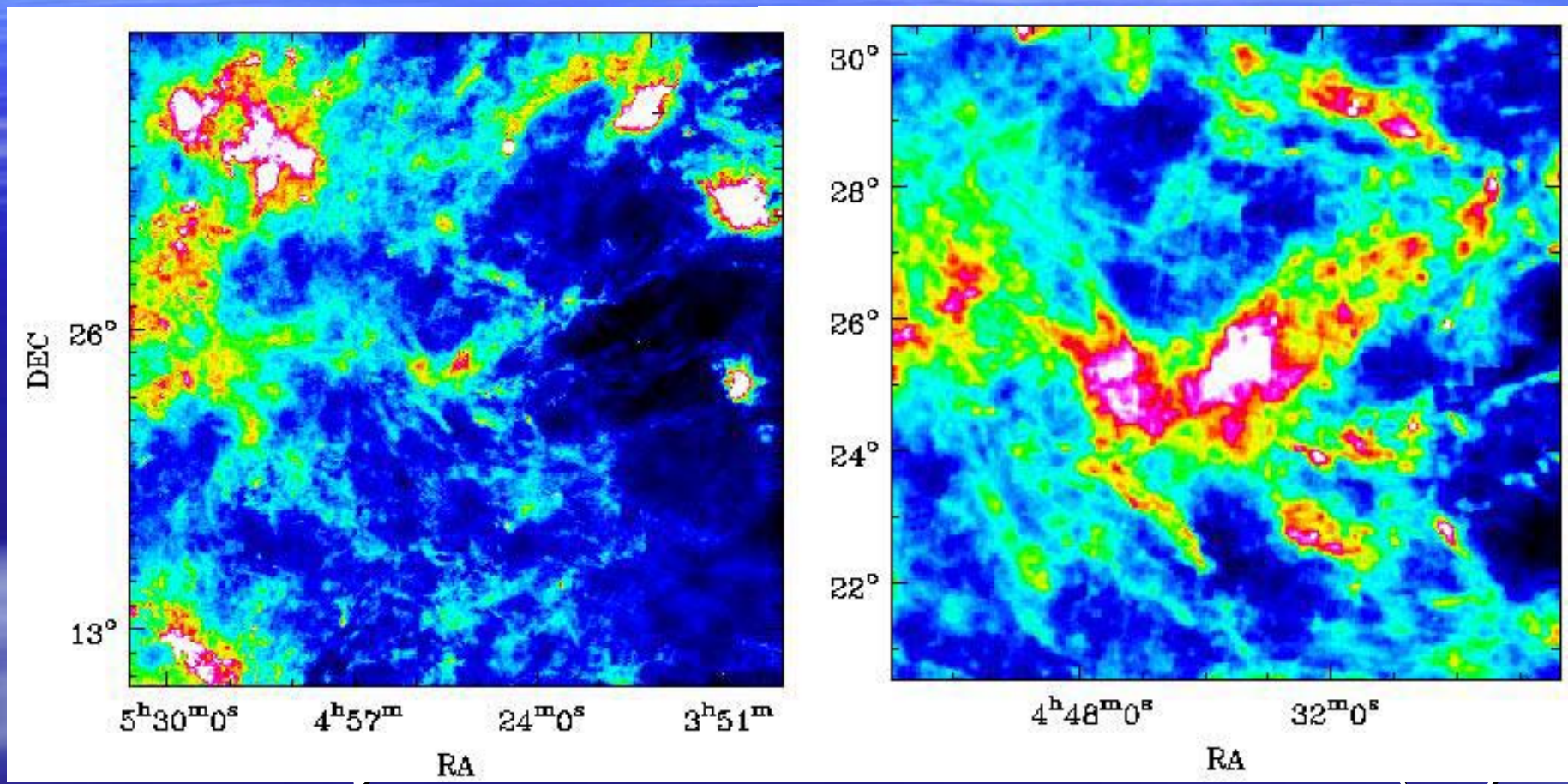
The fractal dimension of projected clouds

