Norwegian
Meteorological Institute
met.no

Simulations vs. measurements of supercooled clouds

Bjørn Egil Kringlebotn Nygaard

Winterwind 2011

In-cloud icing

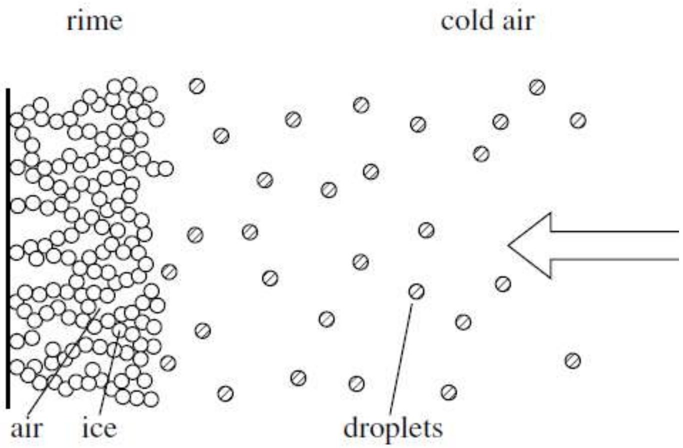
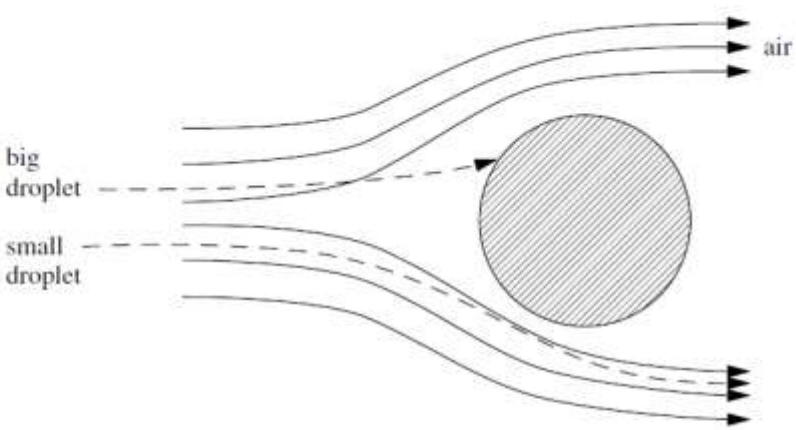


Figure 6. Growth of rime ice (dry growth).



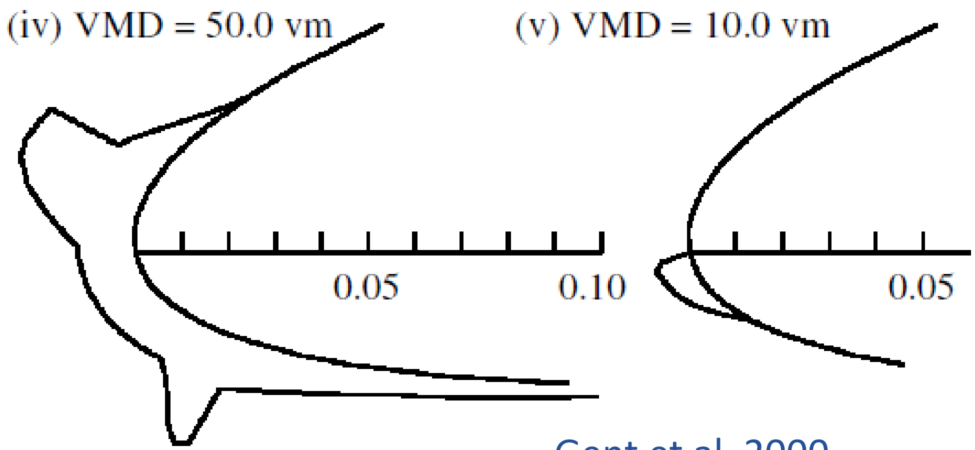
Recipe:

- Temperature below freezing point
- Liquid cloud droplets
- Wind

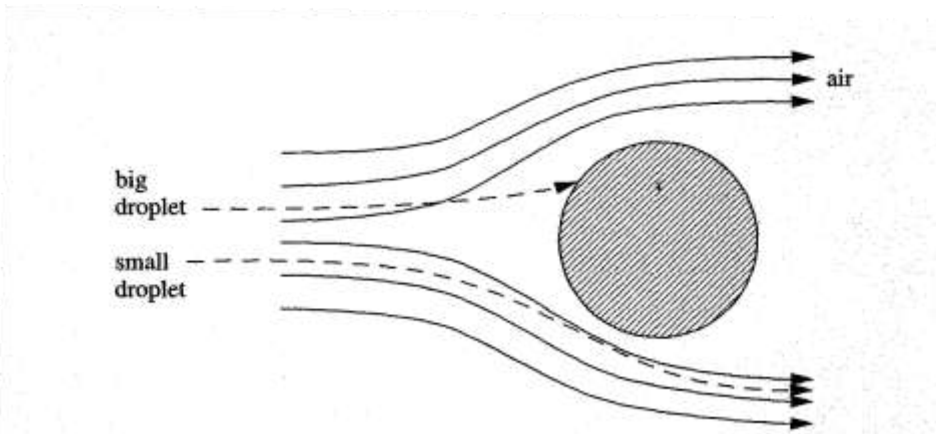
Icing intensity:

- Wind speed
- Liquid Water Content (LWC)
- Droplet size (MVD)
- Object size/geometry

