The Spatial Evolution of Young Massive Clusters

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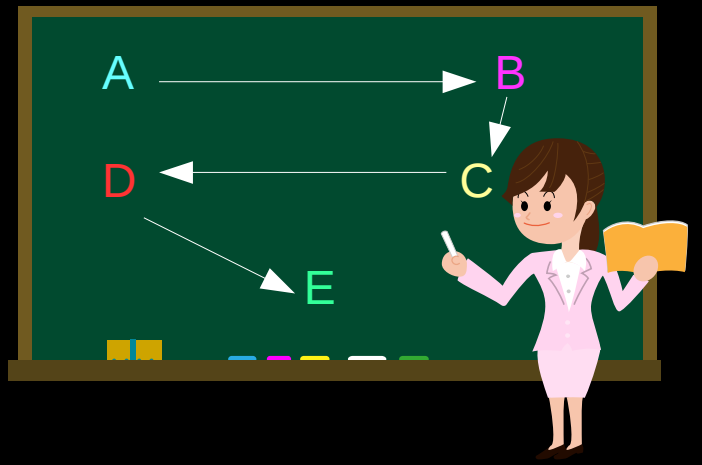
& the SFM Collaboration

SFM STARFORMMAPPER

UNIVERSITY OF LEEDS

Talk Outline

- Young Massive Clusters
- Why study them?
- Stellar substructure
- INDICATE
- Spatial evolution of NGC3372



Young Massive Clusters (YMCs)

- Building blocks of the Galaxy
- Nurseries of OB-type stars
- Mass > 10^4 $M_\odot$
- Age < 100Myr

NGC2264 / Image: ESO

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For talk: ages < 10Myr

i.e. **REALLY** young!

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- 96% of O-type stars form in clusters

  (de Wit et al., 2005)

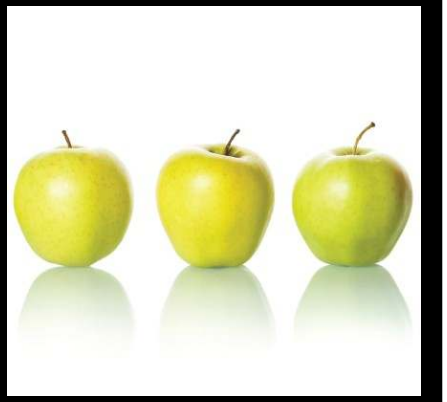
Massive Star Formation

- Three models of massive SF:

  (1) Monolithic Collapse

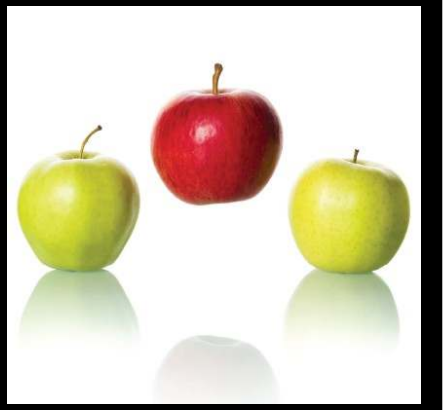
  (2) Competitive Accretion

  (3) Collisions & Mergers



Massive Star Formation

- To distinguish → constrain mechanisms that underlie star/cluster formation & evolution



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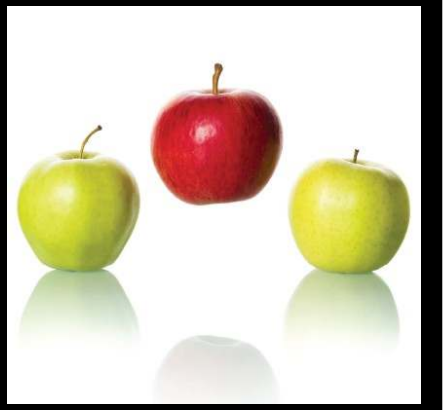

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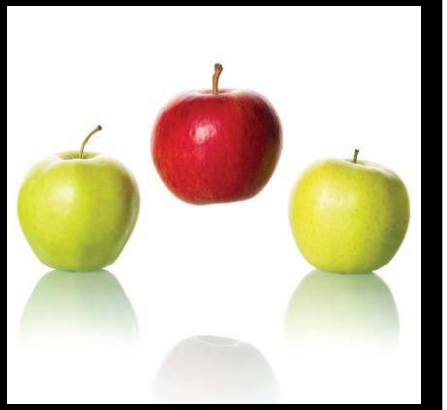
  (1) Stellar substructure

  (2) Mass segregation



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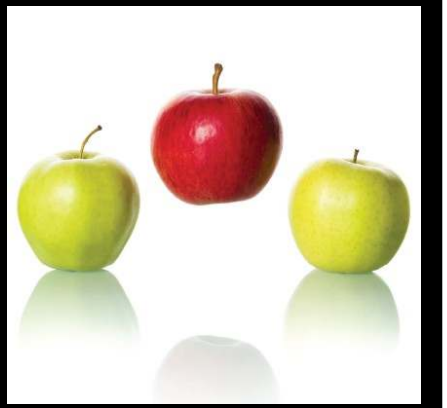
  (3) Star/gas dynamics



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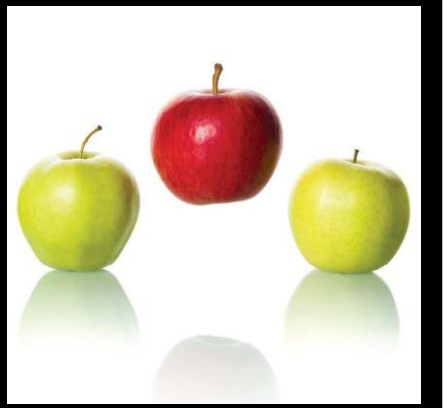

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- Sub-clustering of stars within cluster/SF region

