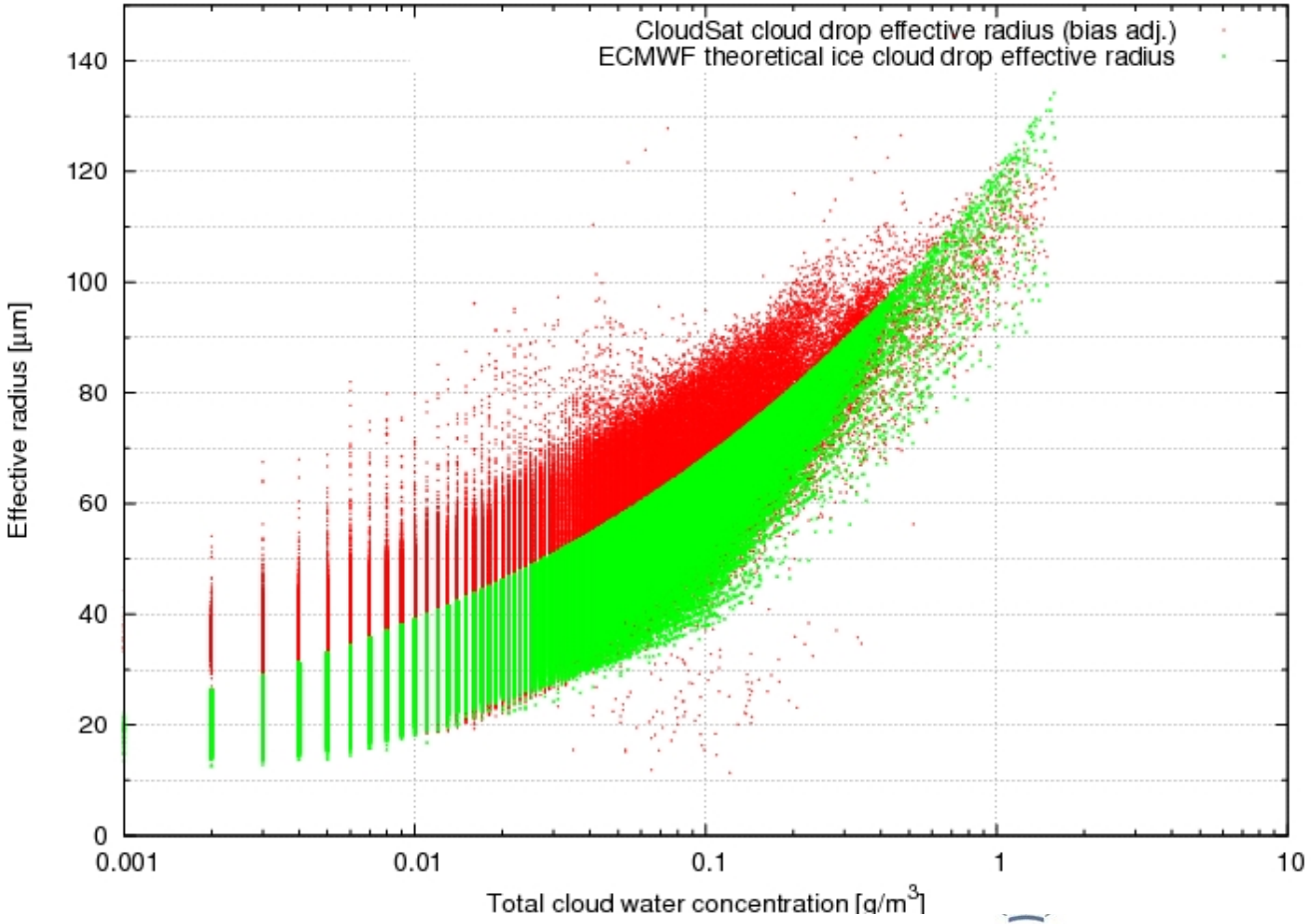


Ou & Liou *et al.* (1995); Wyser *et al.* (1999). (n = 199371)

MINISTRY OF CLIMATE AND ENERGY

IFS $r_{e,ice}$ vs CloudSat $r_{e,ice}$



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MINISTRY OF CLIMATE AND ENERGY

