

3D dust map of the Orion-Eridanus superbubble with Gaia DR2

Sara Rezaei Kh.

Chalmers (Sweden) – MPIA (Heidelberg)

Coryn Bailer-Jones, Juan D. Soler
MPIA (Heidelberg)

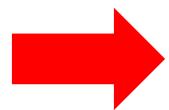
DUST
IT'S WHAT GIVES A
HOME A WARM AND
FUZZY FEELING

Extinction and Dust density

2D vs. 3D

Extinction and Dust density

2D vs. 3D



Individual lines of sight

Extinction and Dust density

2D vs. 3D



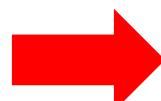
Individual lines of sight



Individual lines of sight + smoothing kernels

Extinction and Dust density

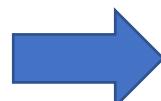
2D vs. 3D



Individual lines of sight



Individual lines of sight + smoothing kernels



Full 3D inference (neighbouring correlation)

Our 3D dust map

- Input: distances and extinction to stars
- 3D neighbouring correlation
- Distance and extinction uncertainty

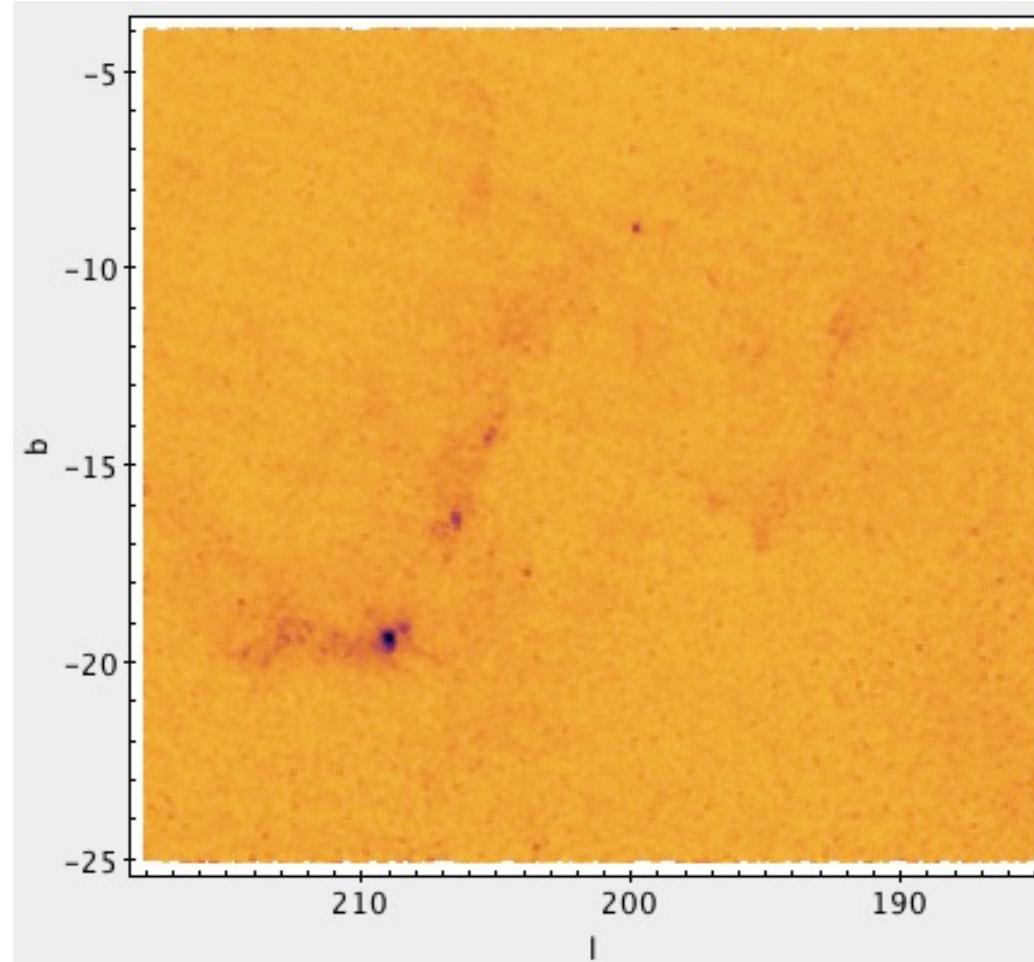
Our 3D dust map

- Input: distances and extinction to stars
- 3D neighbouring correlation
- Distance and extinction uncertainty