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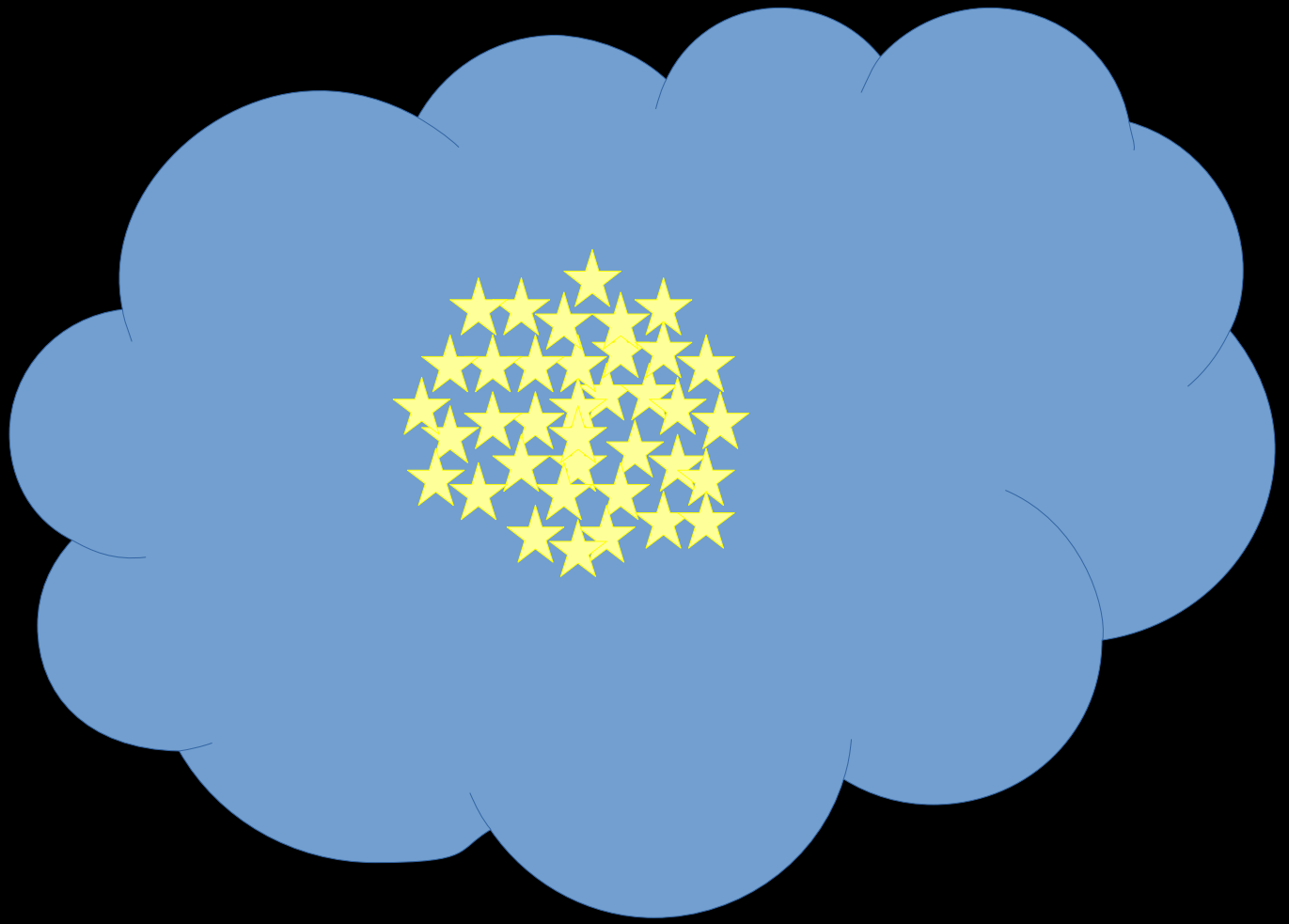

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Tracing Substructure