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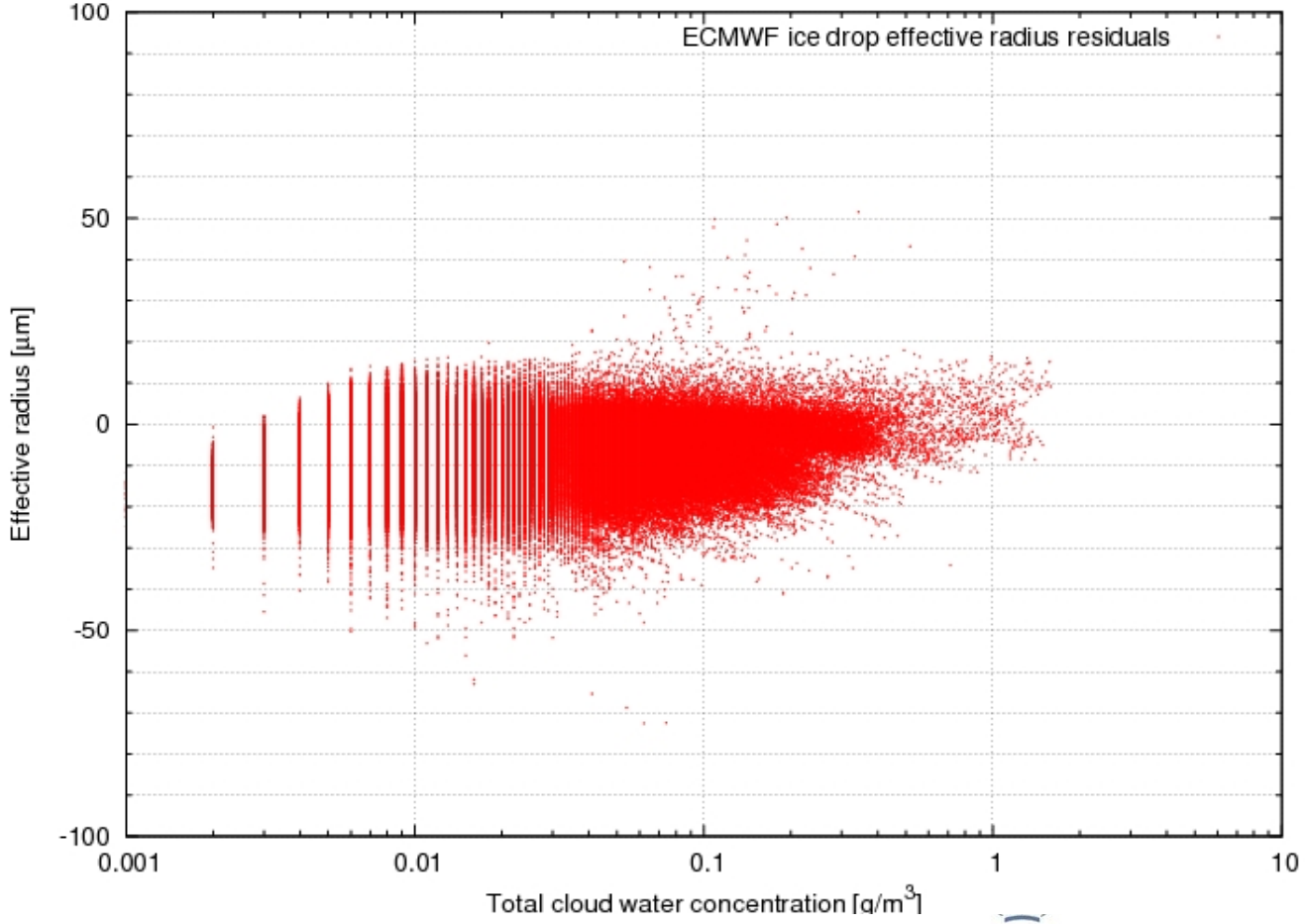

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MINISTRY OF CLIMATE AND ENERGY