Gaia DR2

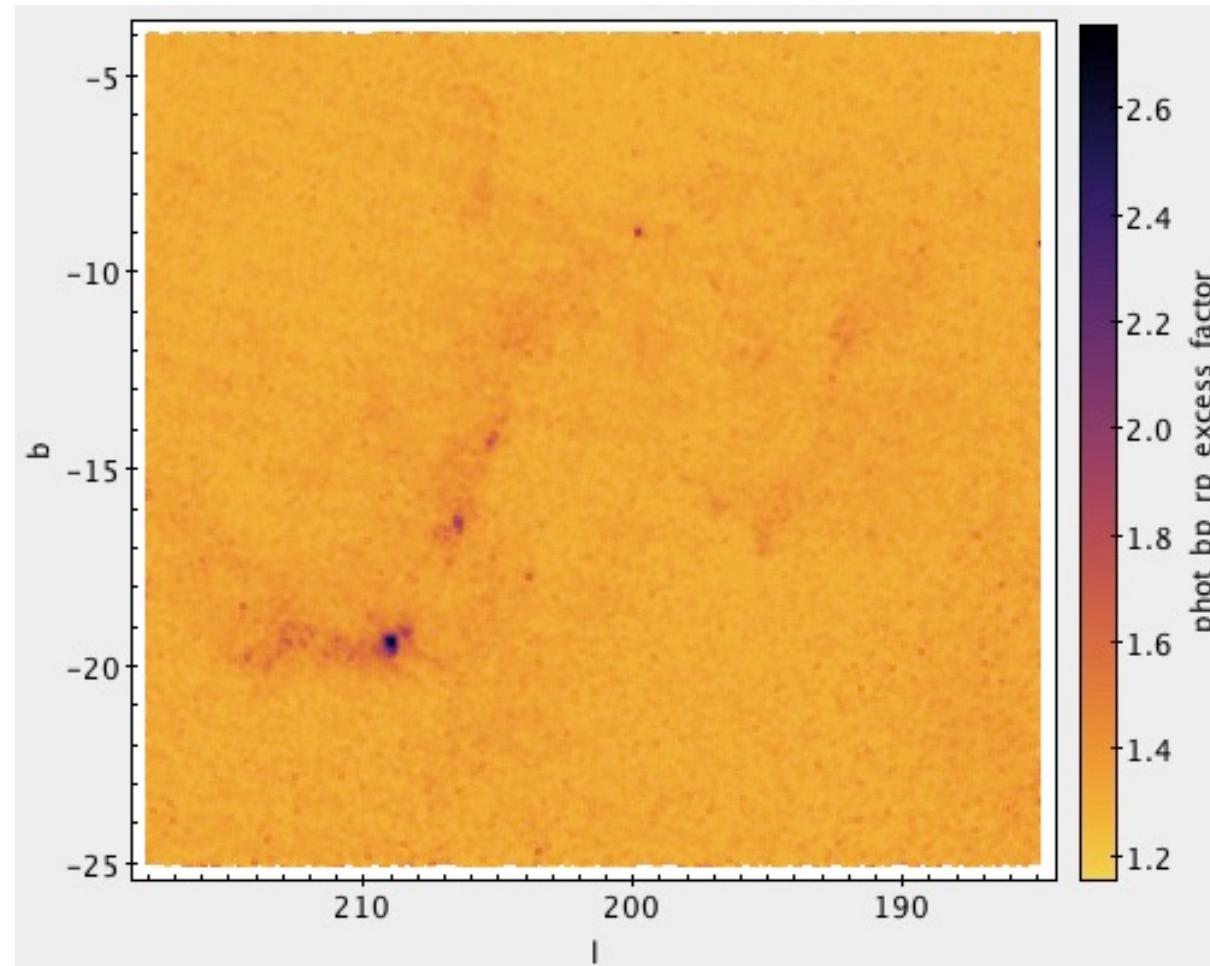
Data quality cut?