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- Clustering algorithms

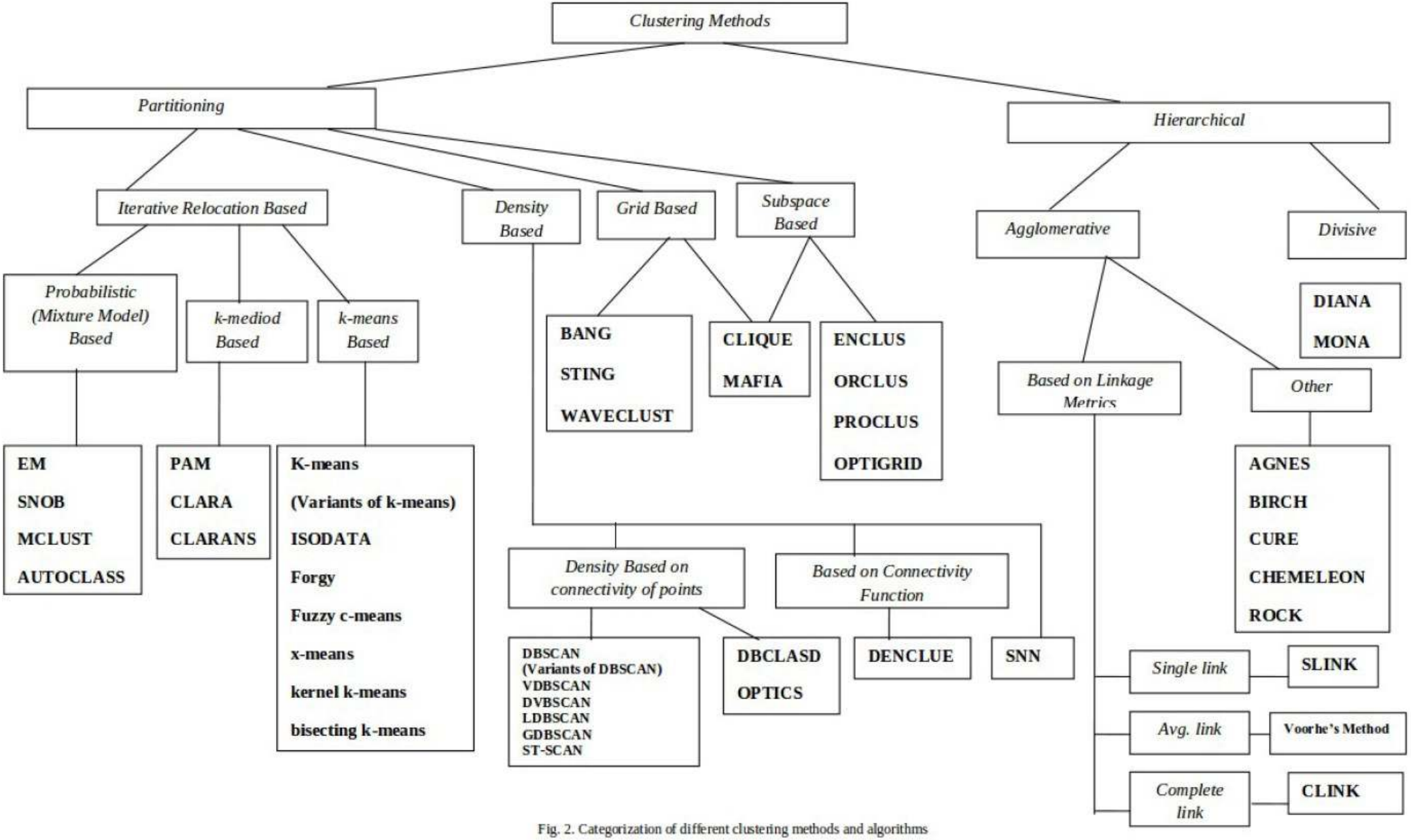
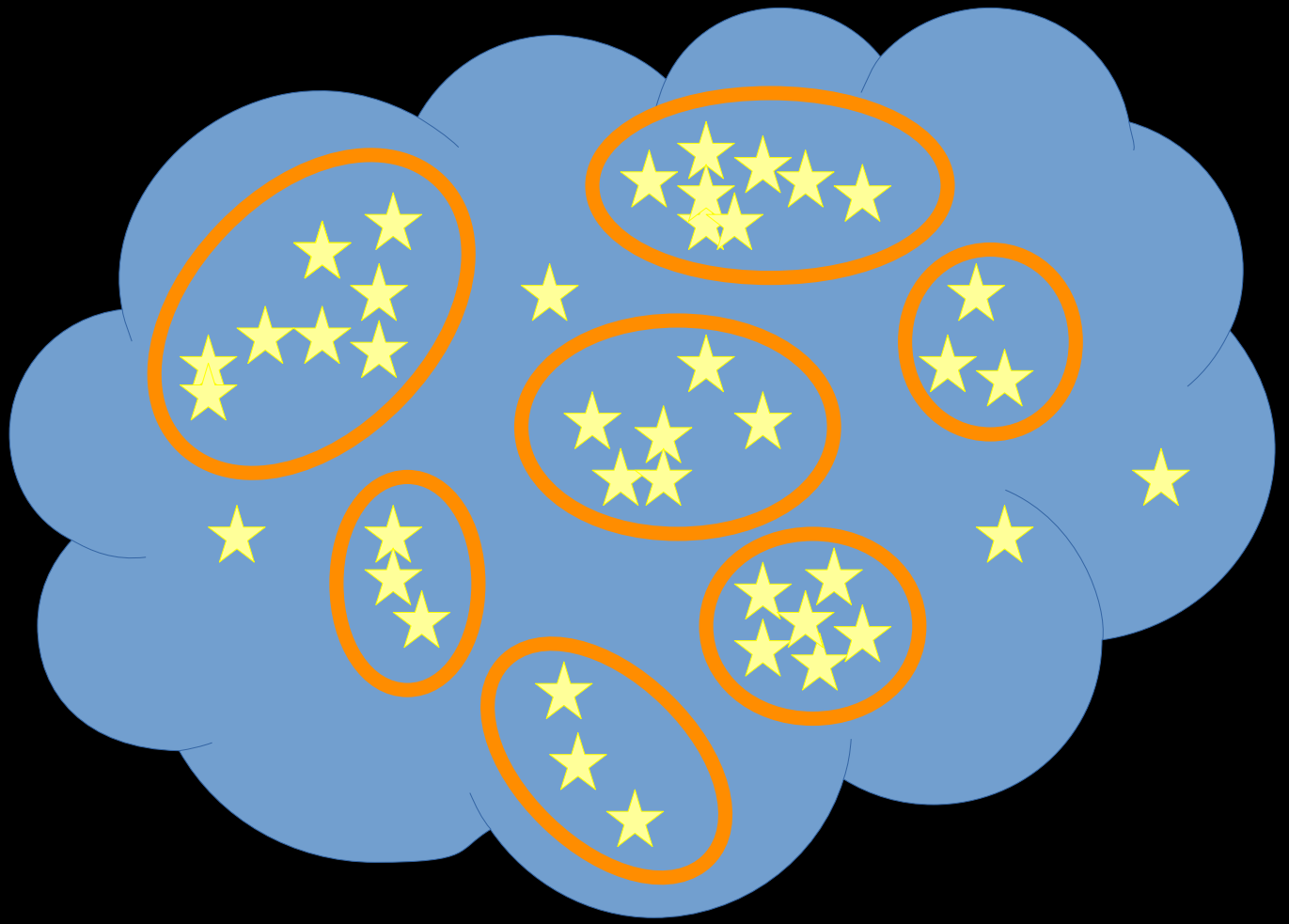