Motivation



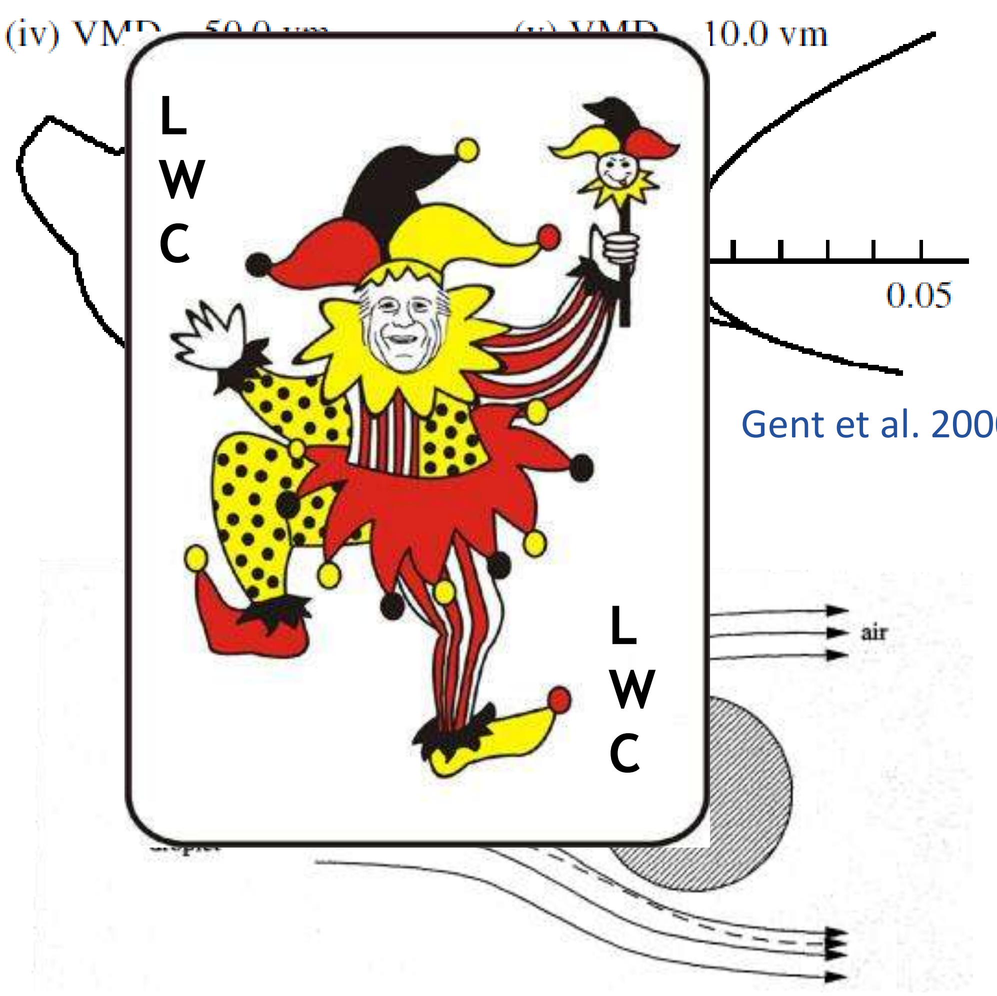
Gent et al. 2000



Simple experiment

- LWC = 0.6 g/m3
- Wind = 20 m/s
- T = -15 °C
- Icing time = 60 min
- **MVD = 10 µm → 0.1 kg/m**
- **MVD = 50 µm → 1.0 kg/m**

Motivation



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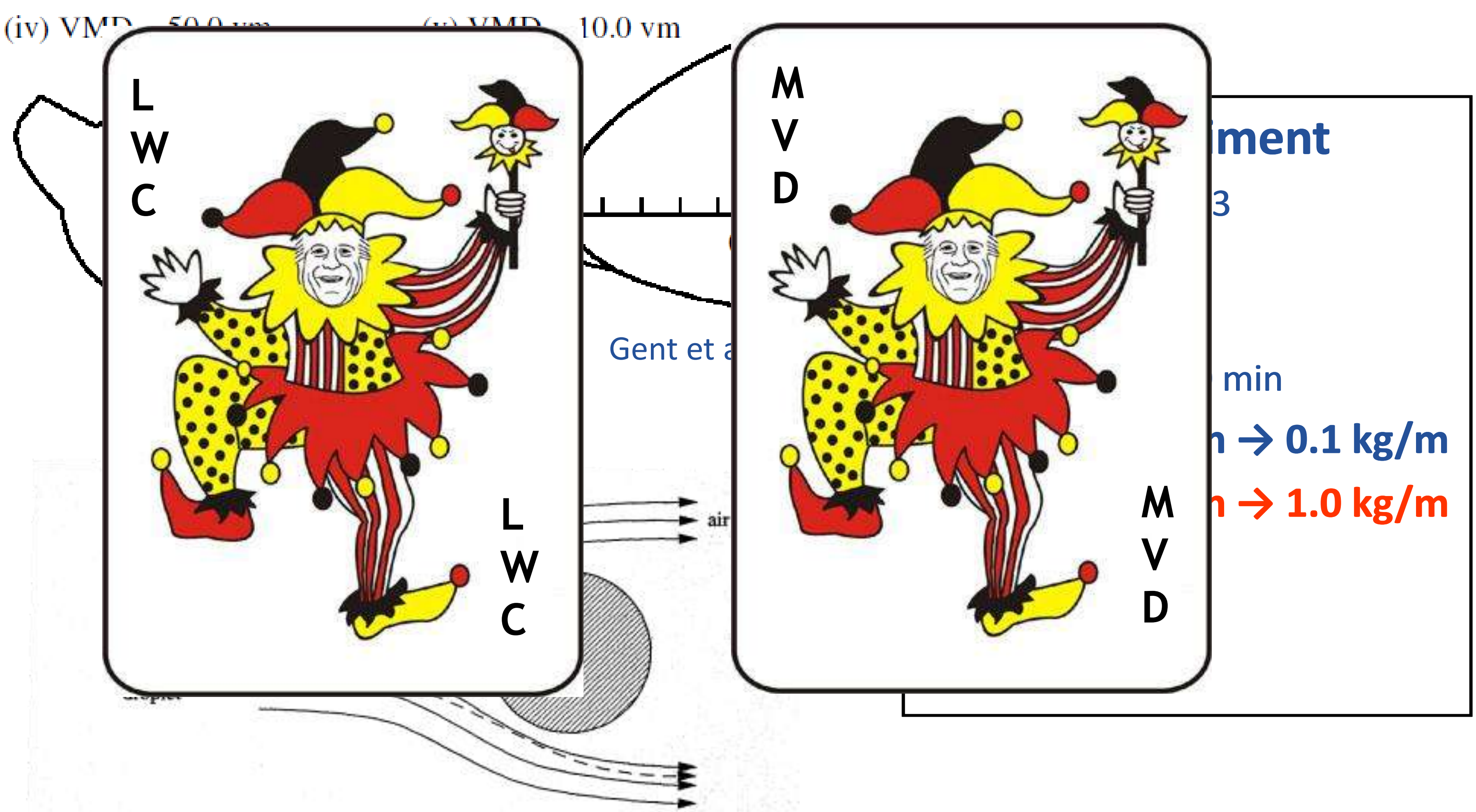
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Motivation

- How well can LWC and MVD be predicted by a NWP model?
- How important is model resolution?
  - computationally expensive
- Does cloud microphysics scheme play any role?