Data quality cut?



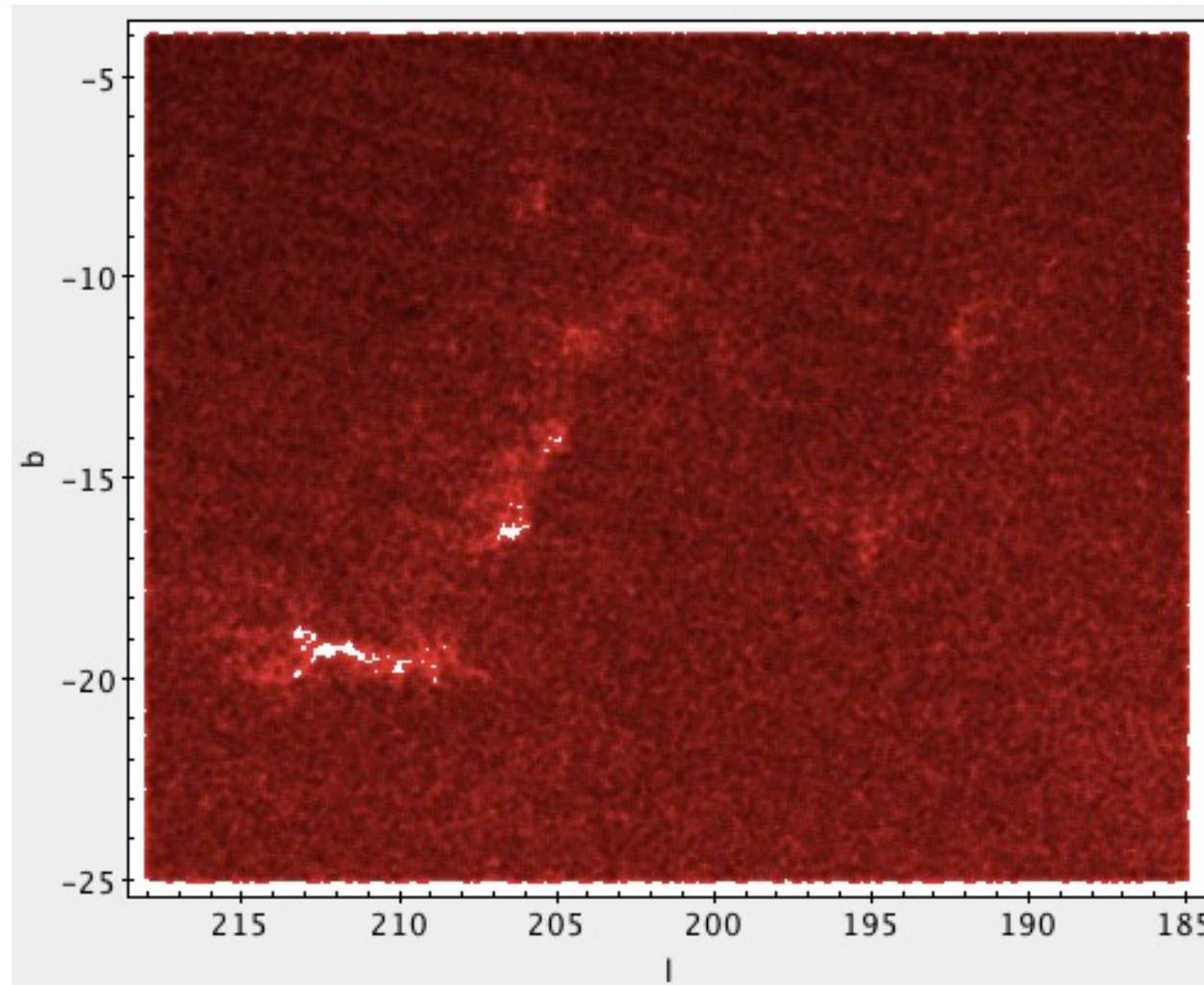
Data quality cut?

