# Cataloguing substructure in Star Forming Regions

M. González, E. Moraux, I. Joncour

IPAG - Grenoble

STARFORMMAPPER

IPAG
Institut de Planétologie et d'Astrophysique de Grenoble

# Objective

**Construction of a catalog of substructure in star forming regions allowing for comparison of the substructure characteristics amongs different regions**

**Substructure Catalog**

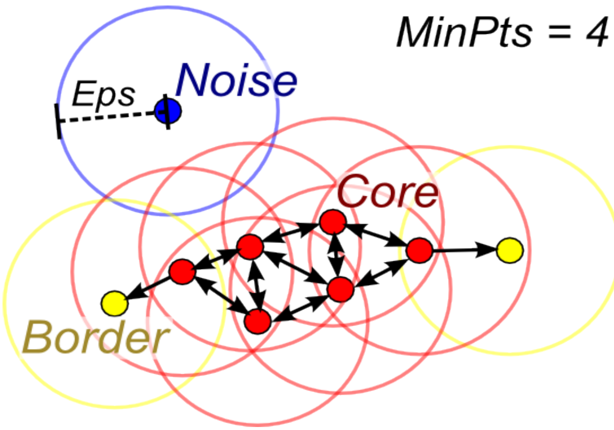
- Reliable
- Homogeneous

**Methodology for detection**

- Reliable
- Homogeneous
- Robust to different inputs

# The procedure

## DBSCAN




**PARAMETERS**

Epsilon

MinPts

A&A 599, A14 (2017)
DOI: 10.1051/0004-6361/201629398


Astronomy & Astrophysics

**Multiplicity and clustering in Taurus star-forming region**

**I. Unexpected ultra-wide pairs of high-order multiplicity in Taurus**

Isabelle Joncour[1,2], Gaspard Duchêne[1,3], and Estelle Moraux[1]

A&A 620, A27 (2018)
https://doi.org/10.1051/0004-6361/201833042


Astronomy & Astrophysics

**Multiplicity and clustering in Taurus star forming region**

**II. From ultra-wide pairs to dense NESTs★**

Isabelle Joncour[1,2], Gaspard Duchêne[1,3], Estelle Moraux[1], and Frédérique Motte[1]