Néstor Sánchez
Emilio Alfaro
Enrique Pérez

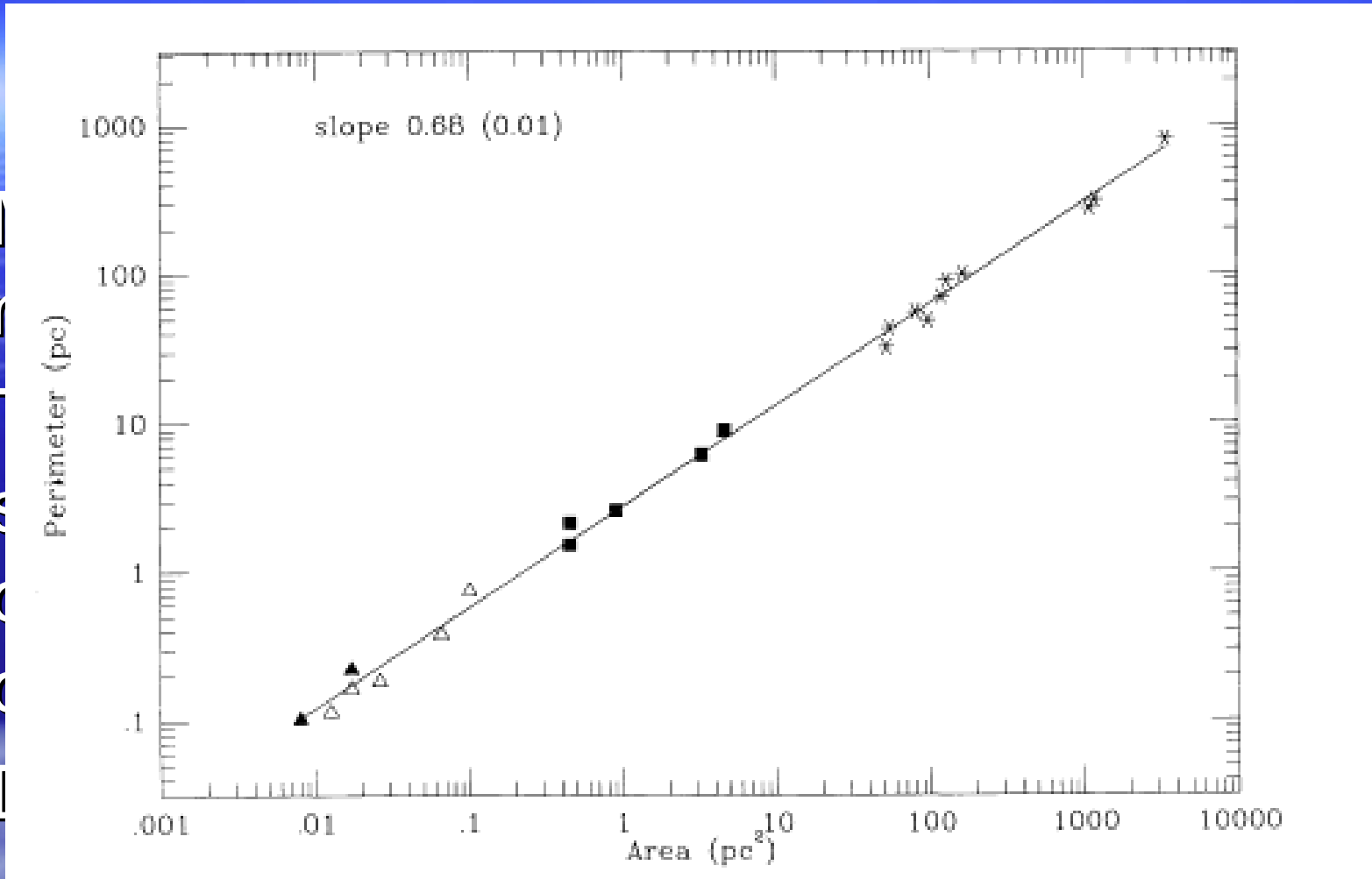
Instituto de Astrofísica de Andalucía, Granada, Spain

3rd Workshop "Estallidos",
Tenerife (December 2th, 2004)

Introduction



Taurus Molecular Cloud (IRAS 100μ emission)



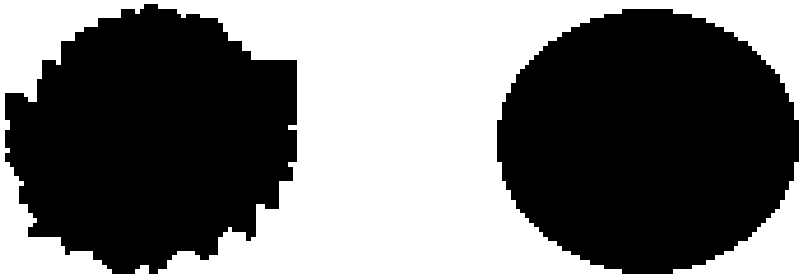
Taurus complex: integrated emission in ^{12}CO (Falgarone et al. 1991)

But clouds are necessarily recorded as projected (2D) images…

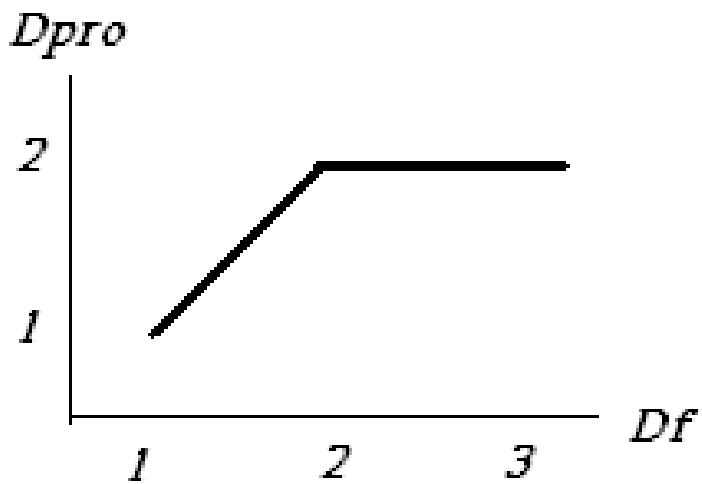
$P \sim A^{Dper/2} \Rightarrow Dper = 1.36$

Introduction

- This suggests that the clouds have fractal "surfaces" with dimension Dsur = Dper+1.
- The intersection of a 3D-fractal (Df) with a plane gives another fractal (Df-1).
- Therefore, Df ≅ 2.35!!! And turbulent diffusion gives Df ≅ 2.3!!!