Fig. 2. Categorization of different clustering methods and algorithms

Neha Soni et al. (2012)

Tracing Substructure

- Clustering algorithms



Tracing Substructure

- ~~Clustering algorithms~~

Not enough quantitative information!

Tracing Substructure??

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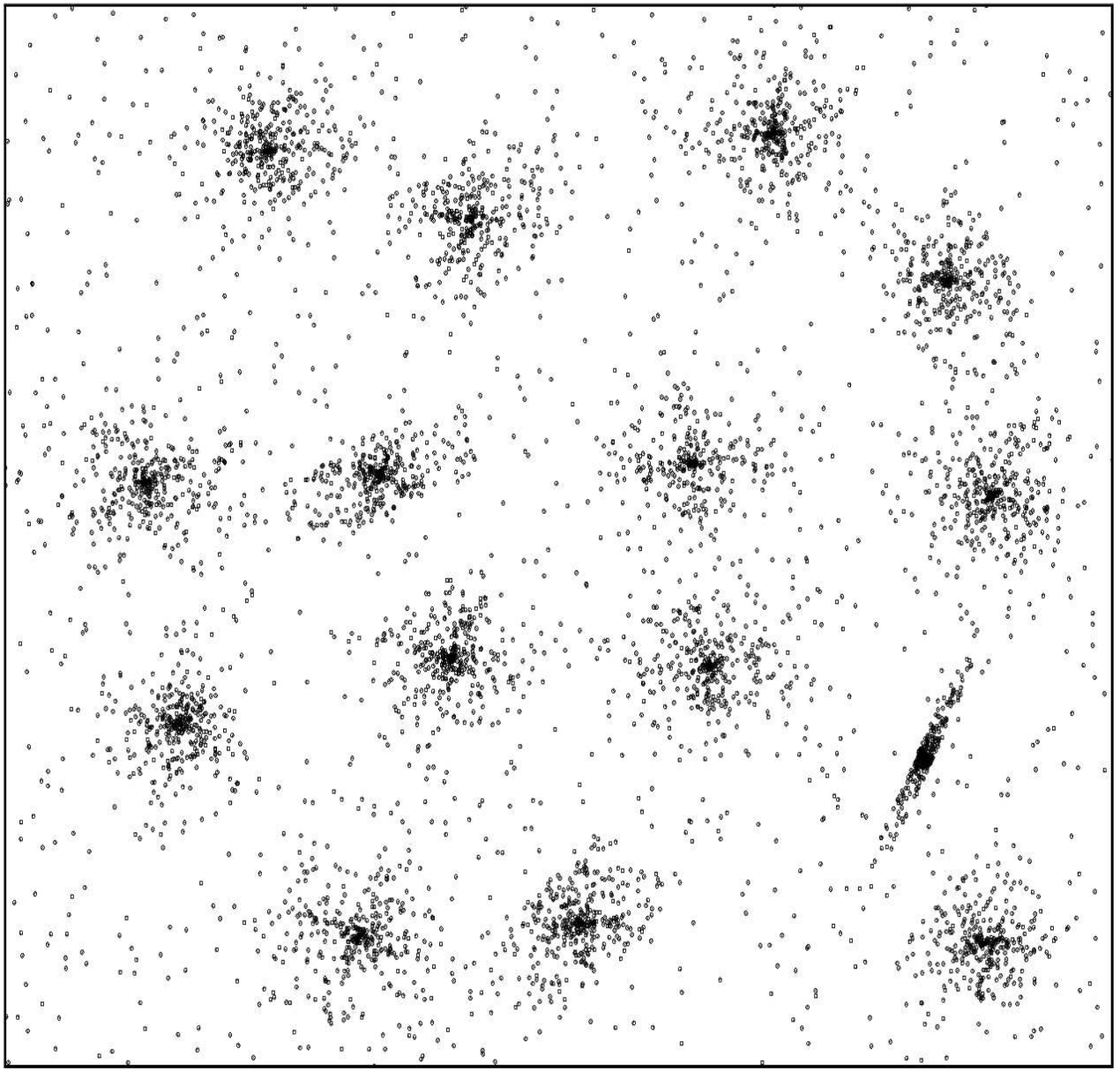
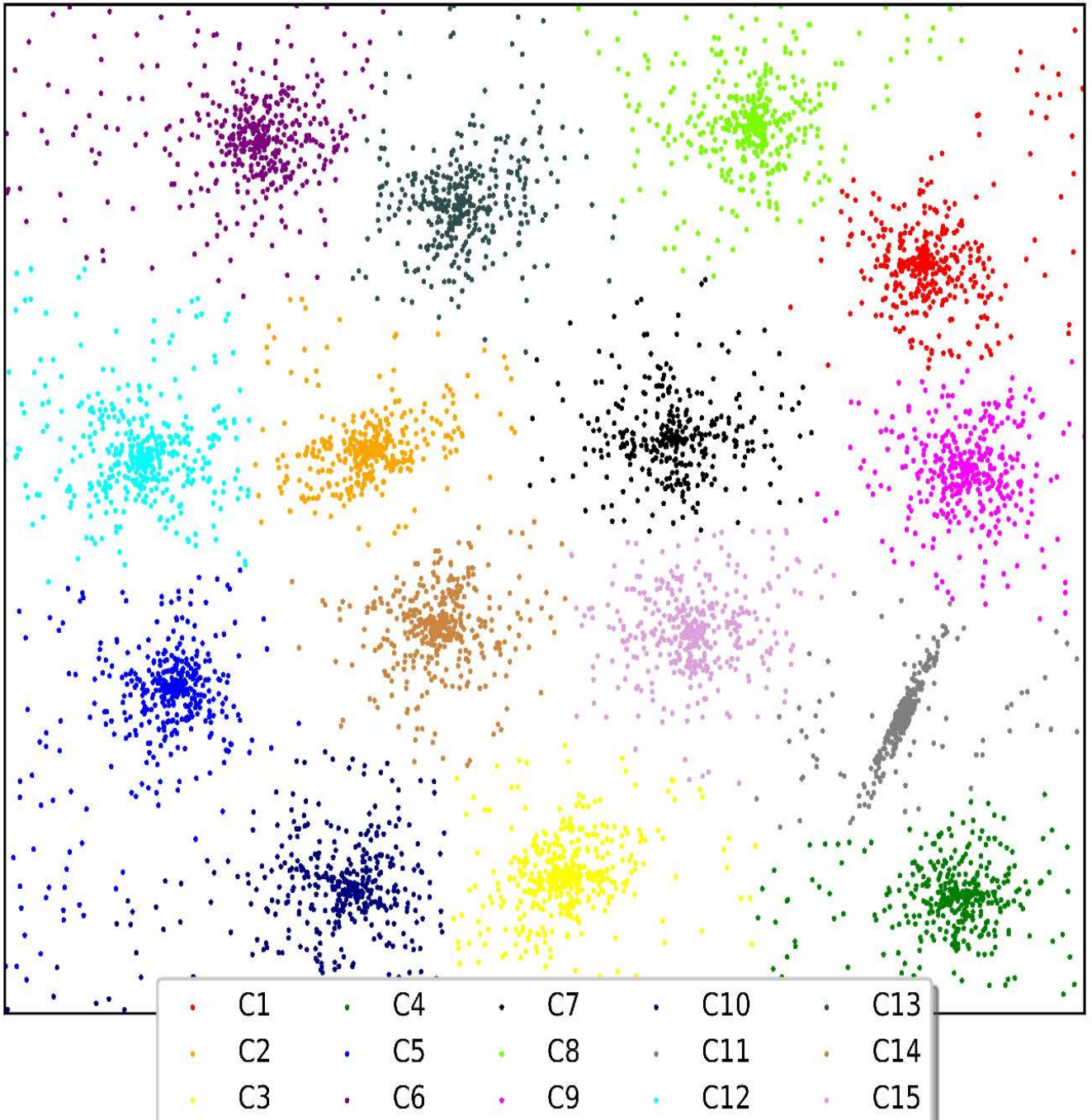
- Higher index → star is more clustered



Clustering Algorithms
(example: k-means)



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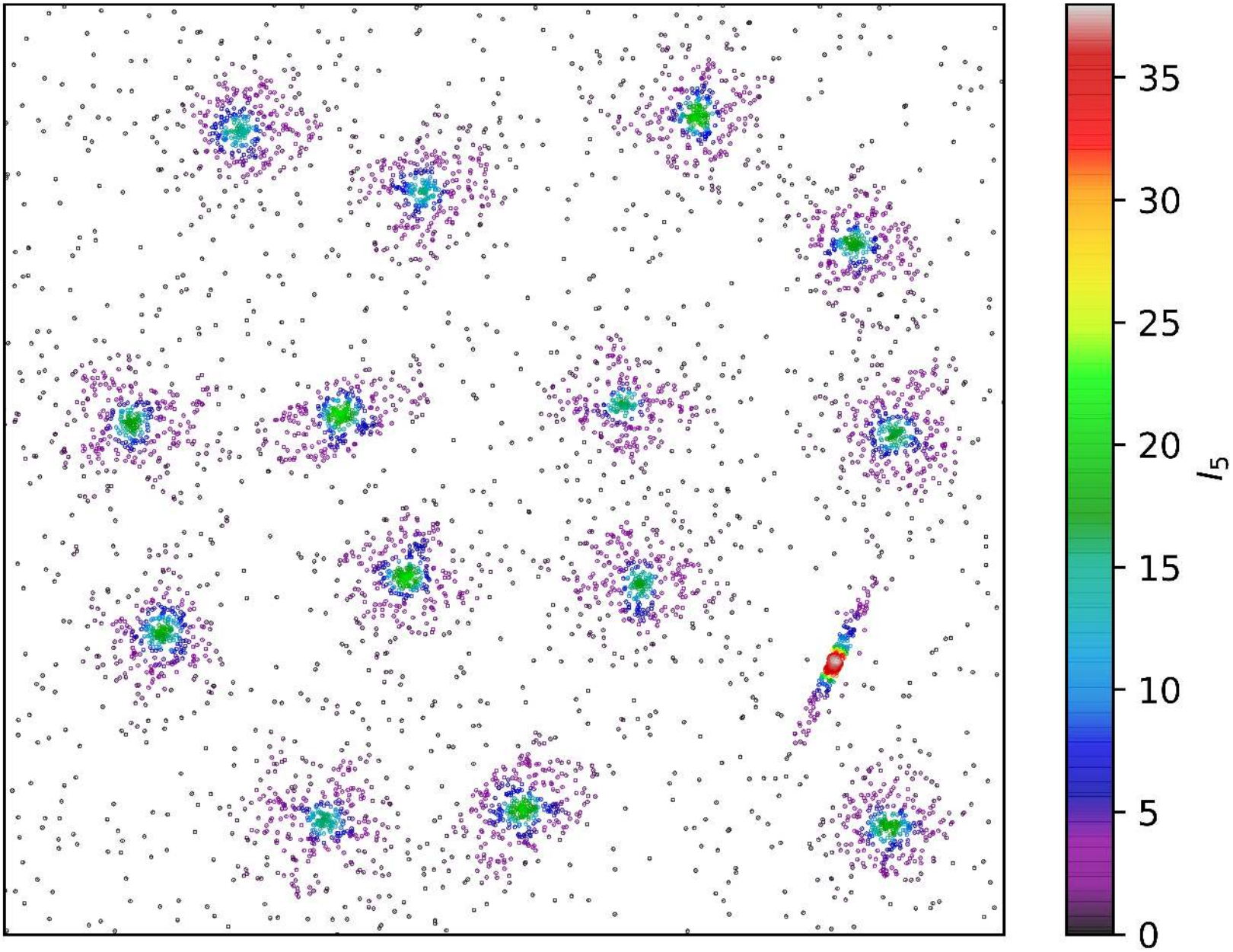