Model validation at Mt. Ylläs, N-Finland

- Mt. Ylläs: 719 m above sea level

Model validation at Mt. Ylläs, N-Finland

Rotating multi cylinder

- Mt. Ylläs: 719 m above sea level

Overview of the 8 cases

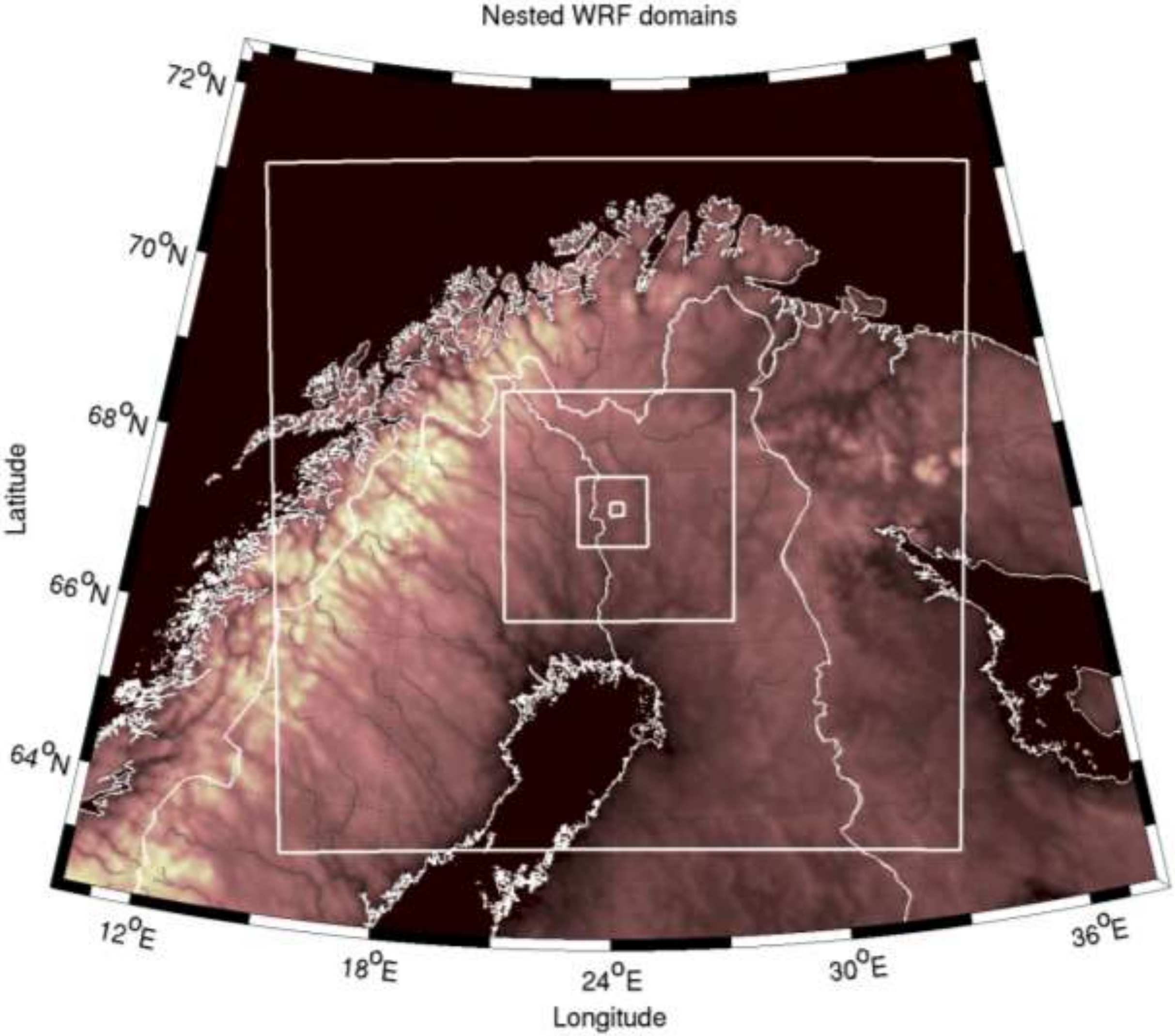
TABLE 1 WEATHER DATA COLLECTED FROM THE YLLÄS TEST SITE.

	Date	Time (UTC)	Wind dir	Wind speed (m s^{-1})	T (°C)	LWC (g m^{-3})	MVD (µm)
•1	08/2/1990	09	NW	6	-3	0.43	15.8
•2	14/2/1990	06	SSE	4	-5	0.27	19.9
•3	17/12/1990	12	SW	14	-4	0.25	15.3
•4	08/12/1994	08	SSE	14	-5	0.40	14.3
•5	12/12/1994	11	W	4	-6	0.09	13.7
•6	19/12/1994	11	SSW	22	-3	0.30	12.1
•7	09/1/1996	11	SW	13	-5	0.30	12.2
•8	10/1/1996	11	SW	20	-5	0.43	13.6