# Choosing epsilon

Compare the sample with complete spatial randomness

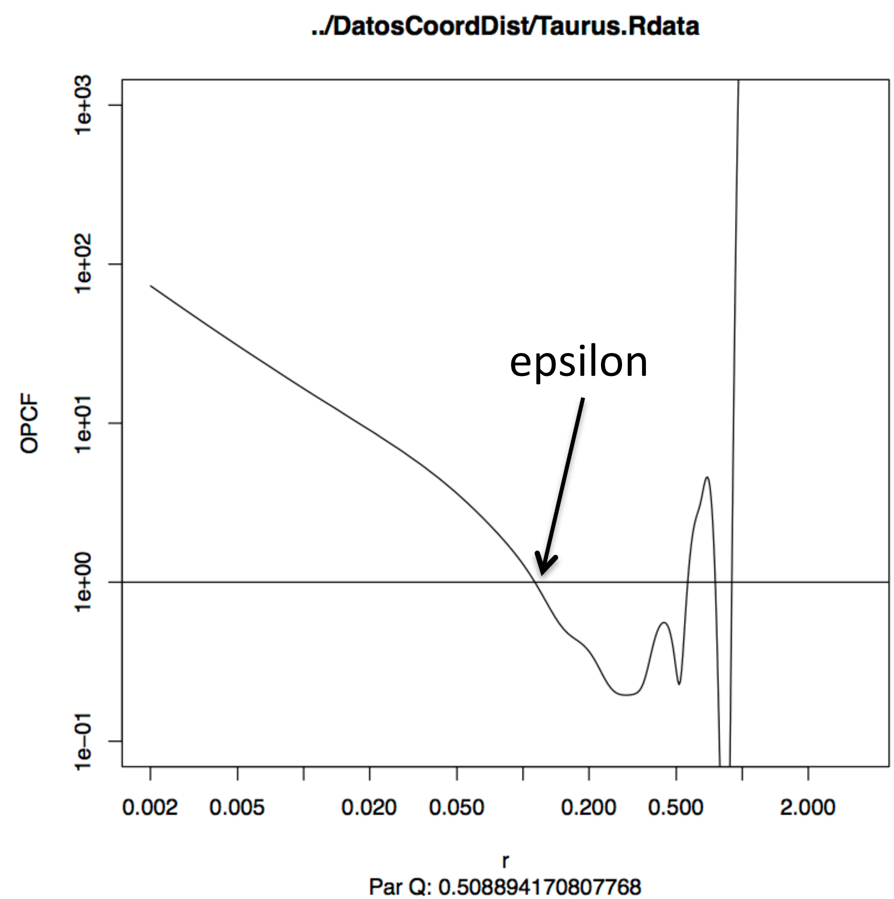
**One point correlation function**

$$\Psi(r) = \frac{w_{samp}(r)}{w_{rand}(r)}$$

*w* is the first nearest neighbour density

$$w_{rand}(r) = 2\pi\rho r \exp(-\pi\rho r^2)$$

Local density from the mean 6th nearest neighbour distance



# Choosing Nmin

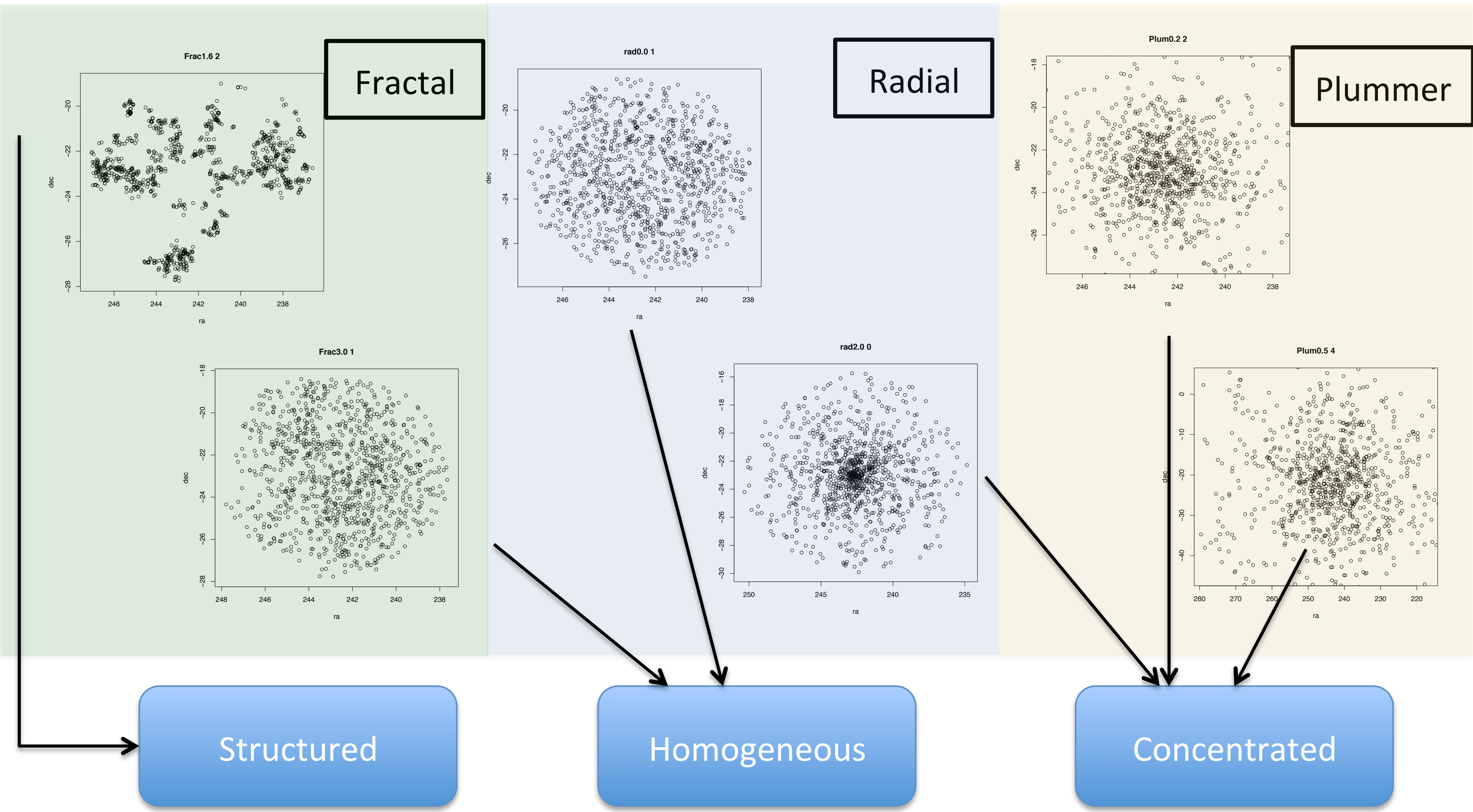
Guarantee reliability over random fluctuations

$$w^n_{rand}(r) = \frac{2(\pi\rho)^n}{\Gamma(n)} r^{2n-1} \exp(-\rho\pi \mathrm{r}^2)$$

$$P(n) = \int_0^{\epsilon} w^n_{rand}$$

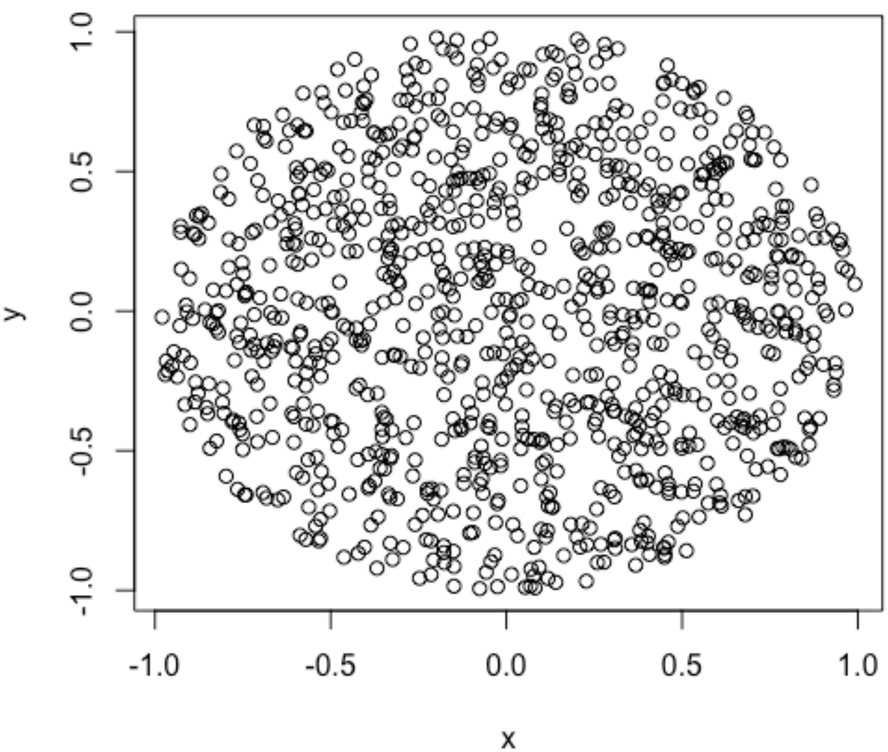
Probability of having at least n neighbours within an epsilon radius for a random distribution.