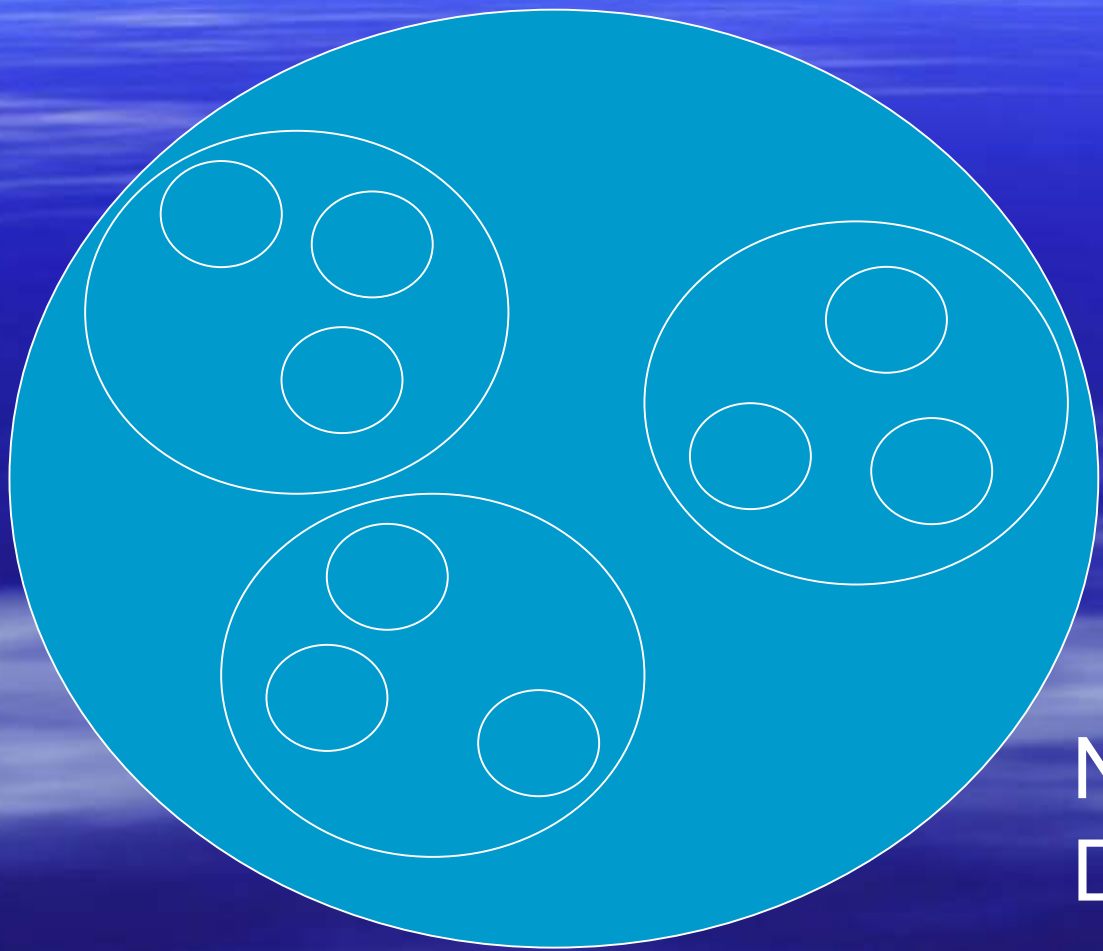
Problem 1: Dsur = Df ?



Falconer (1990)

Problem 2: Intersection ≠ projection !

Simulated clouds



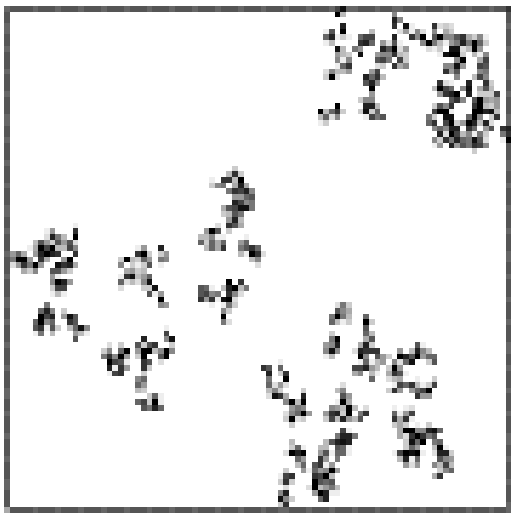
- N spheres
- R → R / L
- H levels

N^H particles with
Df = log(N) / log(L)

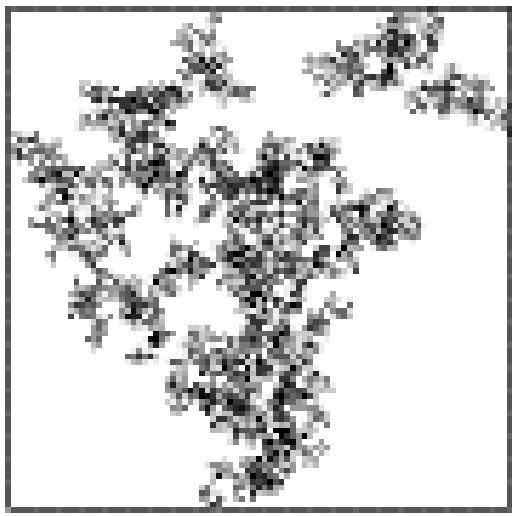
Simulated clouds

N=3 , H=9 (~2×10^4 particles)