Methodology

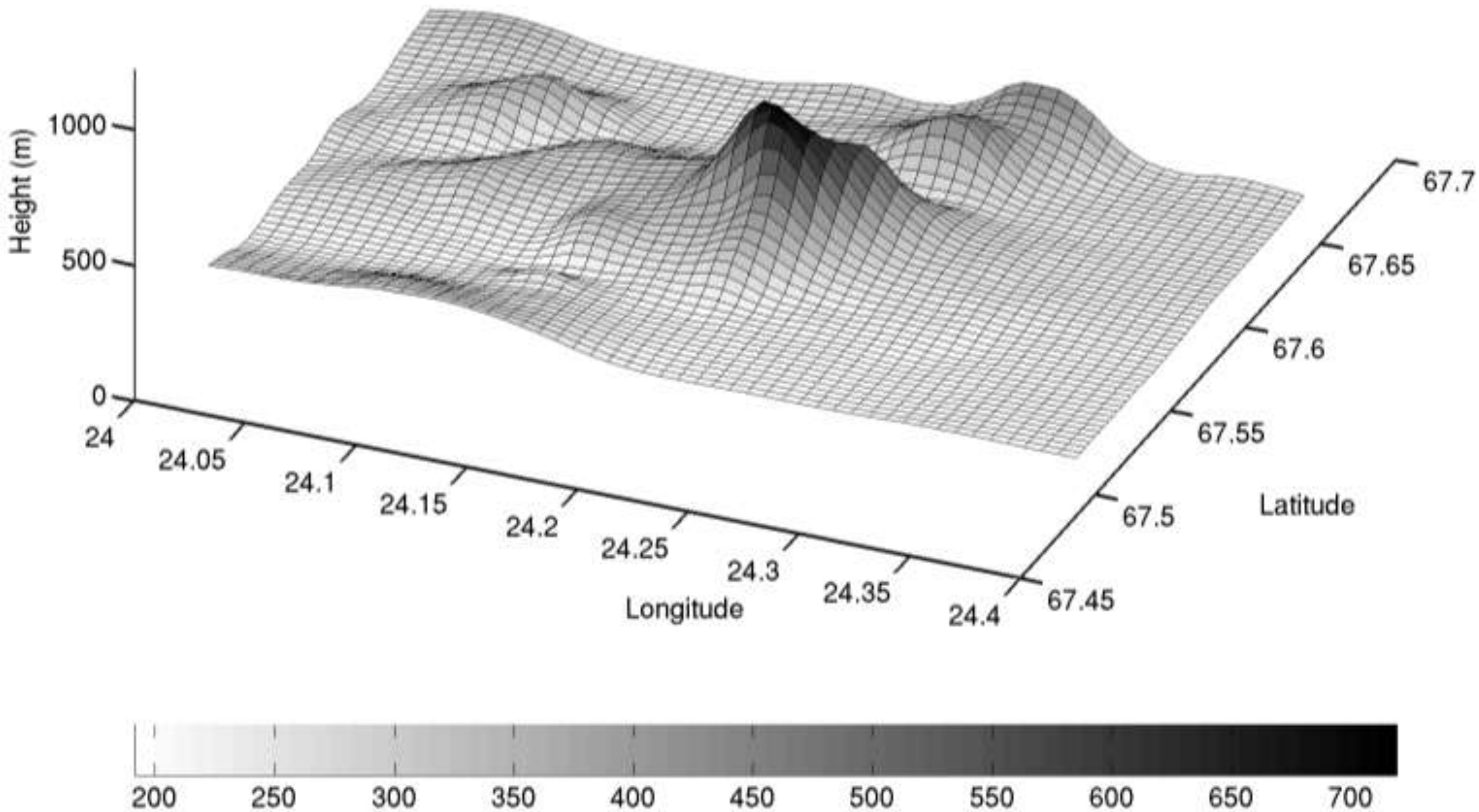
- The non-hydrostatic NWP model **WRF** (version 3.1.1 ARW) is used
- Eight cases are studied
- Horizontal grid spacing of **9 km**, **3 km**, **1 km** and **1/3 km**
- Vertical: 66 levels
- Initial fields and boundary data from ECMWF-ERA40
- Three **cloud microphysical schemes**
  - Two sophisticated schemes; **Thompson** scheme & **Morrison** scheme
  - A more economical typical weather prediction scheme; **EGCP01**