# Simulations

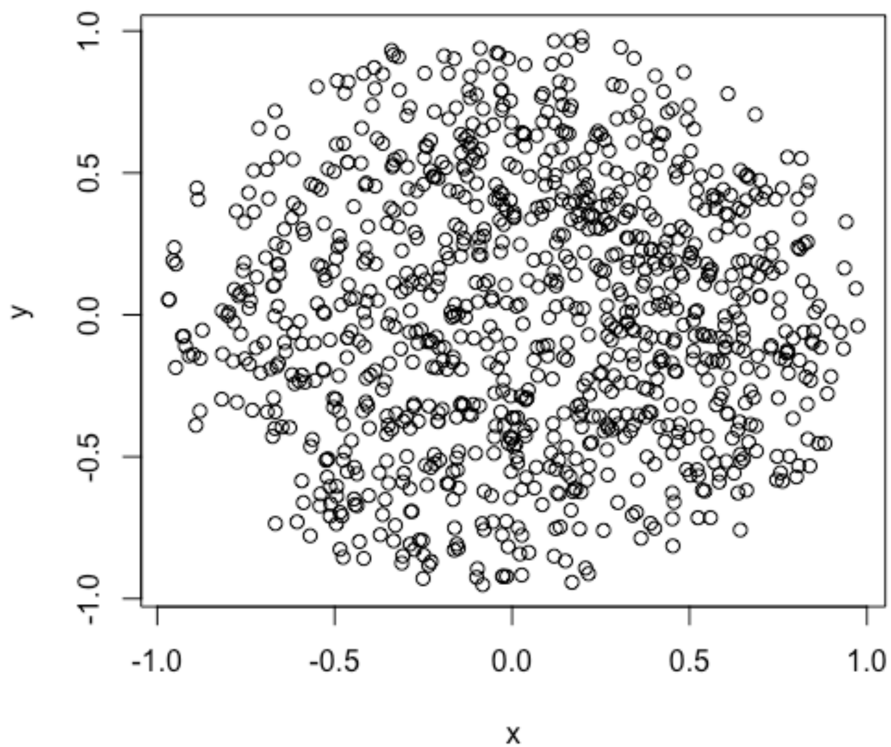



**Q < 0.8** **Q ~ 0.8** **Q > 0.8**

# Projection effects and homogeneous distributions



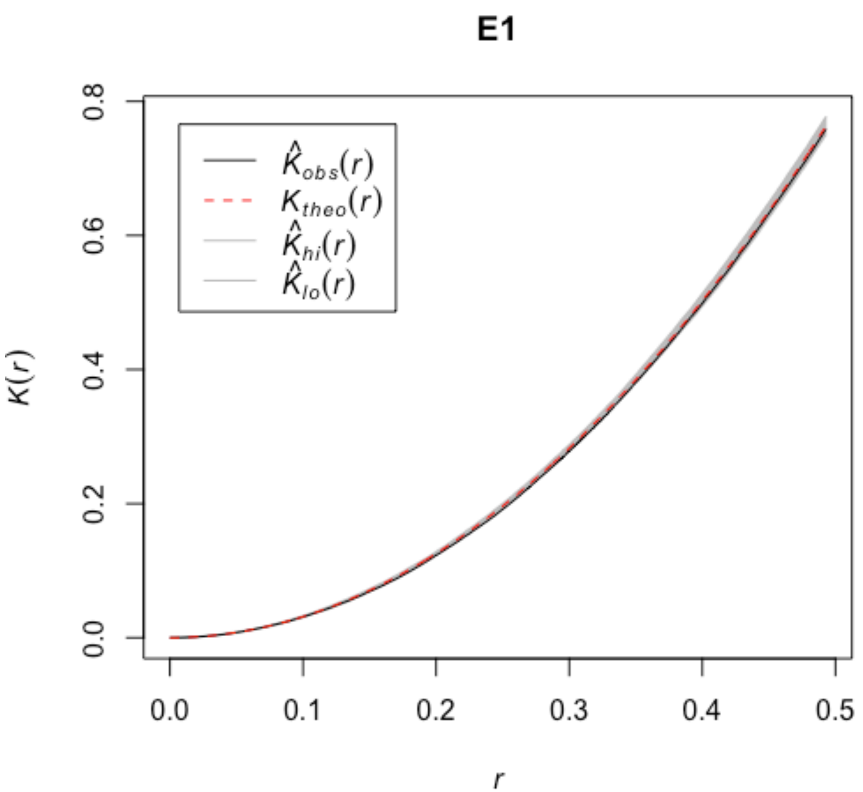

2D homogeneous



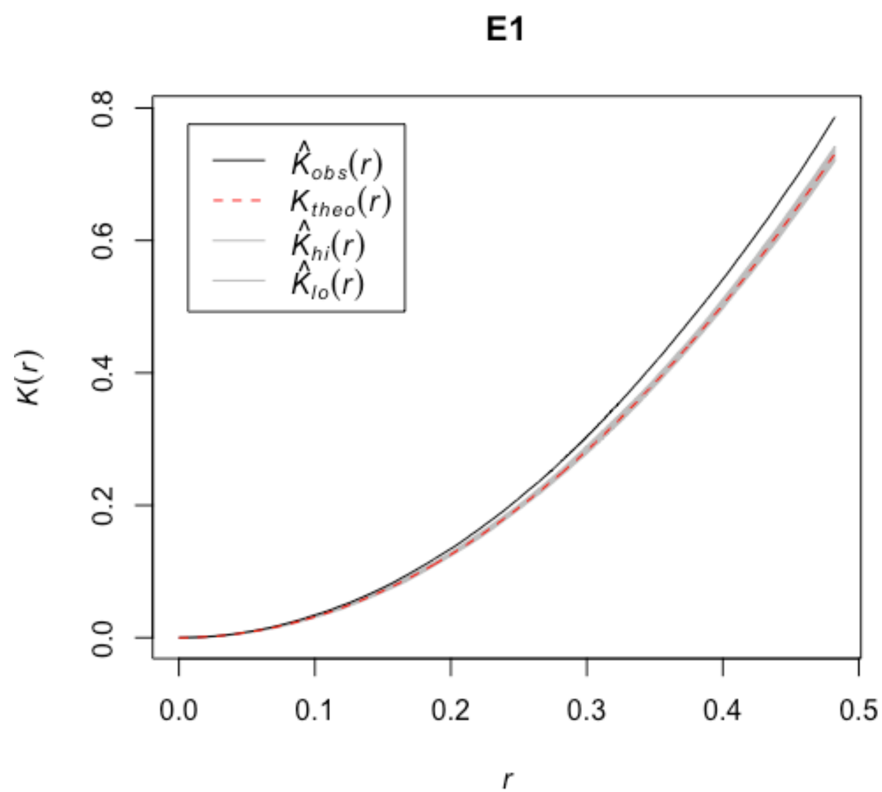

3D projected homogeneous

# Ripley K function

$$K(r) = \rho^{-1} \frac{Card\{p_i, p_j \mid d(p_i, p_j) < r\}}{n} \qquad K_{rand}(r) = \pi r^2$$