Let's do some...

Science!

Carina Nebula

a.k.a NGC3372

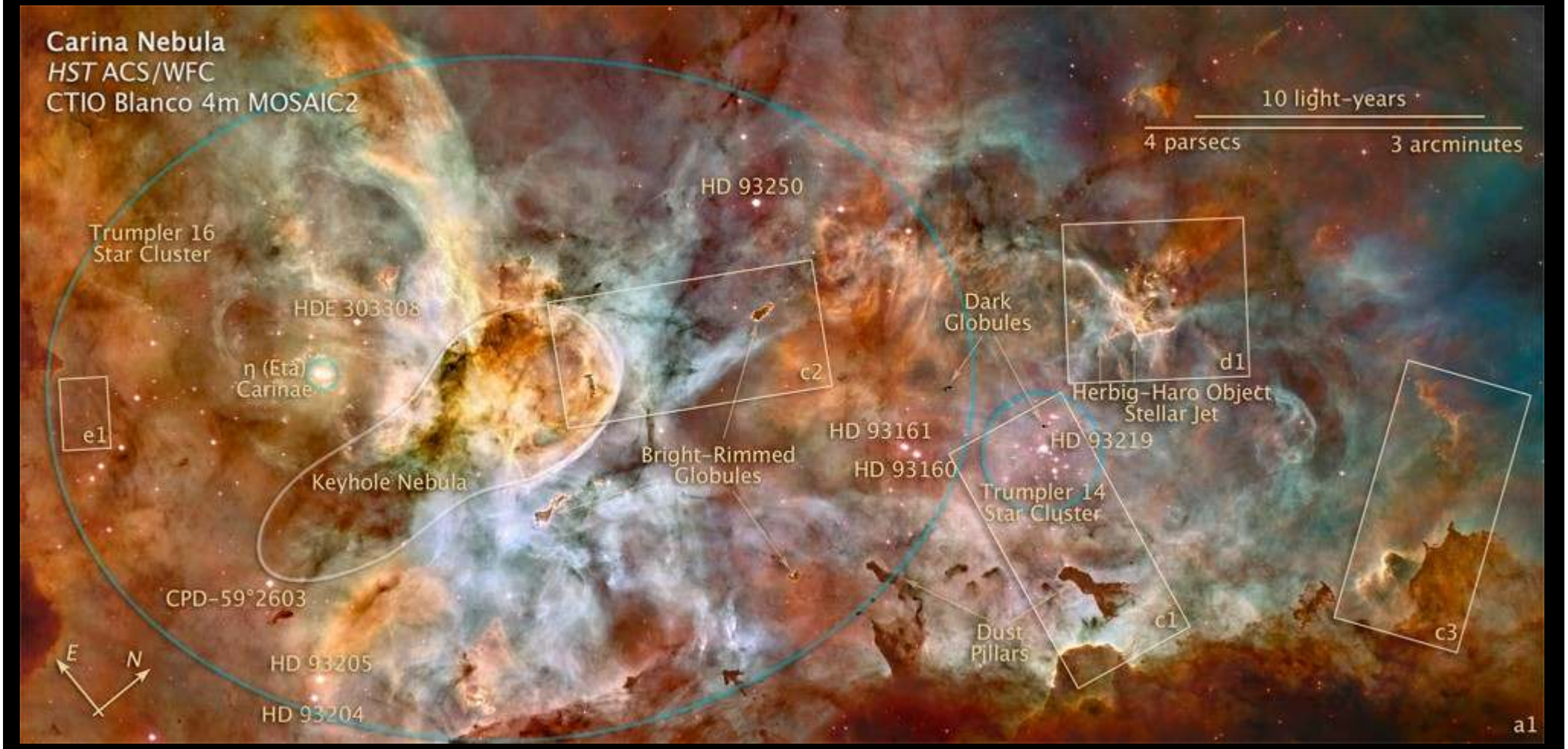
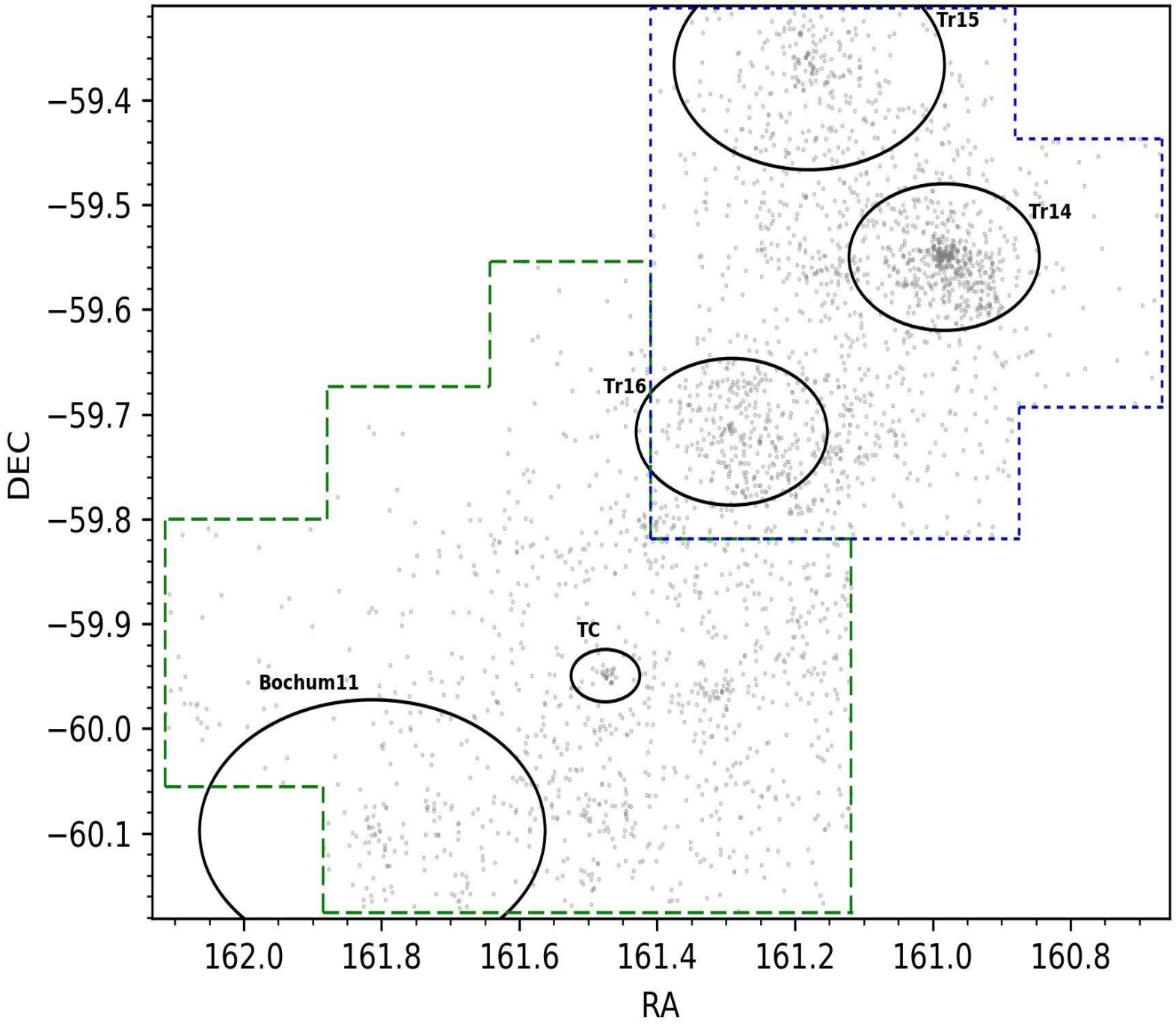
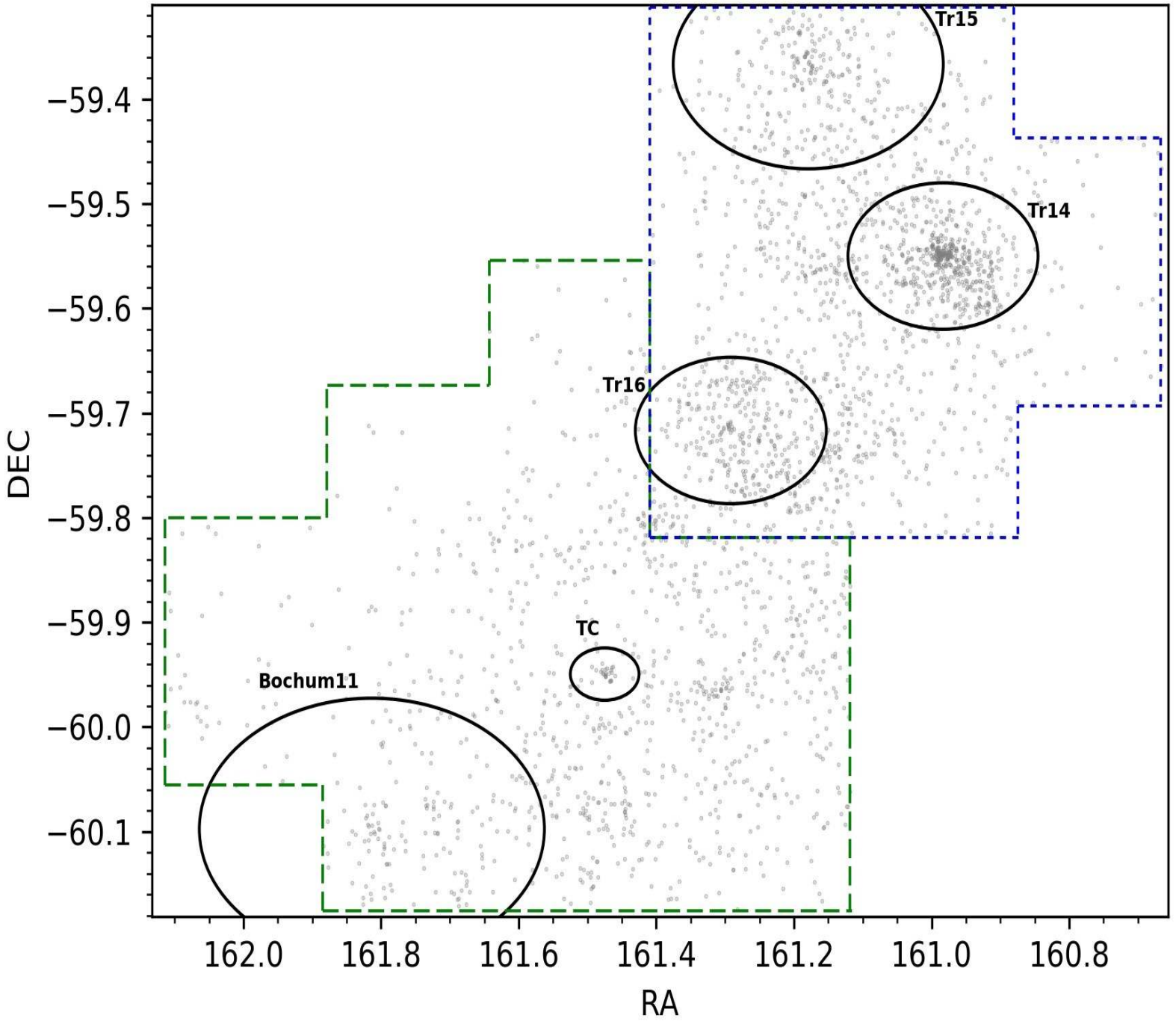