Model setup

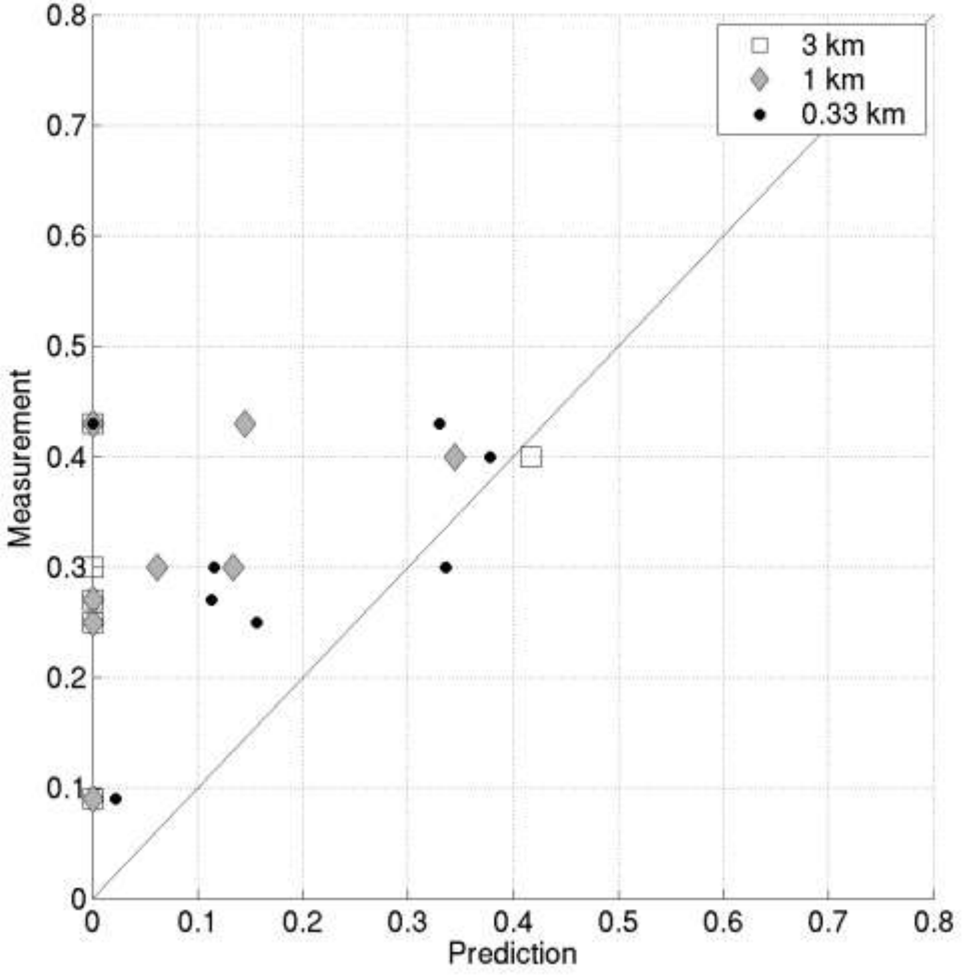


- 9 km
- 3 km
- 1 km
- 1/3 km

Yllästunturi in the finest mesh

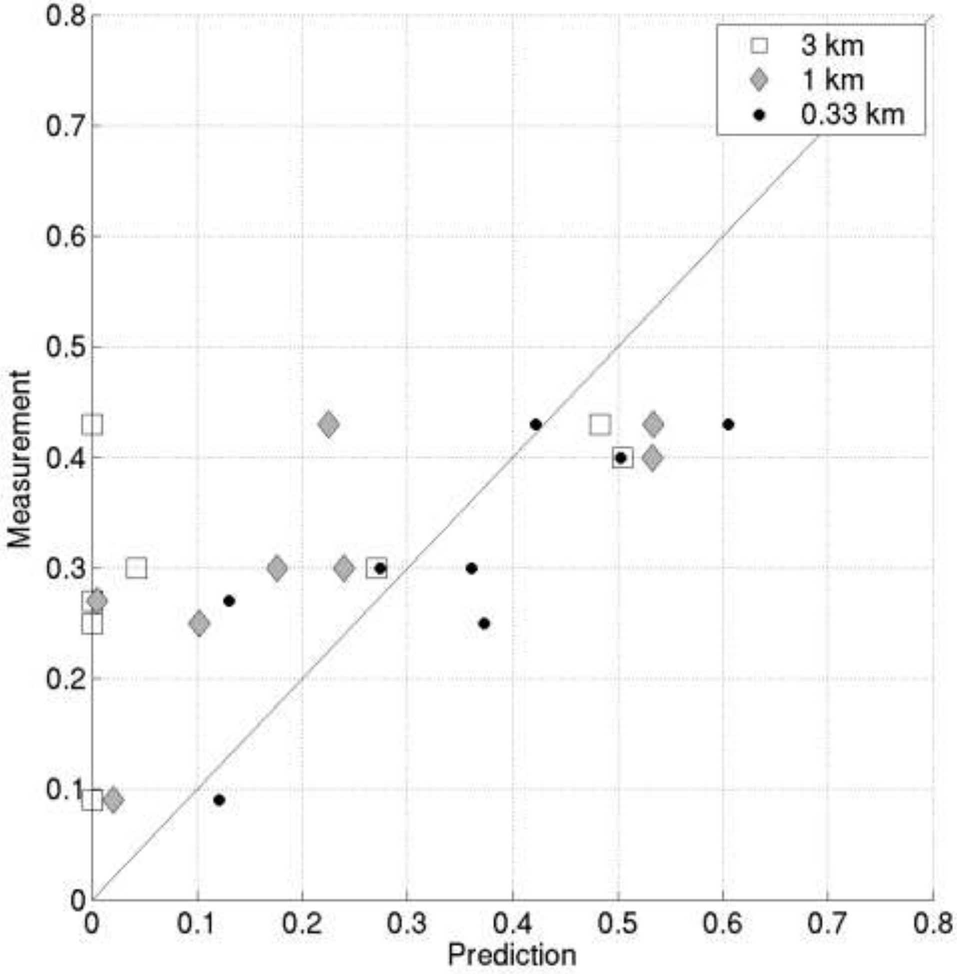


LWC - Validation



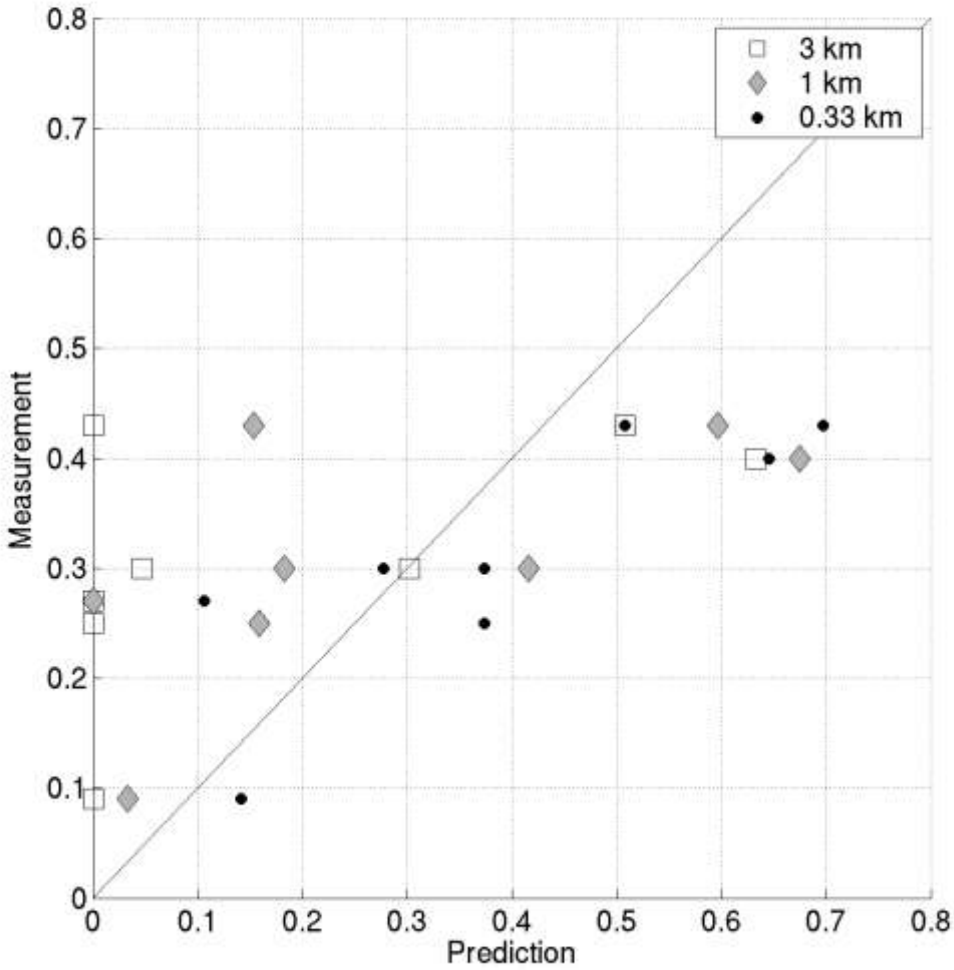
- EGCP01 (Ferrier)
- Most efficient scheme