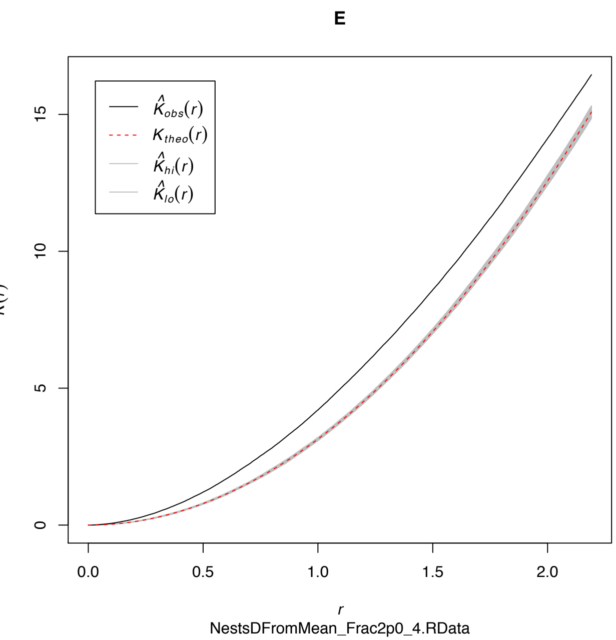


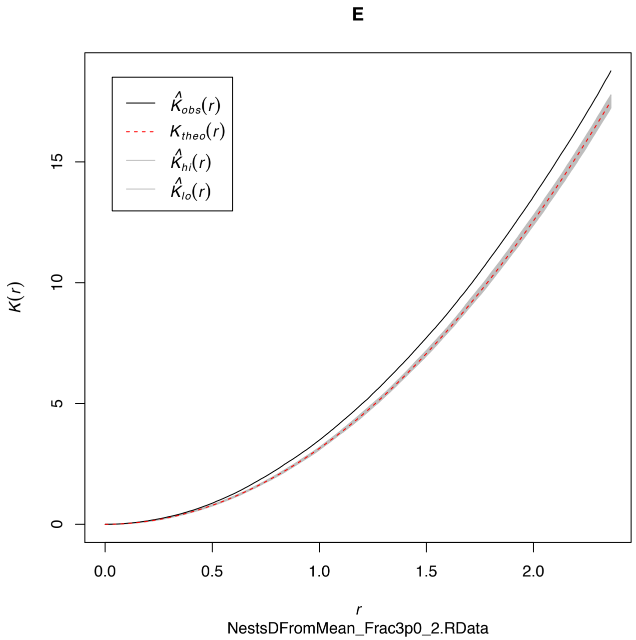

2D homogeneous

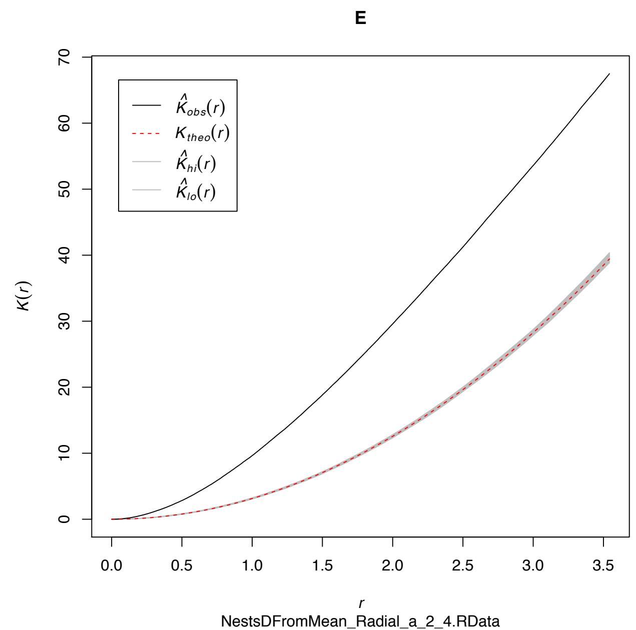



3D projected homogeneous

# Radius of local homogeneity



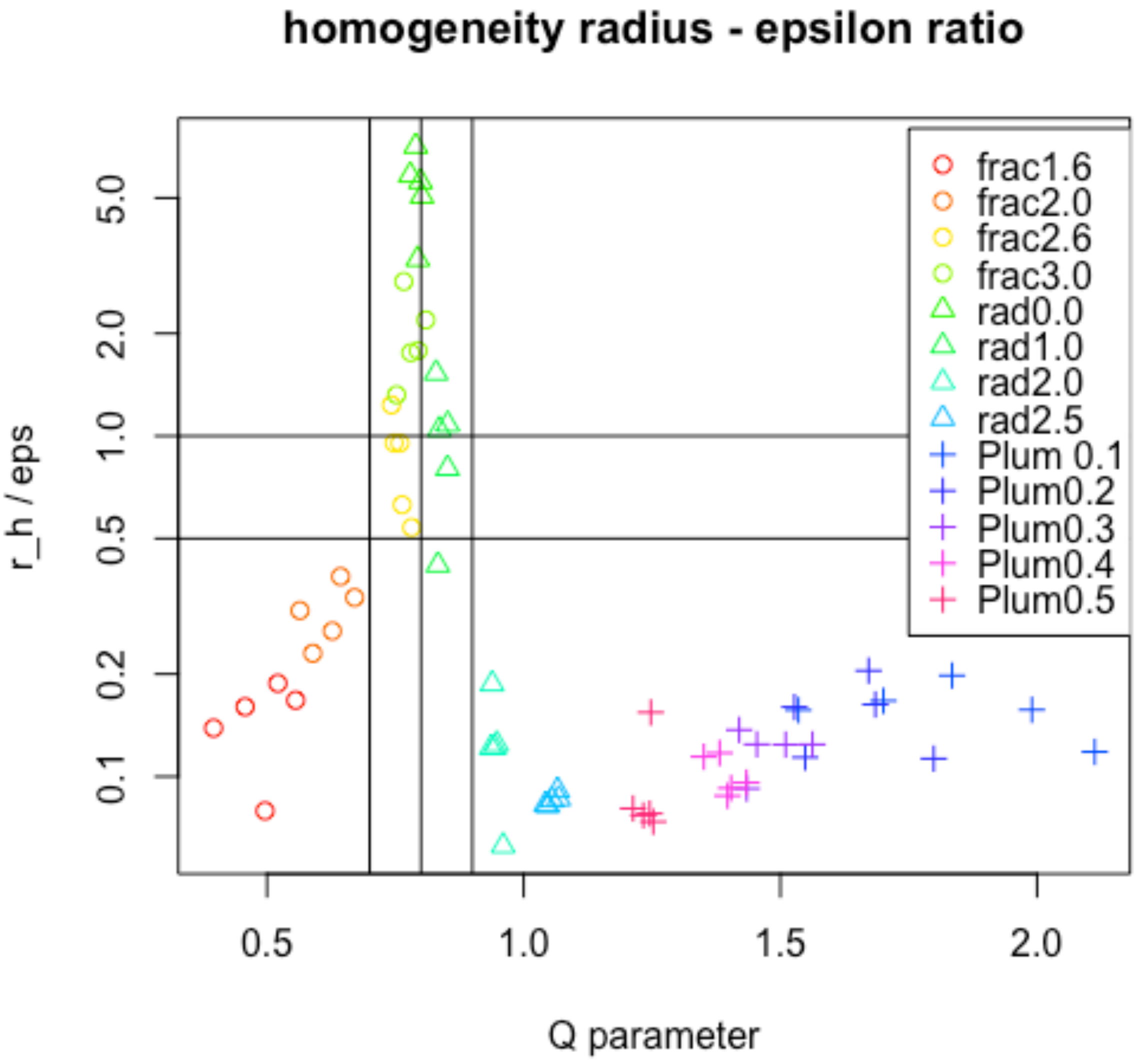