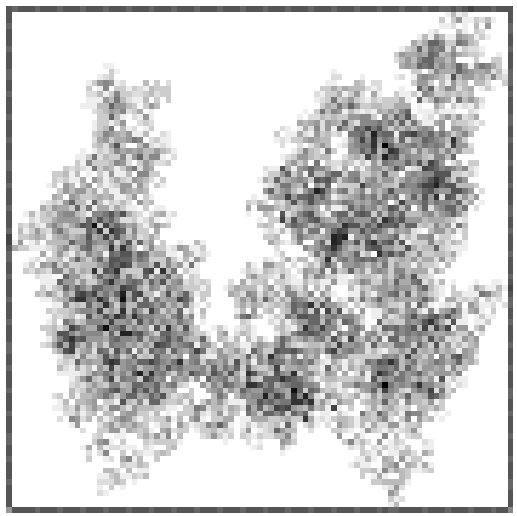
$D_f = 1.5$



$D_f = 2.0$



$D_f = 2.5$

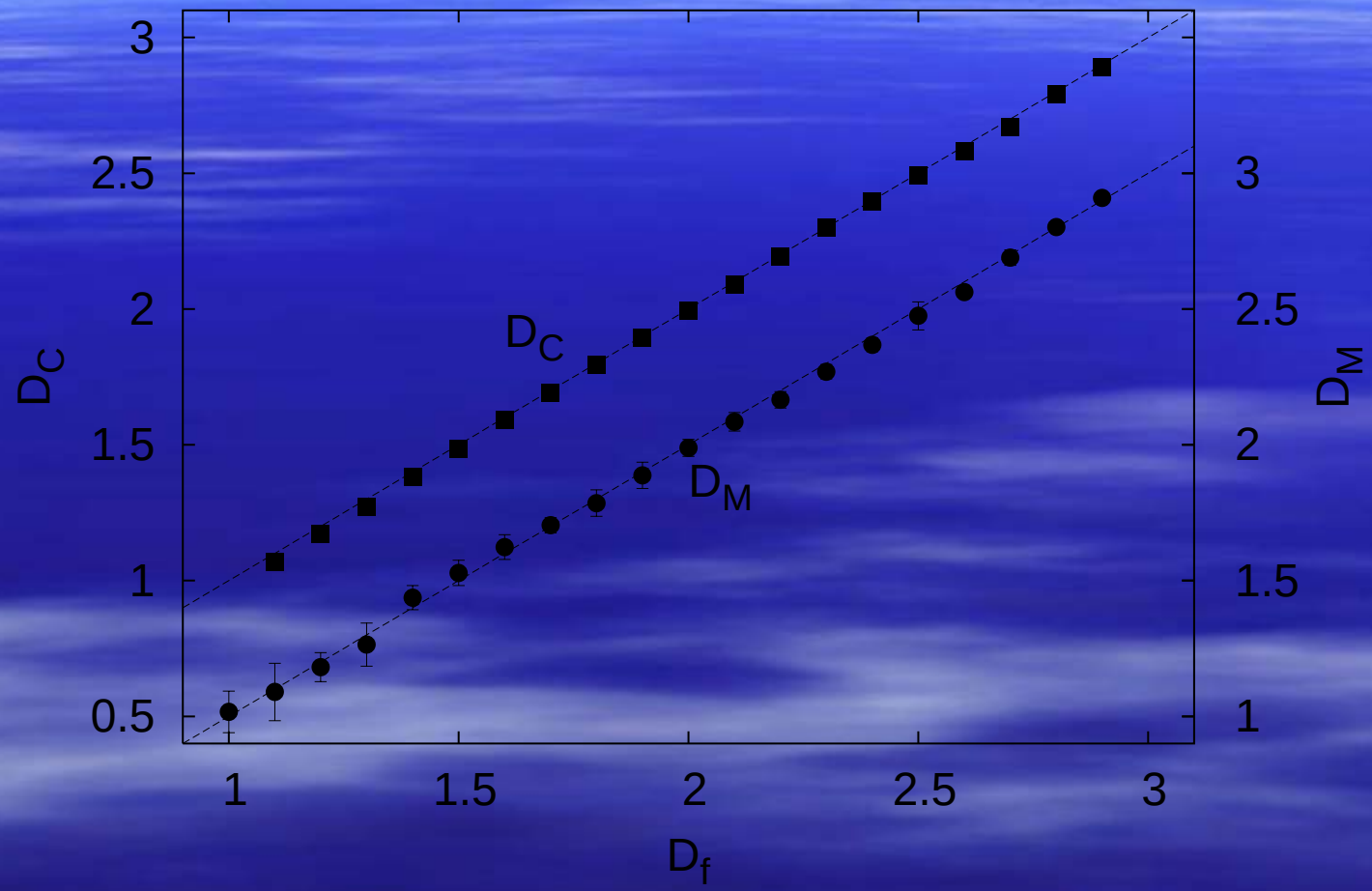


Fractal dimension estimation

- Correlation dimension (Dc):
- C(r): number of pairs with distance < r
- $C(r) \sim r^{Dc}$