LWC - Validation



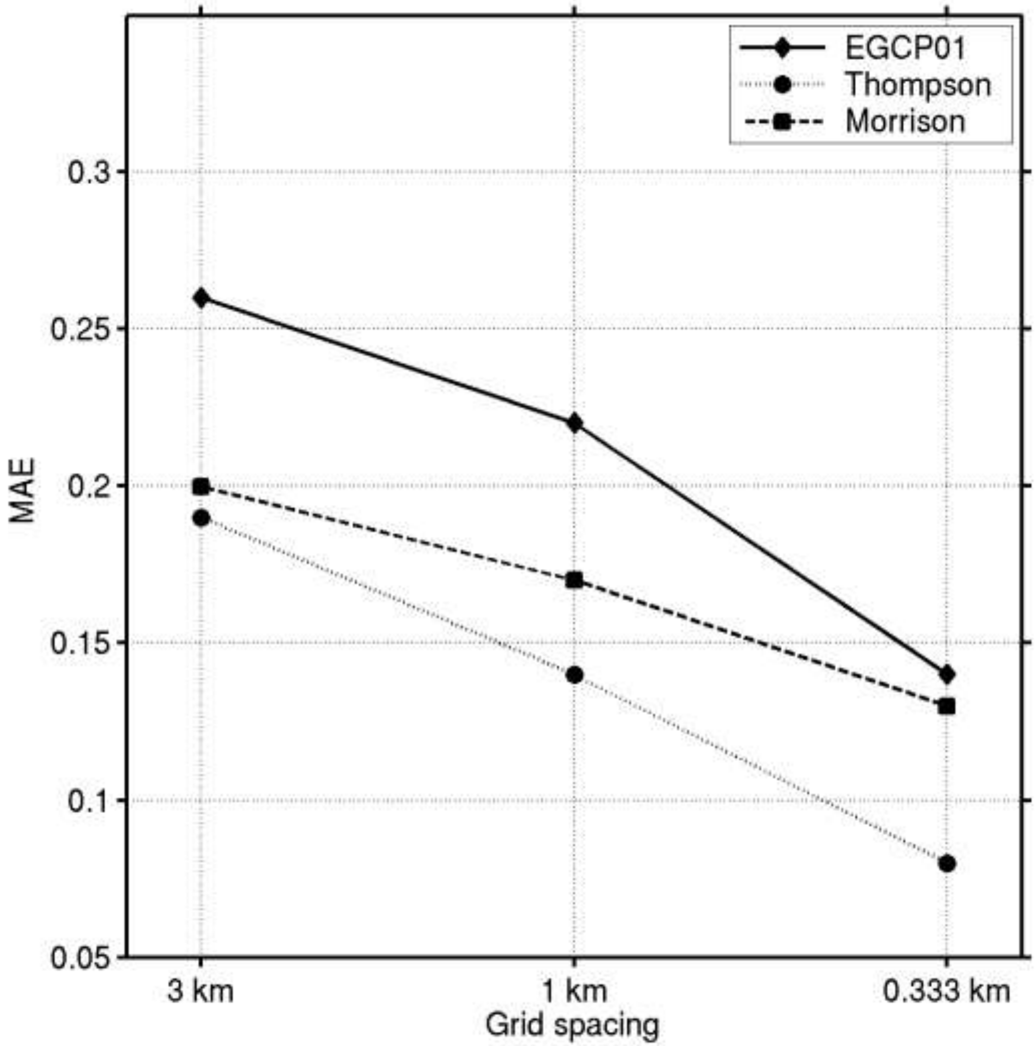
- **Thompson scheme**
- 19 % more expensive