Image: Hubble Heritage



Buckner et al. (in review)

Q. How does the degree of clustering of stars vary across the region?



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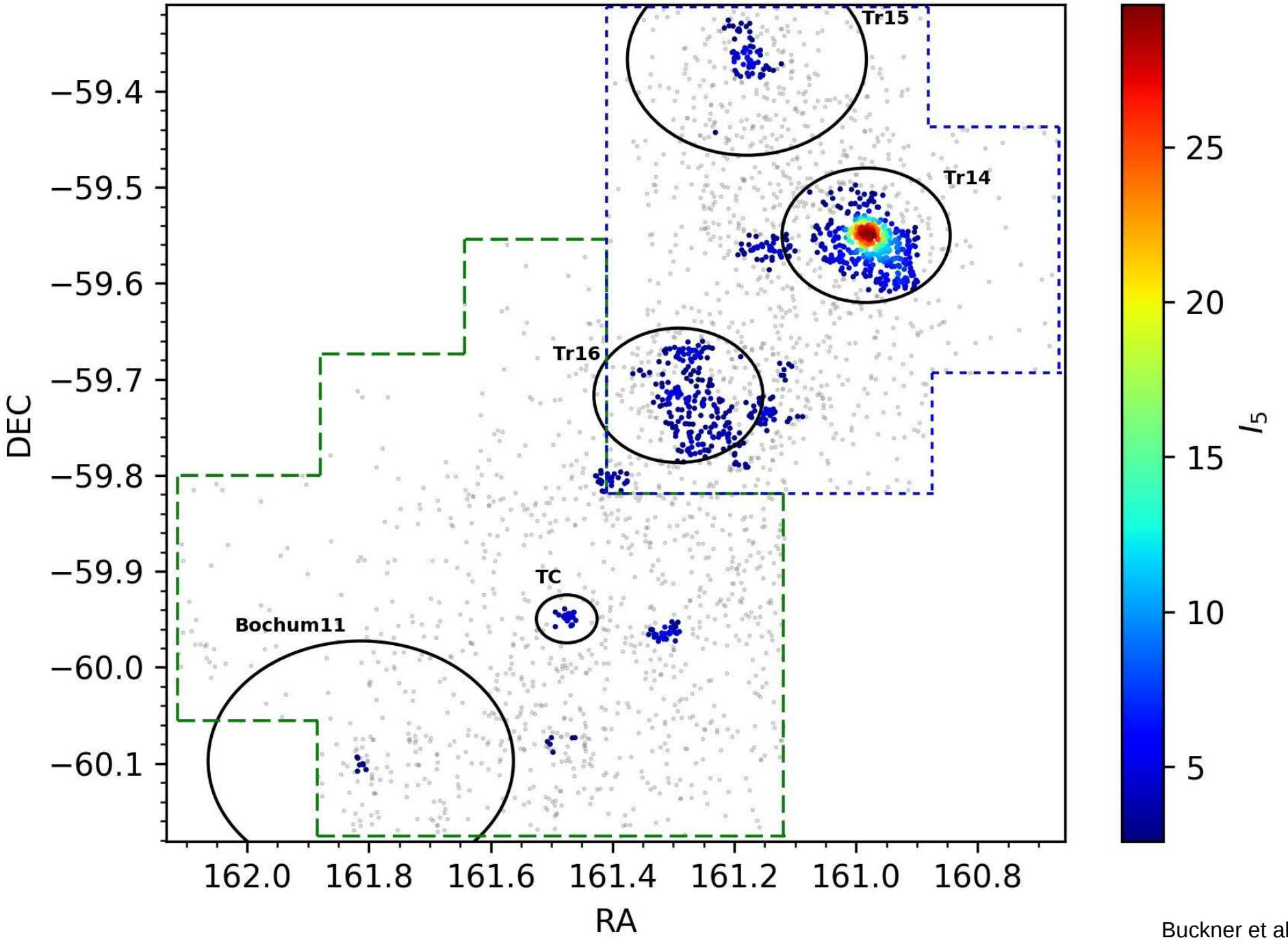

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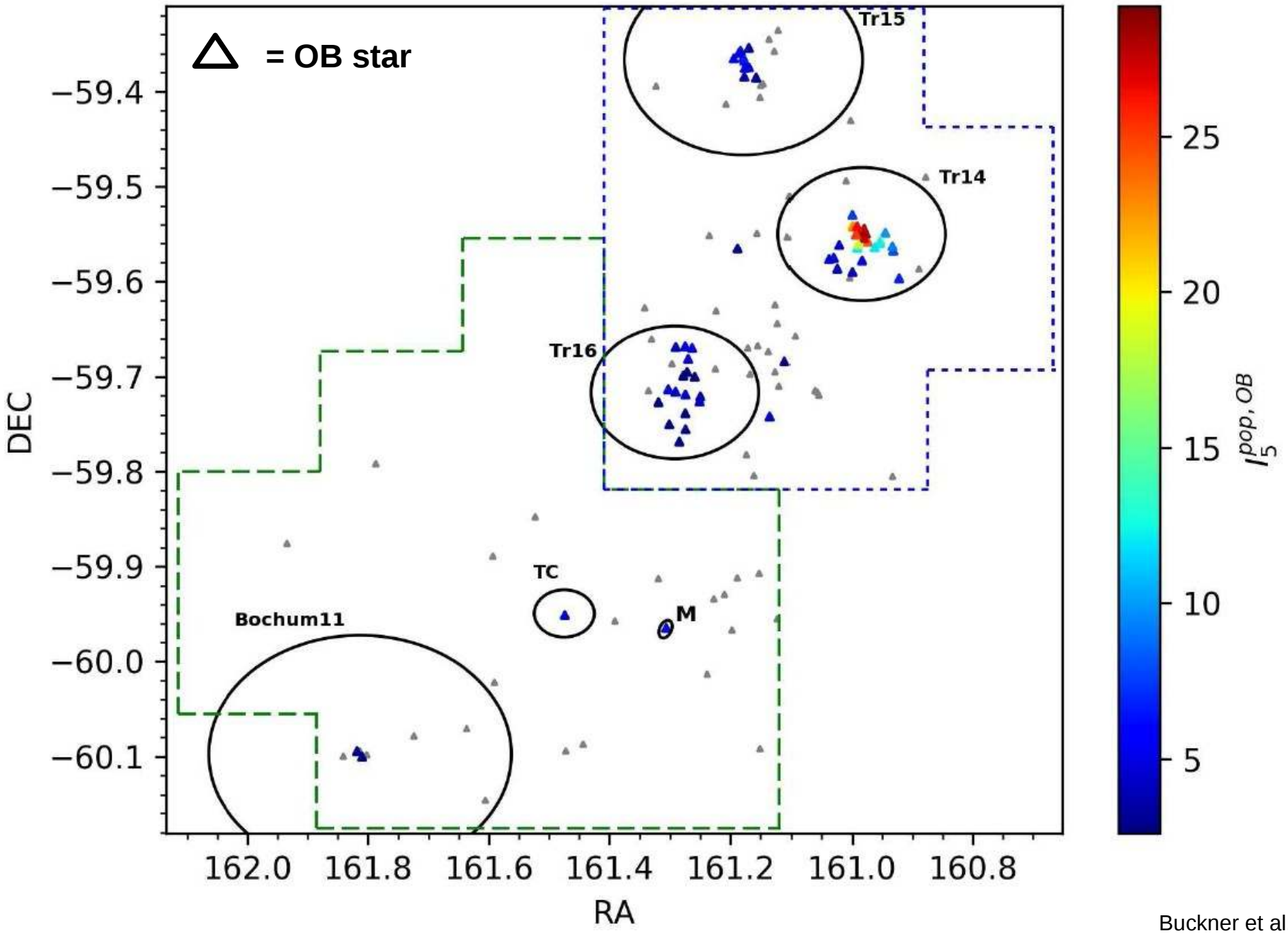