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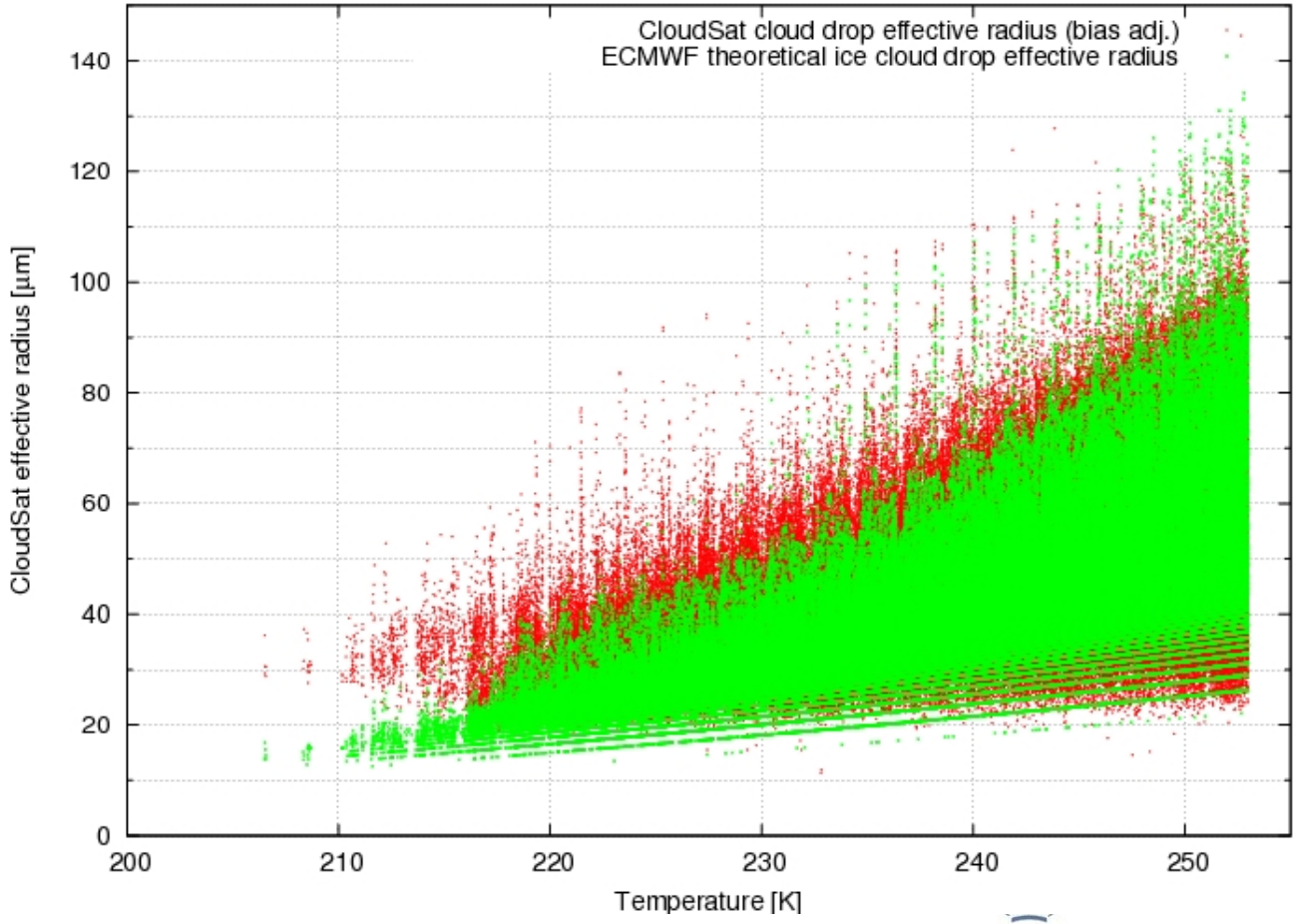