Structured

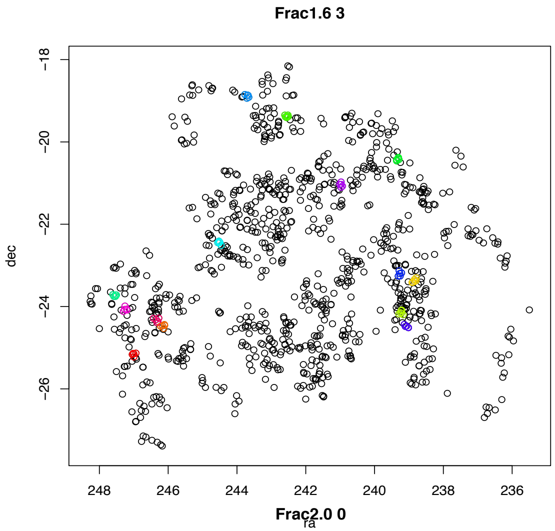
Homogeneous

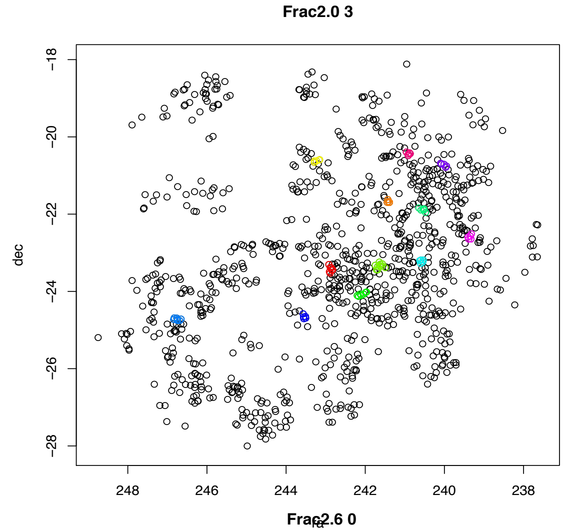
Concentrated

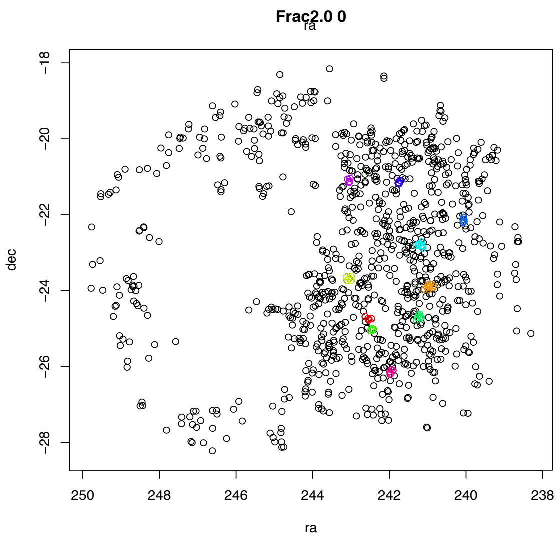
# Locally homogeneous regions

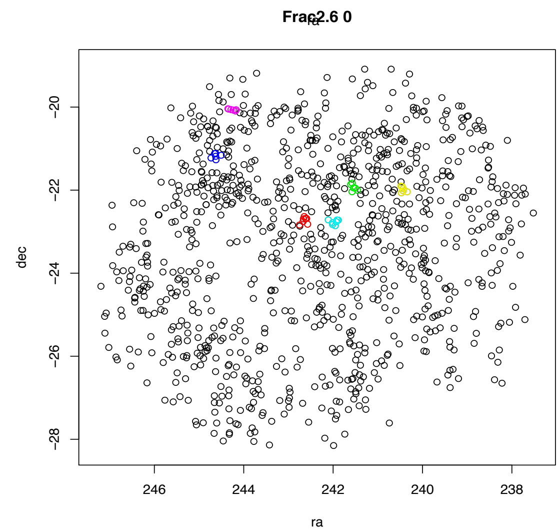