LWC - Validation



- **Morrison scheme**
- 31 % more expensive

LWC - Validation



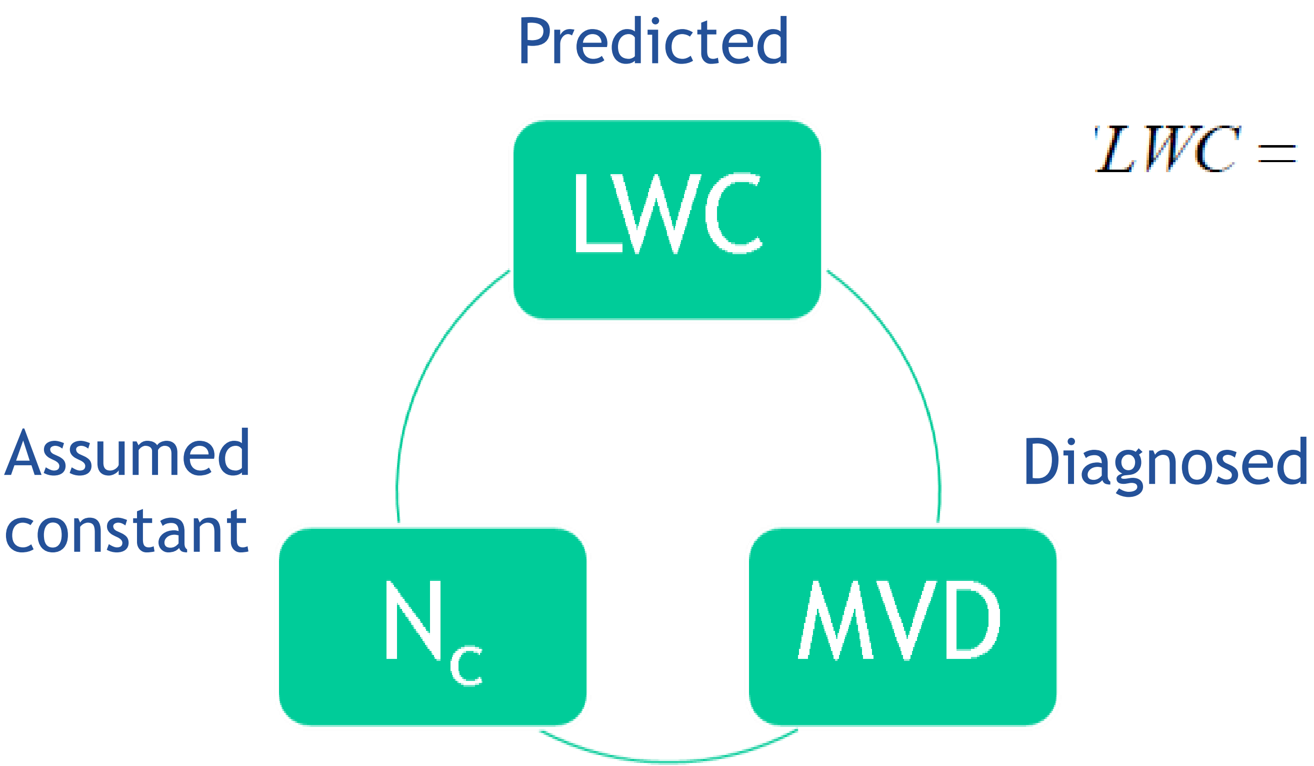
Mean Absolute Error

- EGCP01
- Morrison

- Thompson

MAE = 0.08 g/m^3

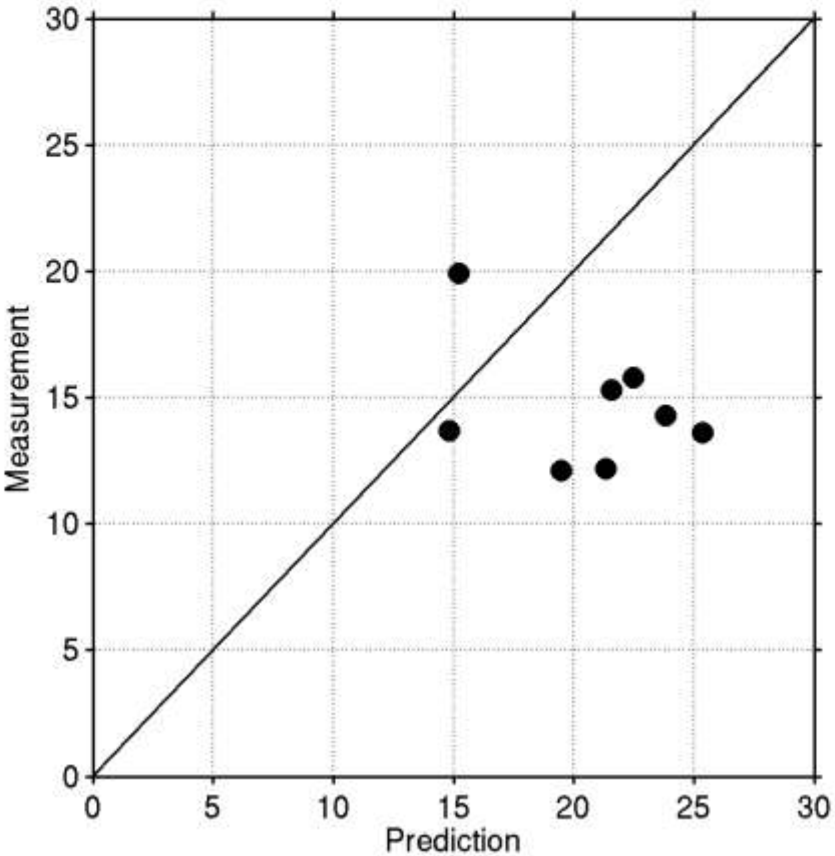
Prediction of MVD



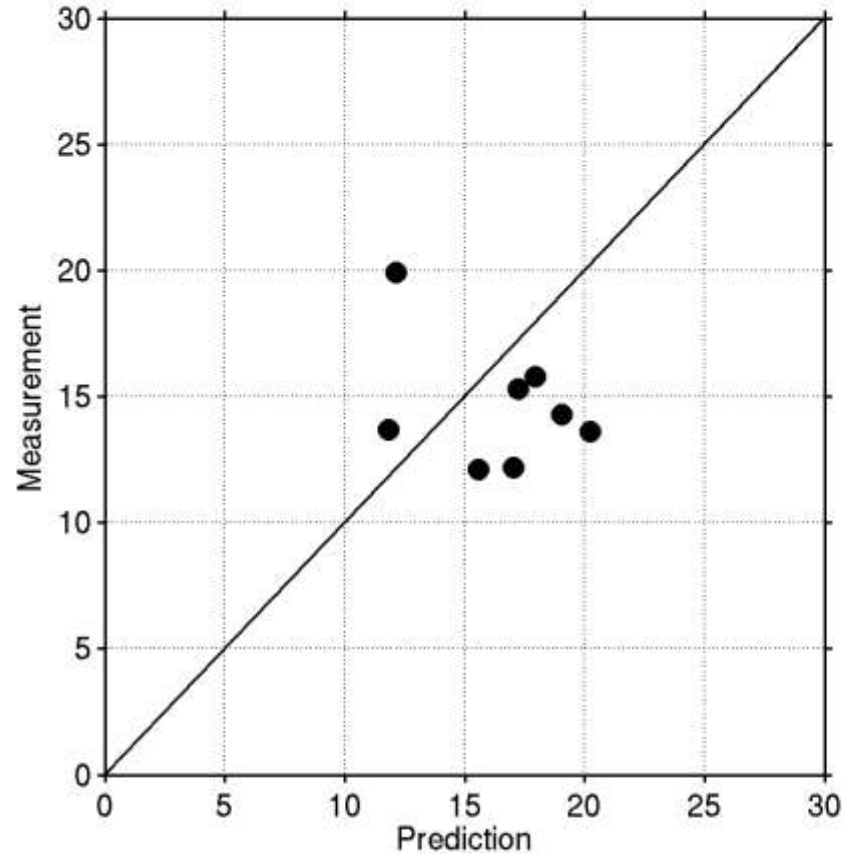
$$LWC = \frac{\pi}{6}(MVD)^3 \rho_w N_c$$