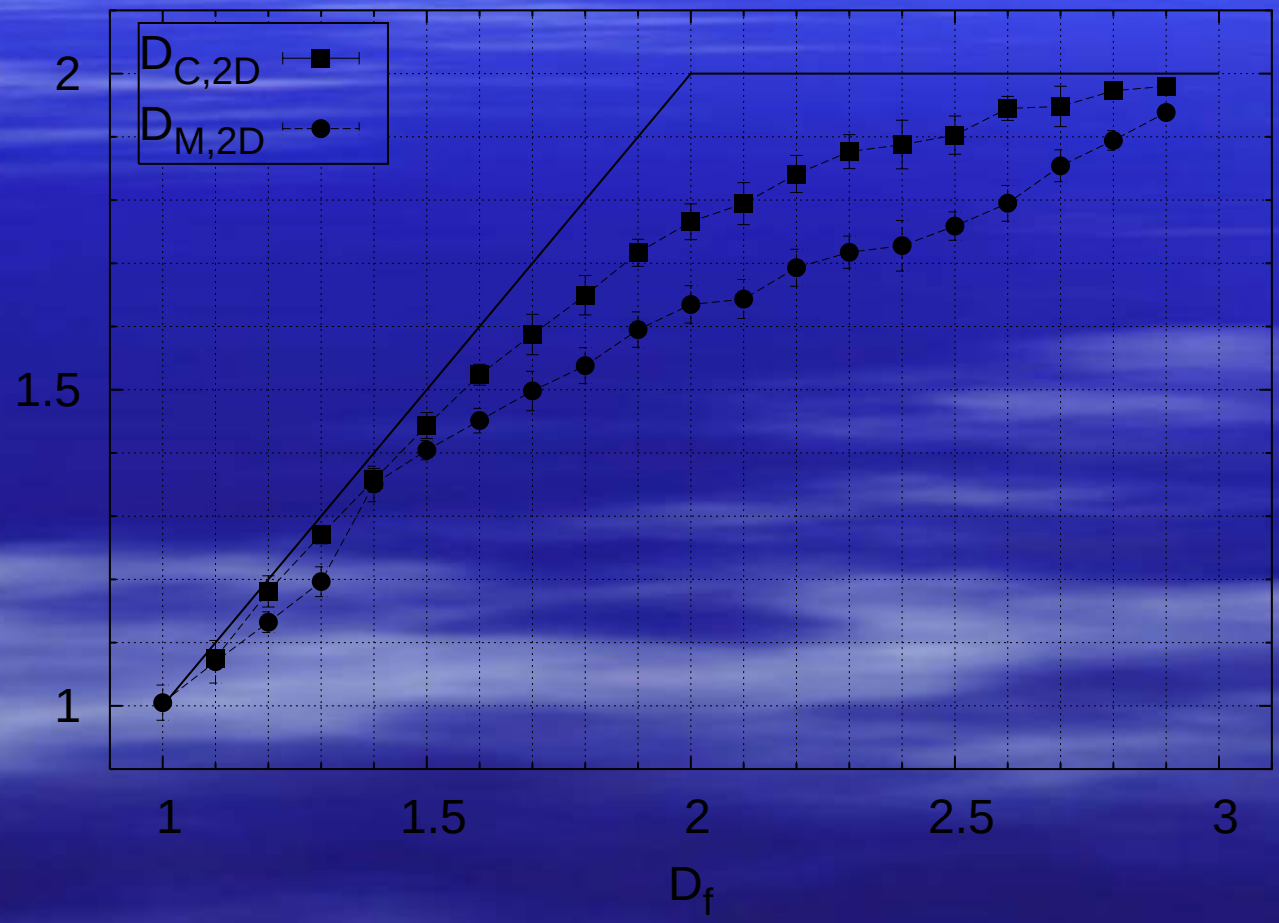
- Mass dimension (Dm):
- M(r): mass inside a sphere of radius r
- $M(r) \sim r^{Dm}$

Fractal dimension estimation



Ok...