# Structured regions

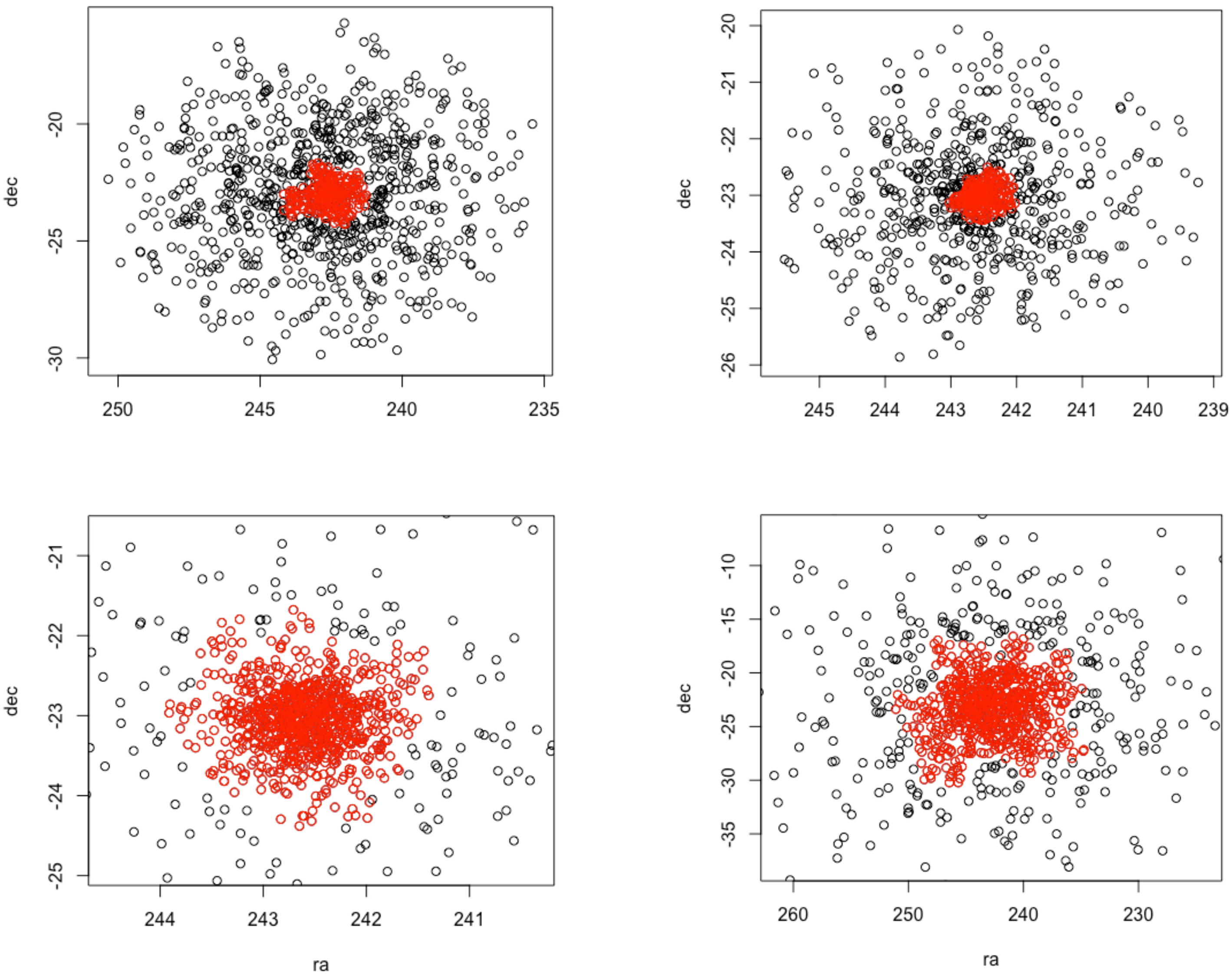


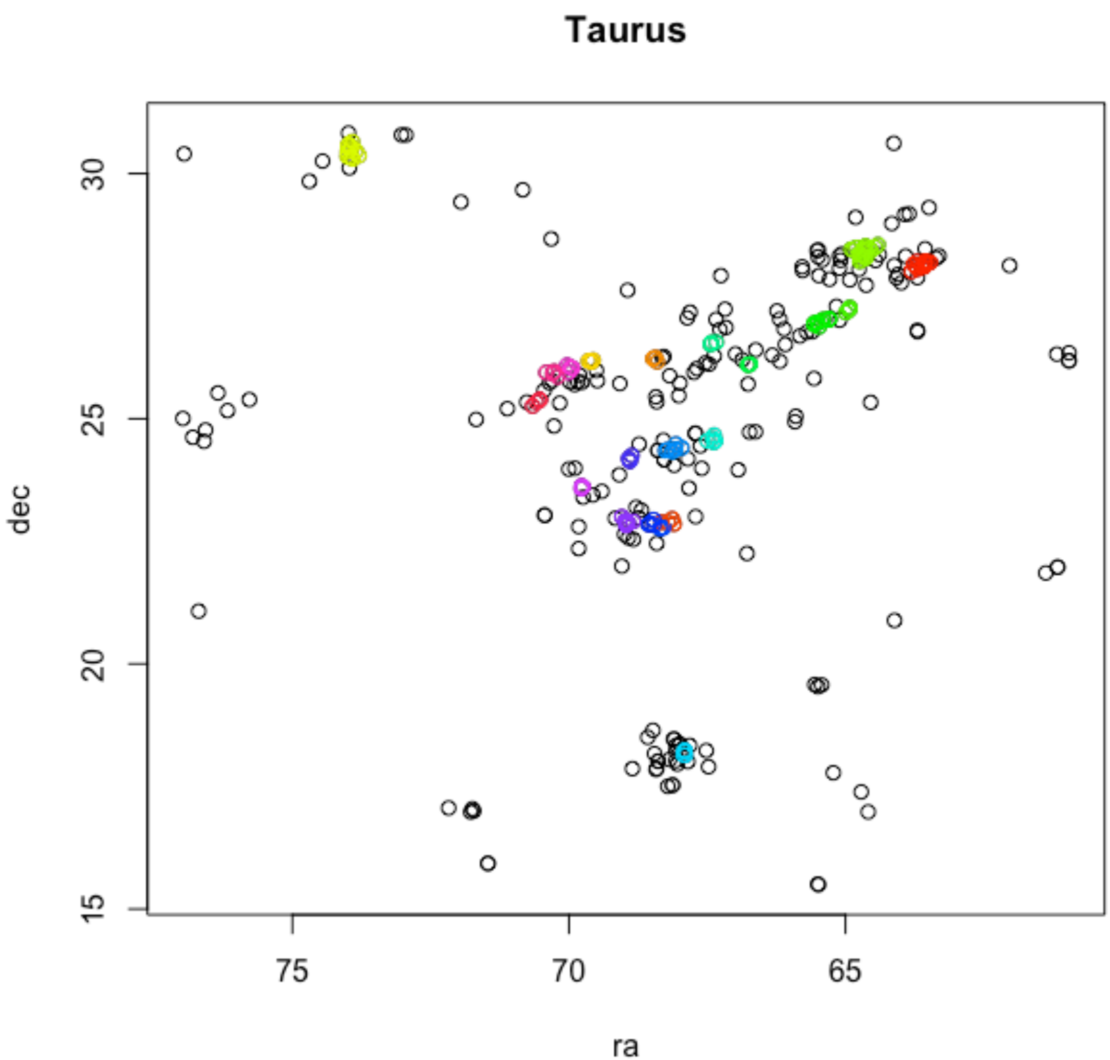



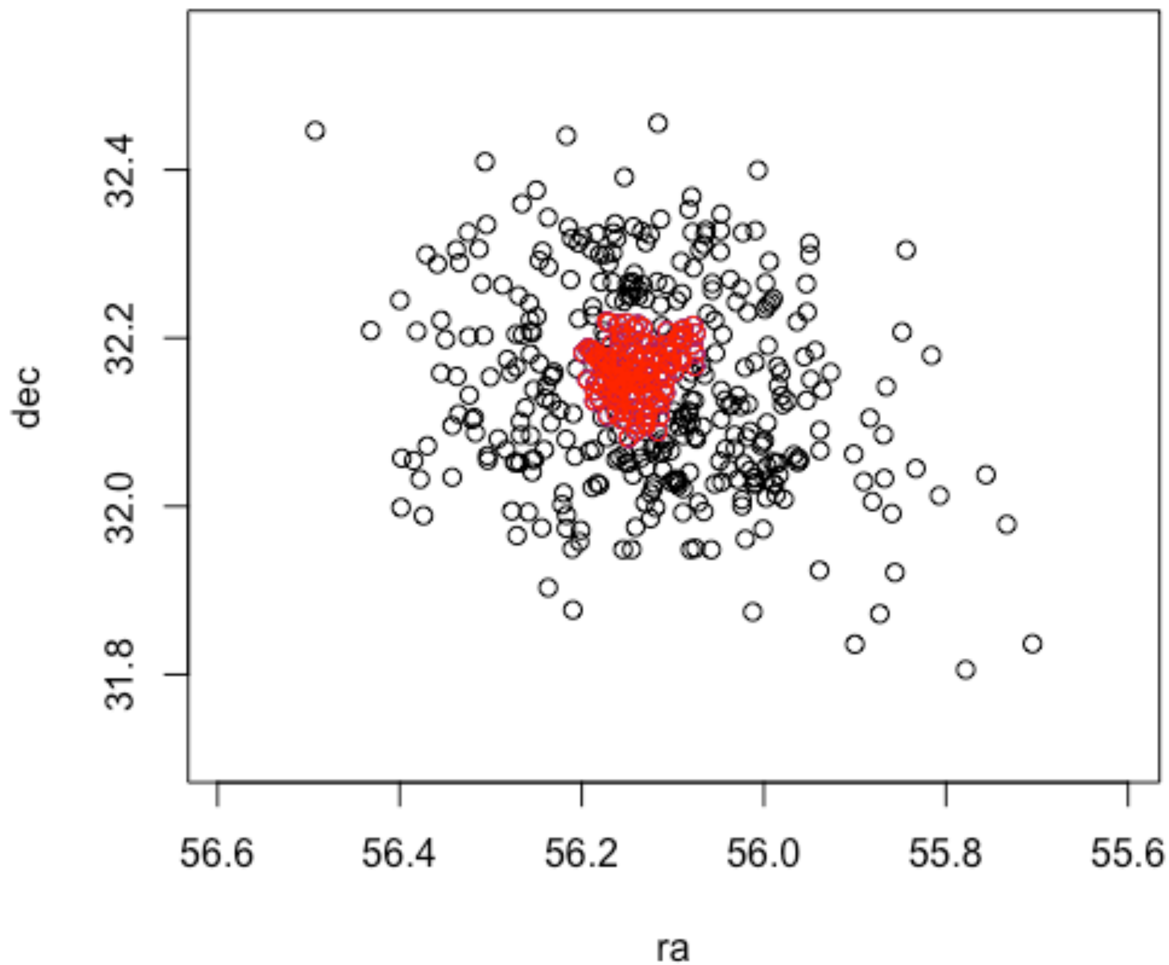
# Concentrated regions



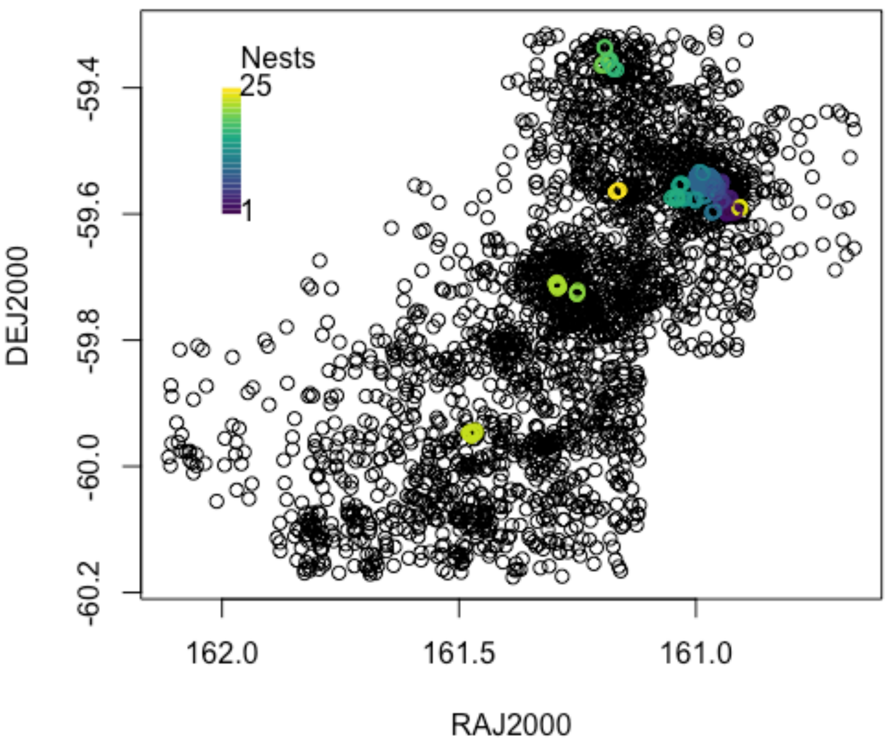