N_c = Droplet concentration

Prediction of MVD

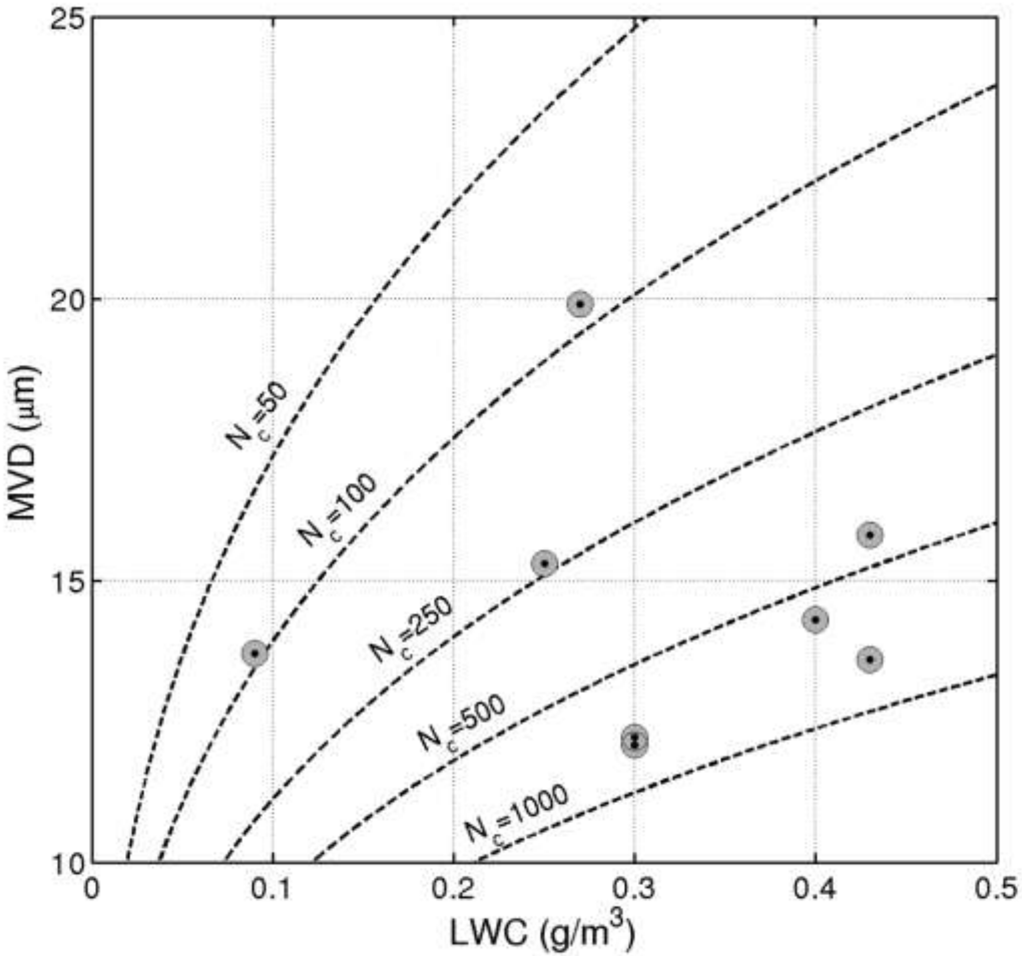


$N_c = 100\ cm^{-3}$



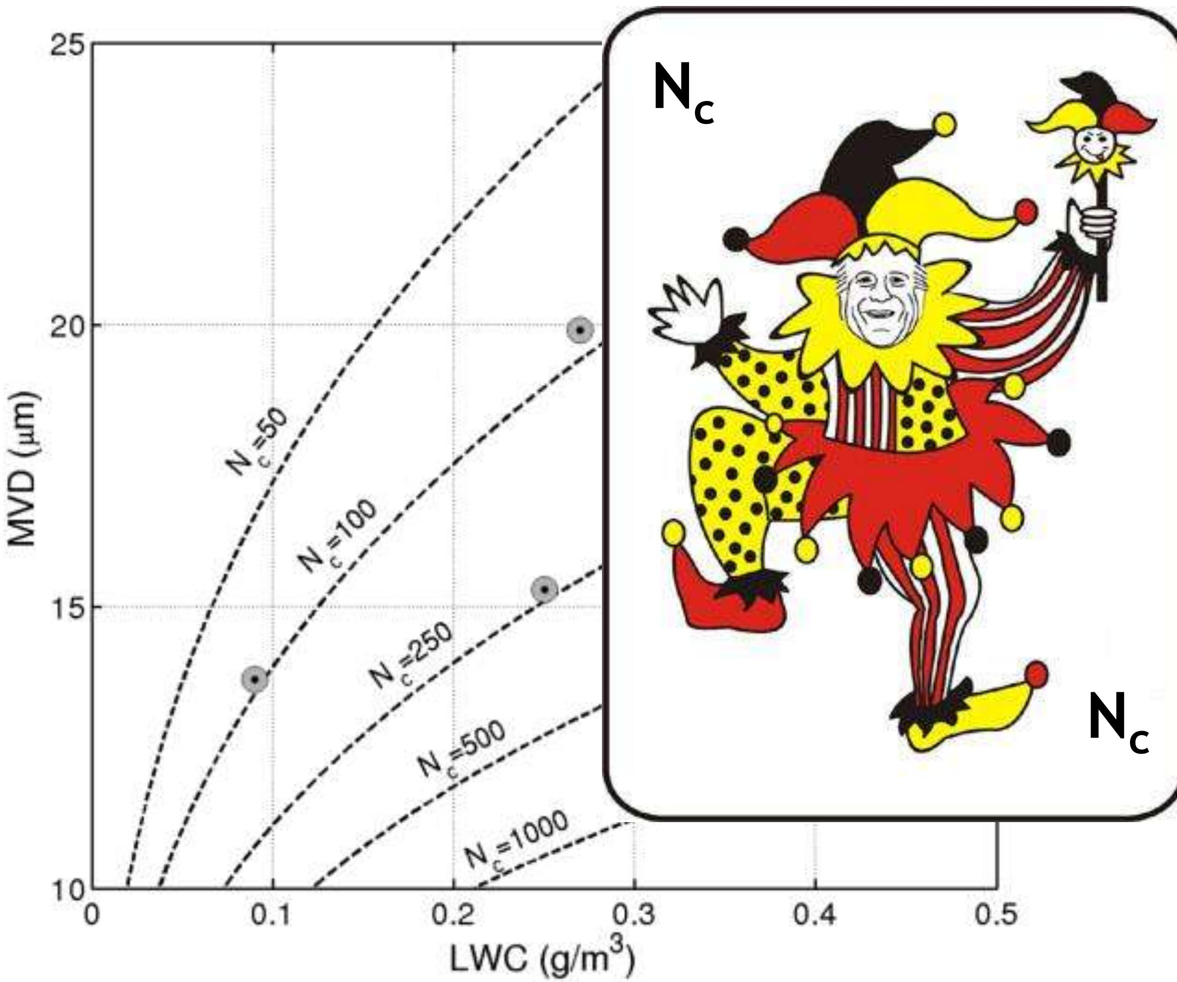
$N_c = 250\ cm^{-3}$

Prediction of MVD



- N_c **is far from being constant**
- Better than constant MVD?
- Variation in N_c is probably much less for coastal sites

Prediction of MVD



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Conclusions

- Good prediction of LWC is possible
  - High resolution
  - Detailed microphysics
  - False alarm rate not studied
- MVD predictions not better than fixed value
- Prognostic droplet concentration in future microphysics schemes may improve icing predictions