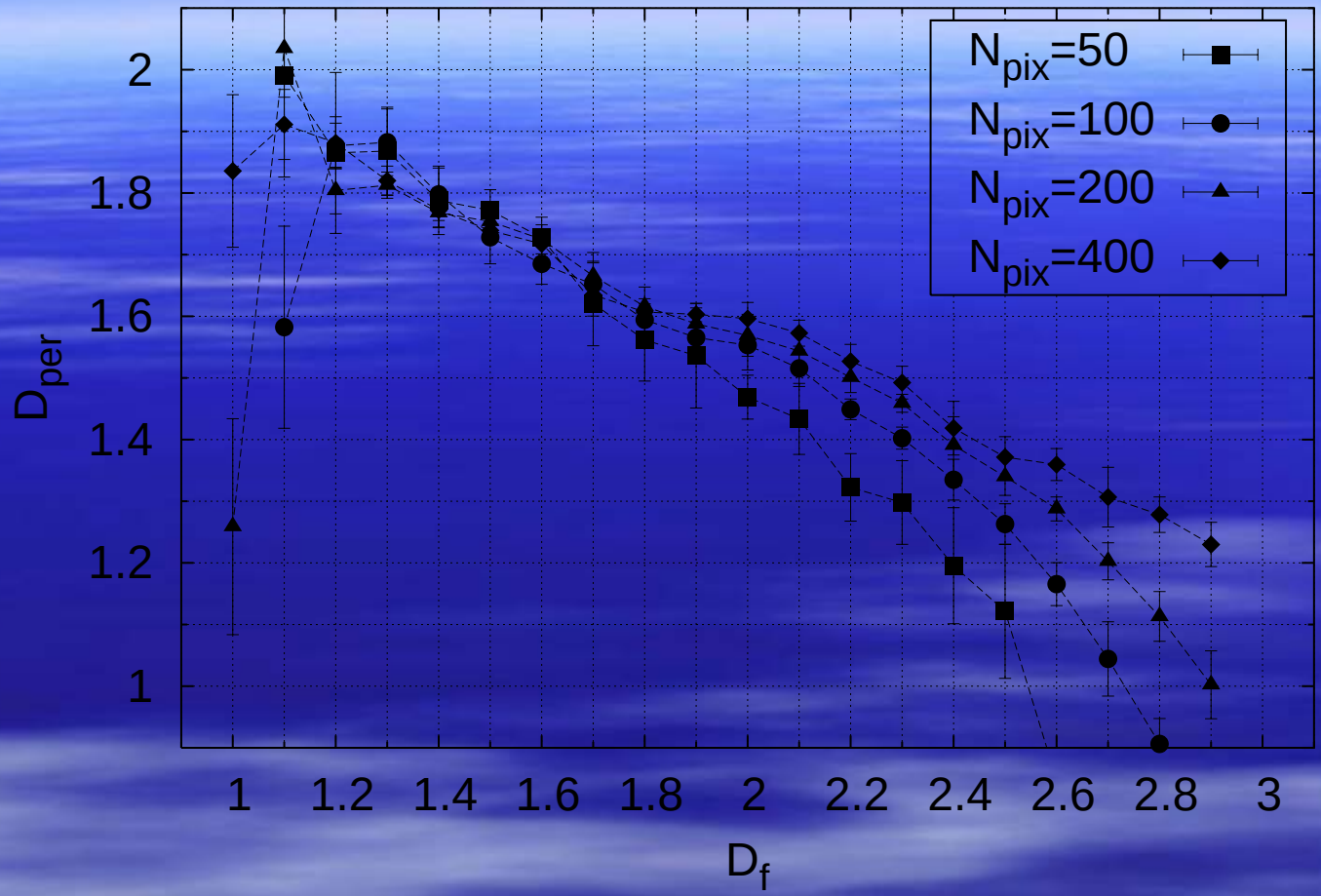
Projected fractal dimension



Perimeter-area relation

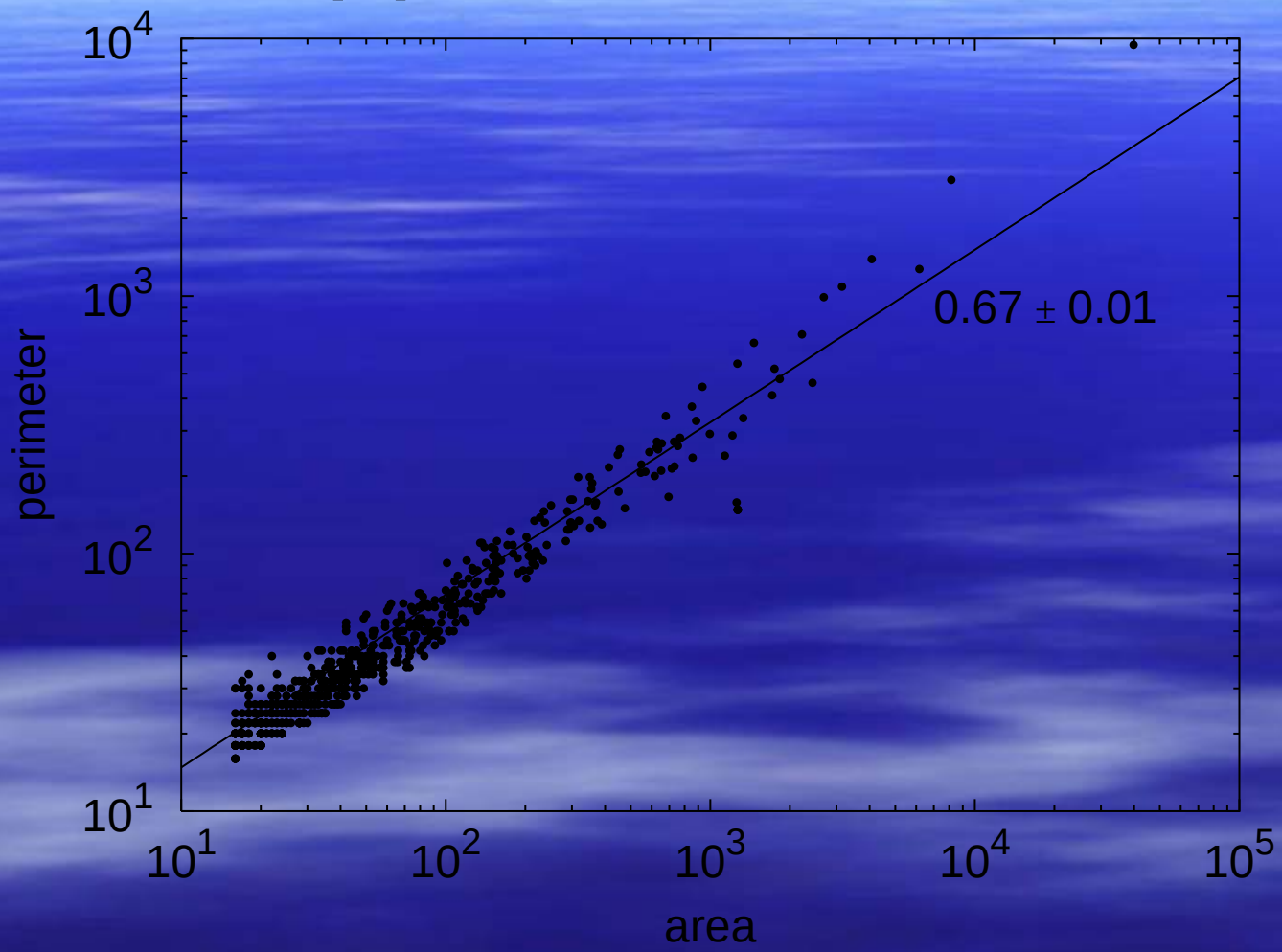
- $P \sim A^{Dper/2}$ $(1 \leq Dper \leq 2)$
- Dper=1: smooth contours
- Dper=2: very convoluted contours