Photometric excess factor

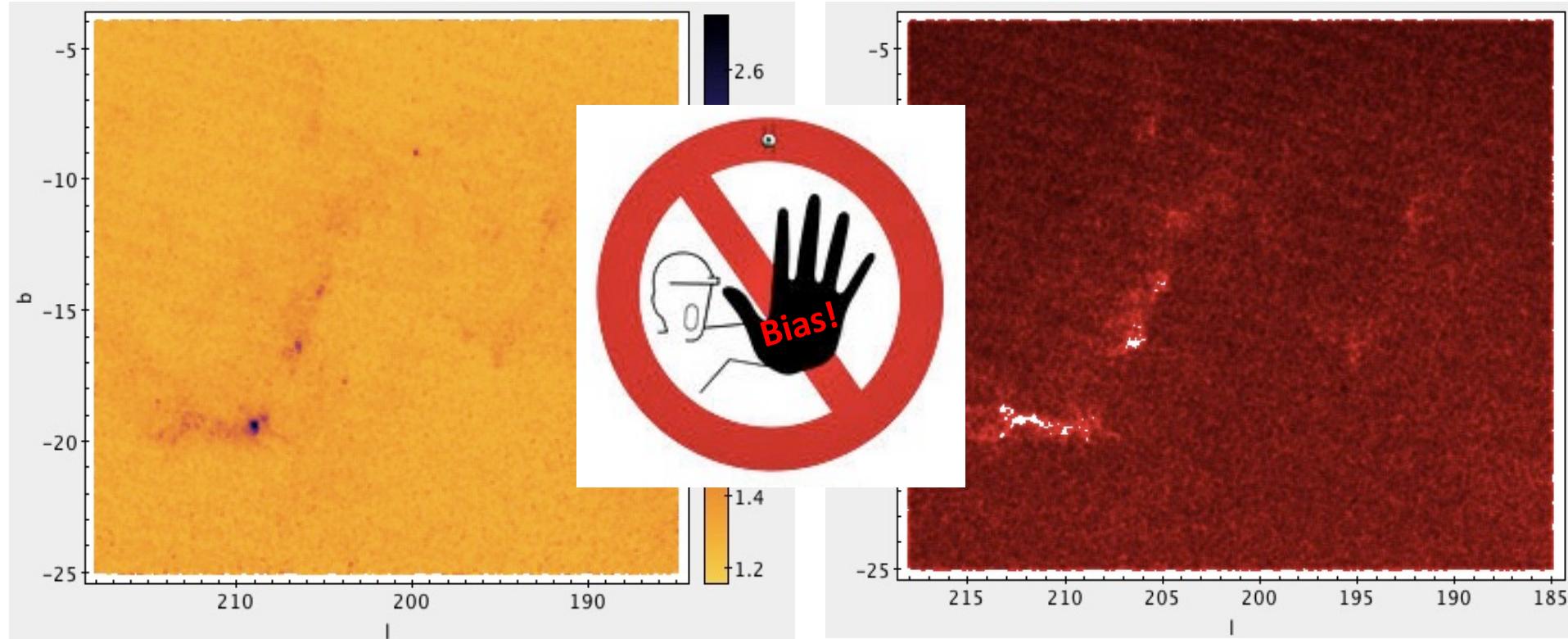


Data quality cut?

Parallax_over_error < 0.2
Distance > 500 pc



Data quality cut?



Our 3D dust map

- Input: distances and extinction to stars
- 3D neighbouring correlation
- ✓ • Distance and extinction uncertainty



Robust 3D dust map
without artefact

Our 3D dust map

- Input: distances and extinction to stars
- 3D neighbouring correlation
- Distance and extinction uncertainty