# Real data: Taurus

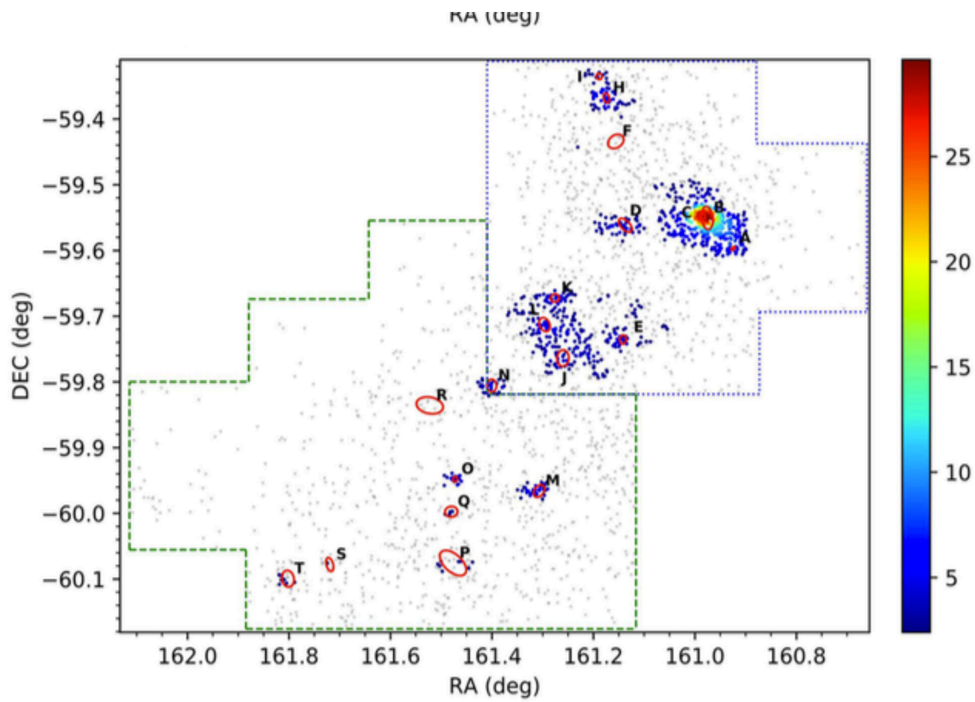


# Real data: ic348



# Real data: Carina Nebula




Buckner et al 2019
(ellipses: Khun et al 2014)

# Summary

- Developed a robust methodology to retrieve structures on a variety of different nature inputs
- Objective, statistically-based srategies to ensure reliability and mitigate projection effects.
- Limits: single scale → density. Multiscale version already on development.