- Dper depends on both the 3D fractal dimension (Df) and the resolution (Npix)!



If Dper =1.35 then 2.5 < Df < 2.7 !!!

Application to Orion A

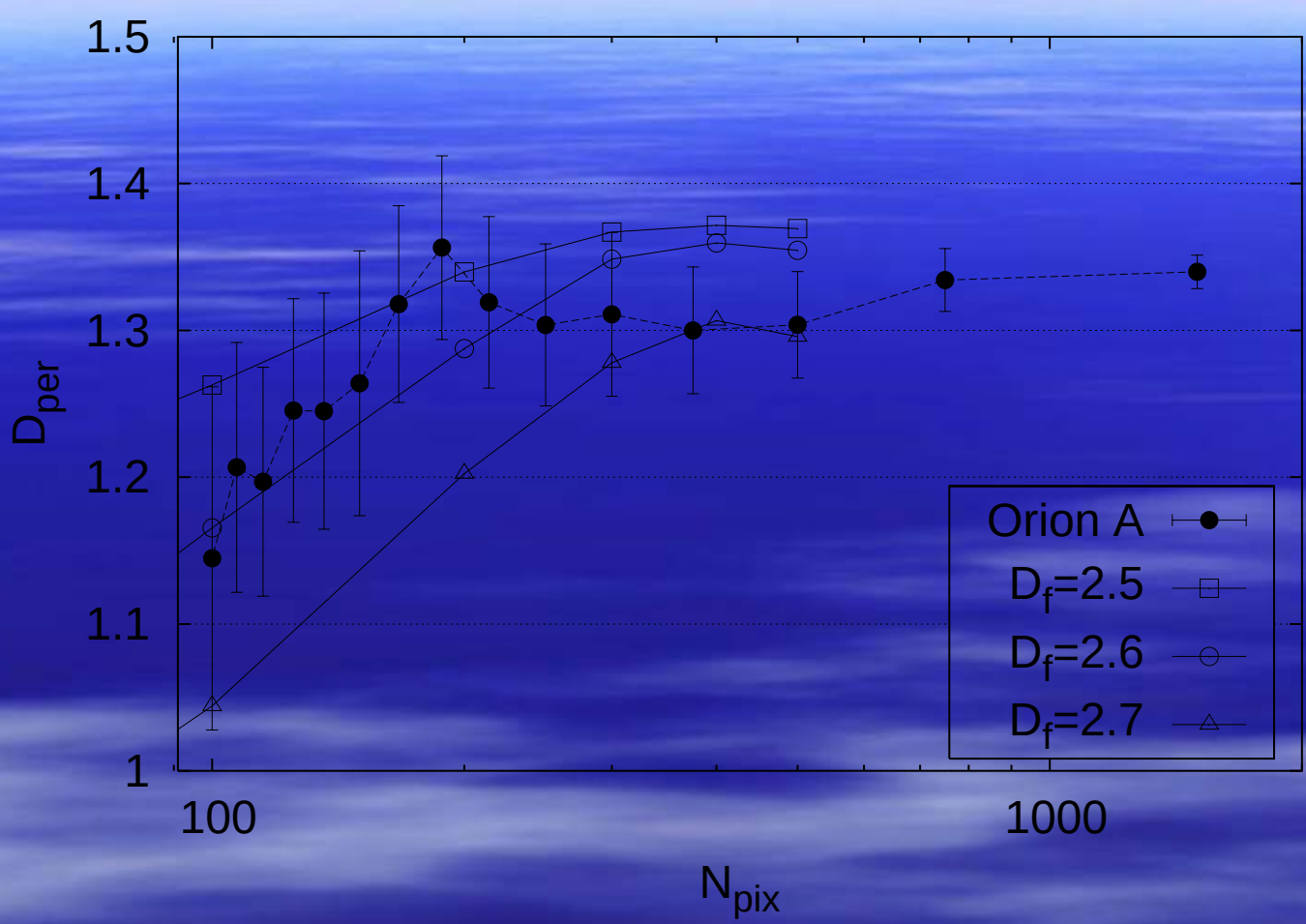


Dper=1.34

Df=2.5-2.7

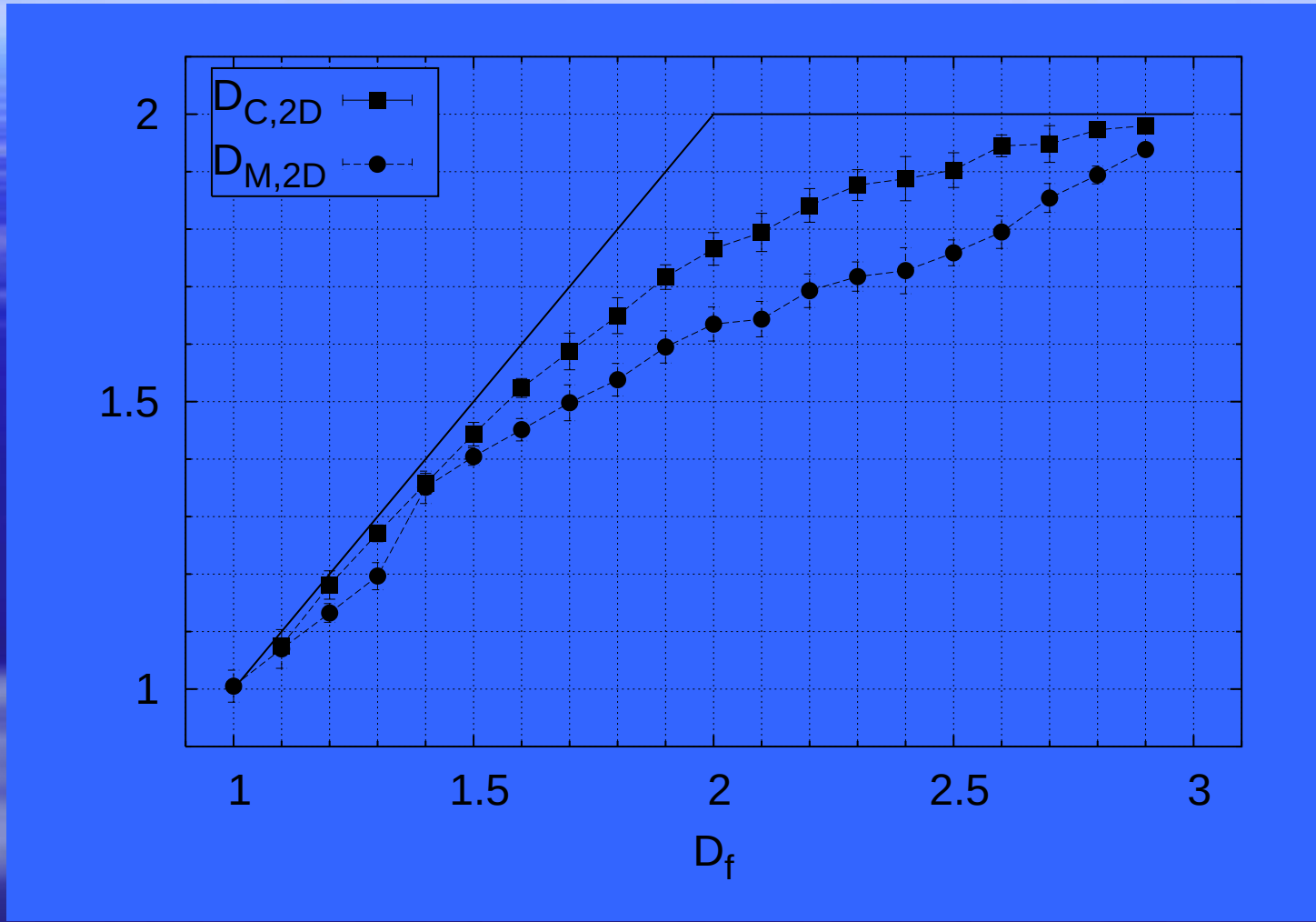
From a CS(1-0) integrated intensity map (Tatematsu et al. 1993)

Decreasing the resolution...



Again, 2.5 < Df < 2.7...

Finally, the "mass" dimension...



Dm = 1.77 $\Rightarrow$ Df = 2.5-2.6

Conclusions

- Main result: the relations between 3D and 2D fractal dimension estimators.
- Df ≠ Dper + 1, i.e, Df ≠ 2.3 !
- It seems that Df is around 2.6 !

In progress:

- Dper, Dper vs resolution, and Dm in other cloud complexes: Df = ???
- Df ↔ star formation process (IMF) ?
- ...

Thanks...