Robust 3D dust map
without artefact

Distance to and structures of the
molecular clouds; e.g. Orion

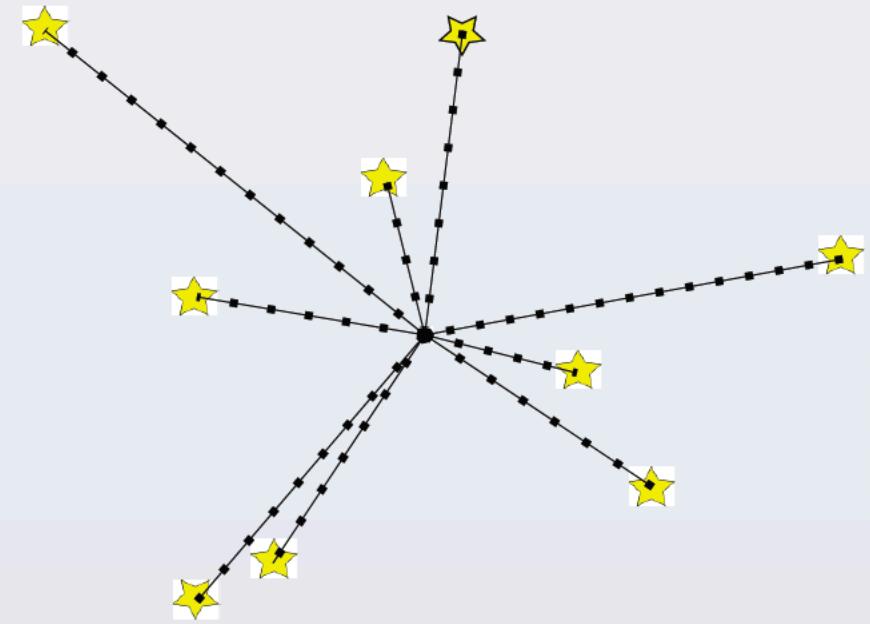
Method

Method

Likelihood

Input: distances and extinctions to individual stars

- Divides each line of sight to small 1D cells



Method

Likelihood

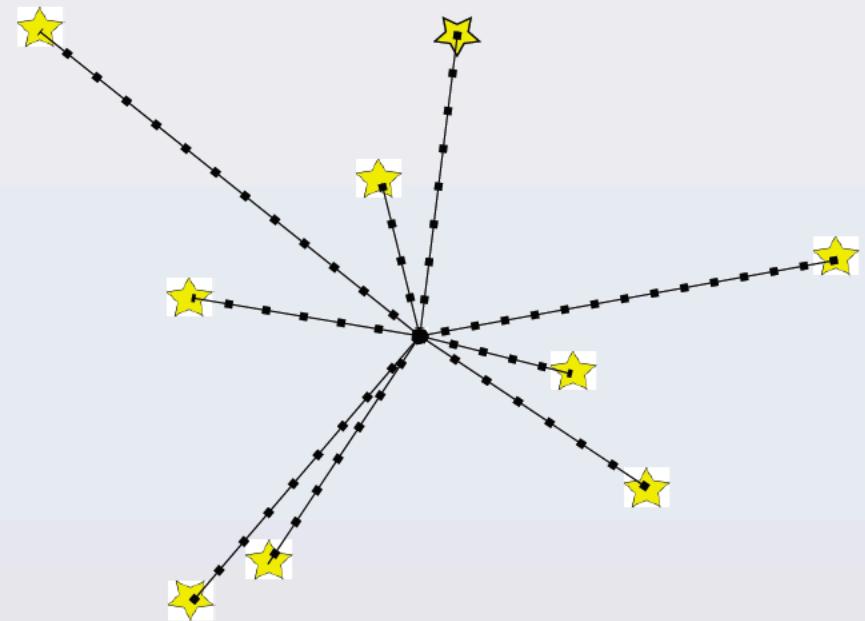
Input: distances and extinctions to individual stars