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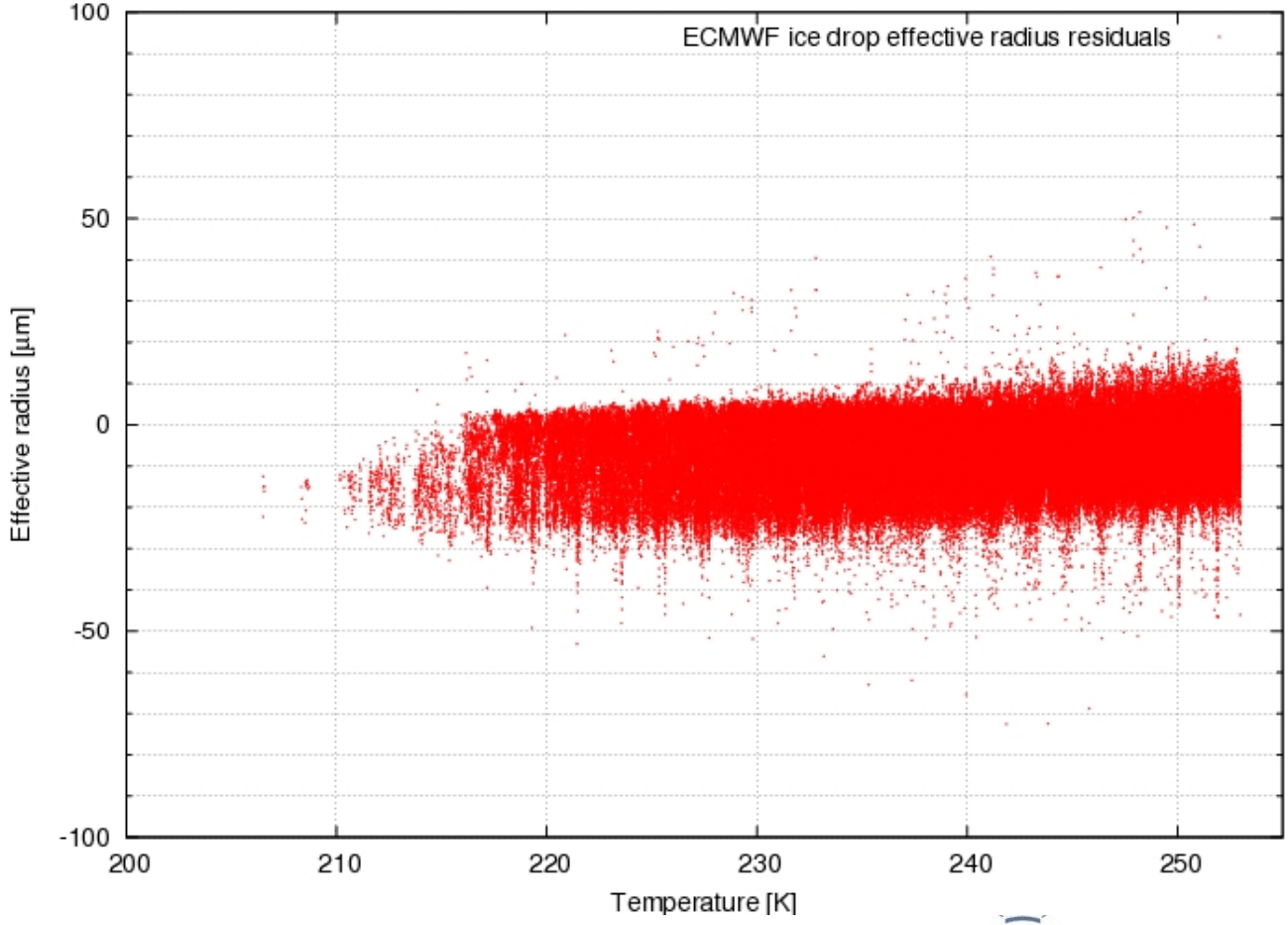
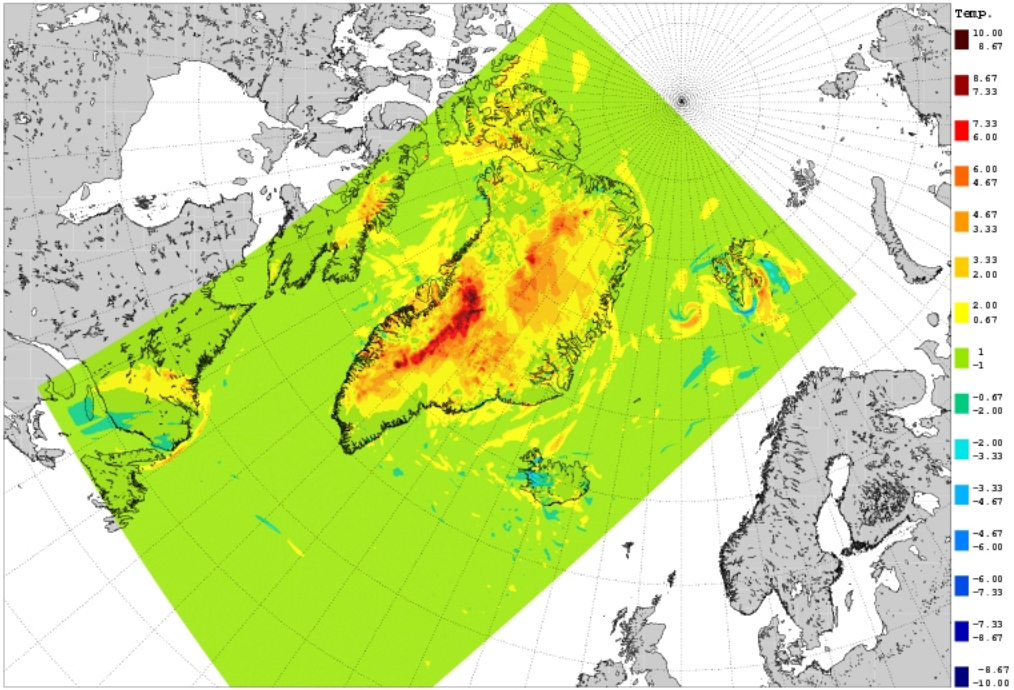


Sun & Rikus (1999); Sun (2001). (n = 199371)

MINISTRY OF CLIMATE AND ENERGY

Effect of $r_{e,ice}$-parametrization in an NWP-model



Temperature difference [K] between HIRLAM K05L65 run with $r_{e,ice,IFS}$ and $r_{e,ice,HIRLAM}$, respectively.
36h forecasts run at 2011-03-07 00 UTC.

MINISTRY OF CLIMATE AND ENERGY

Concluding remarks

- **Accurate cloud physical properties in models are essential for prediciting cloud radiative forcing.**
- **MSG 2D cloud physical properties are useful for verifying NWP models.**
- **CloudSat 3D cloud physical properties are useful for verifying microphysical parametrizations.**

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