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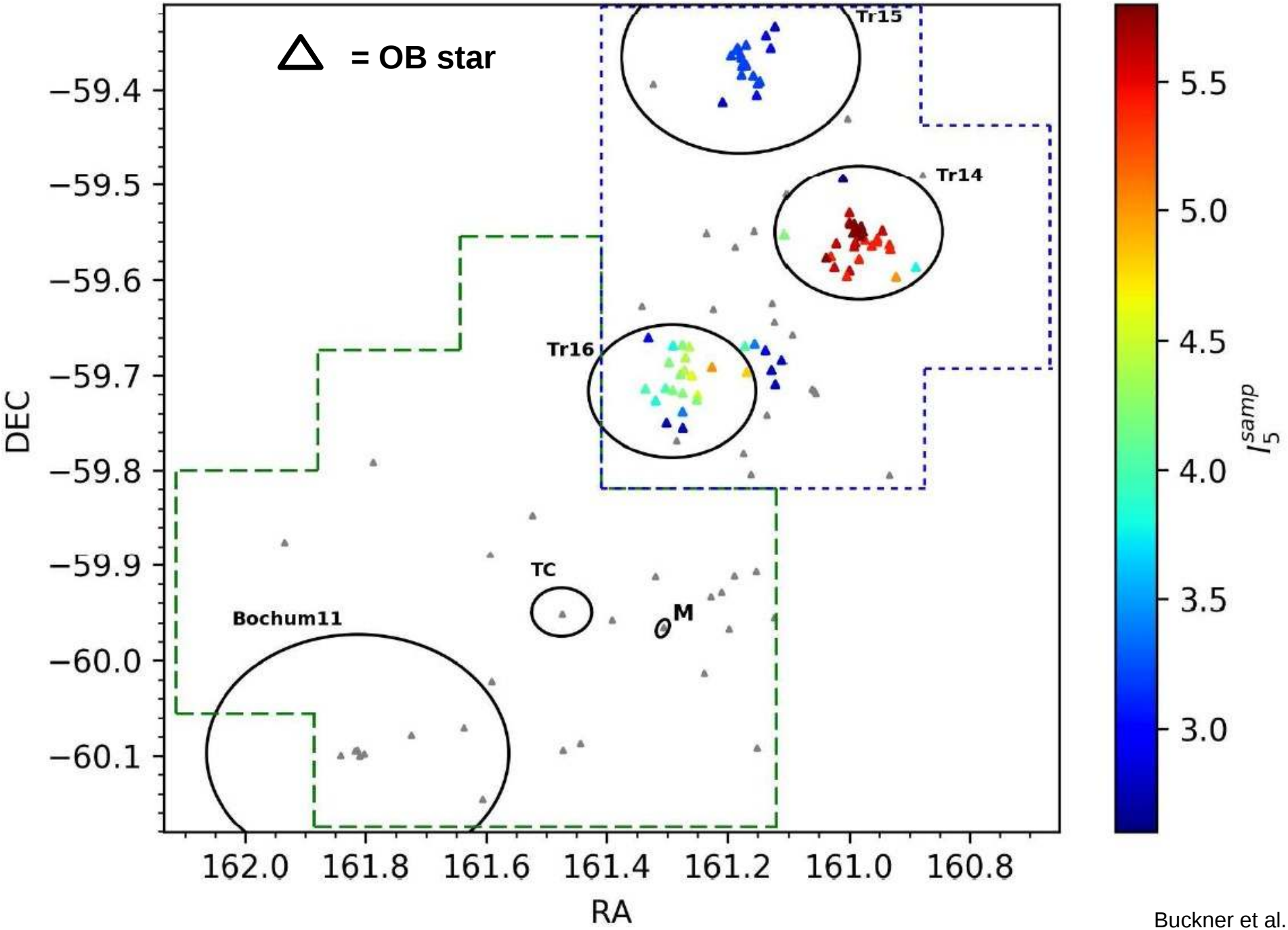

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(3) Stellar concentrations are more frequent around massive stars than typical for the general population

(4) No primordial signatures of mass segregation in the SE region


MAY THE
FOURTH
BE WITH YOU

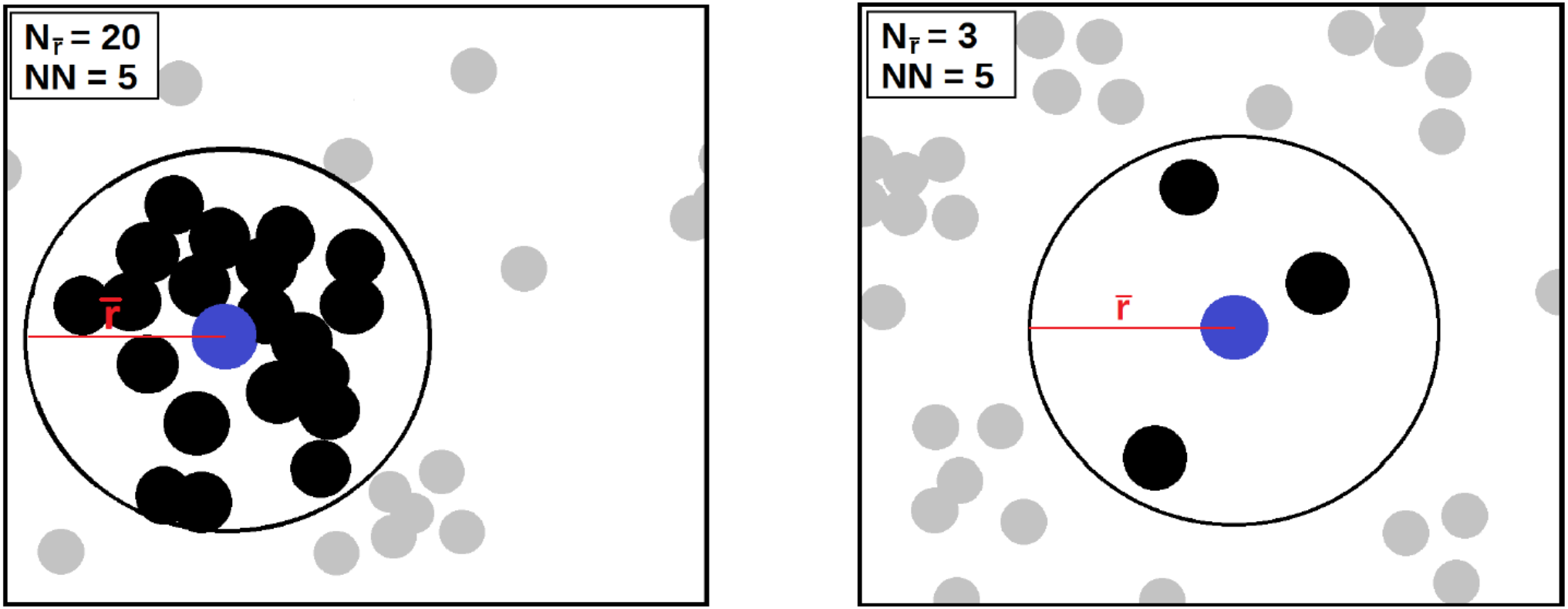

Fig. 1. Demonstration of how INDICATE defines the index, $I_{j,NN}$, for a point. All points within a radius of $\bar{r}$ of the selected point (marked in blue) are counted ($N_{\bar{r}}$) and compared to the number of points expected within the same radius in an evenly spaced uniform distribution with the same number density as the points parent sample (NN). The index of the blue point is calculated using Eq. 8 as (Left:) $I_5 = 4.0$ and (Right:) $I_5 = 0.6$.

$$I_{j,NN} = \frac{N_{\bar{r}}}{NN}$$