- Divides each line of sight to small 1D cells

A_n : extinction to star n

$g_{n,j}$: length of the cell j to the star n

$\rho_{n,j}$: density in the corresponding cell



$$A_n \propto \sum_j g_{n,j} \rho_{n,j}$$

Gaussian Process Prior

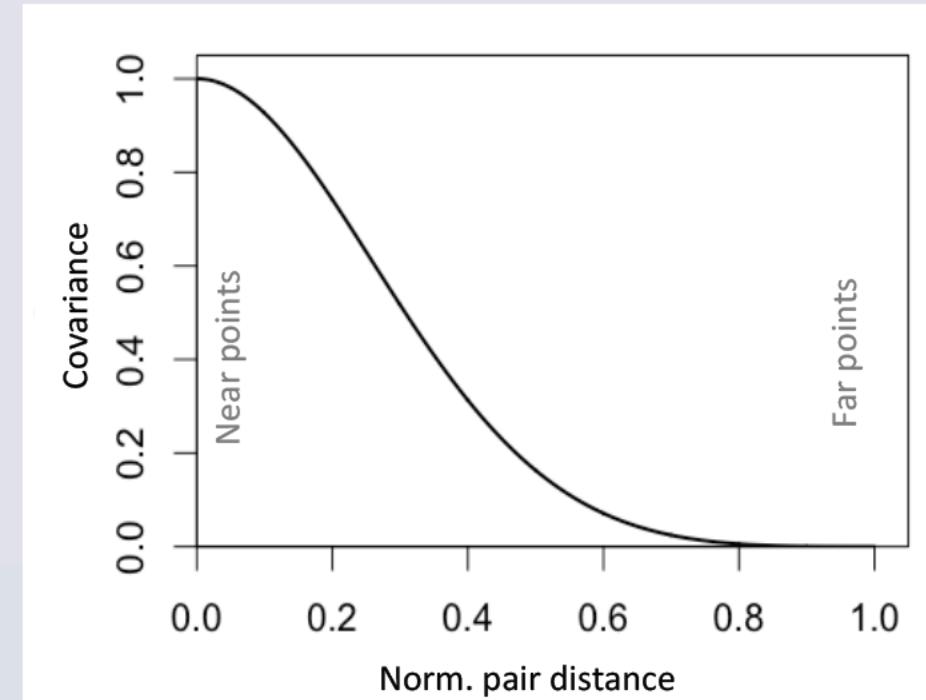
Connects all cells in 3D space

3D spatial correlation matrix between all cells;
the closer 2 points, the more correlated they are.

Gaussian Process Prior

Connects all cells in 3D space

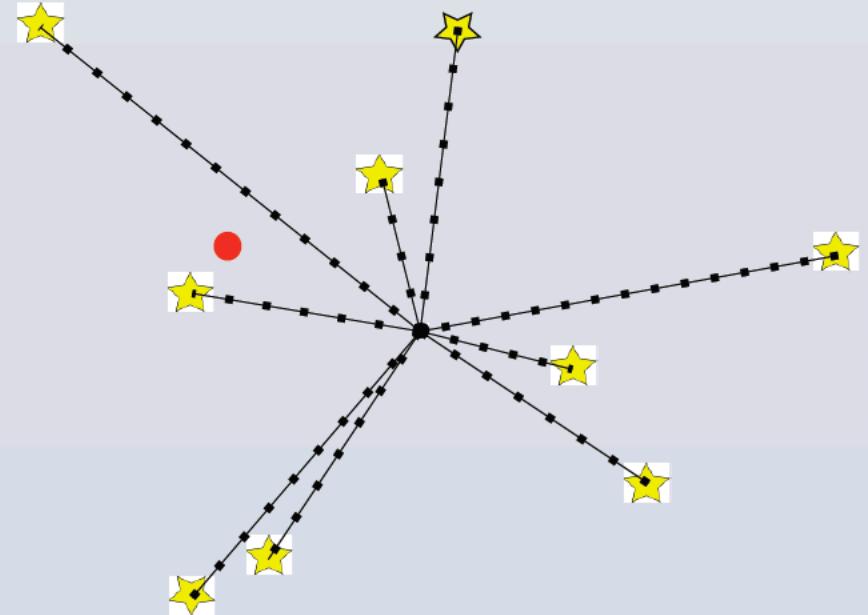
3D spatial correlation matrix between all cells;
the closer 2 points, the more correlated they are.



Posterior PDF

Finds the probability distribution function of the dust density at any arbitrary point; even along the line of sight without primary observation.

Takes into account both distance and extinction uncertainties



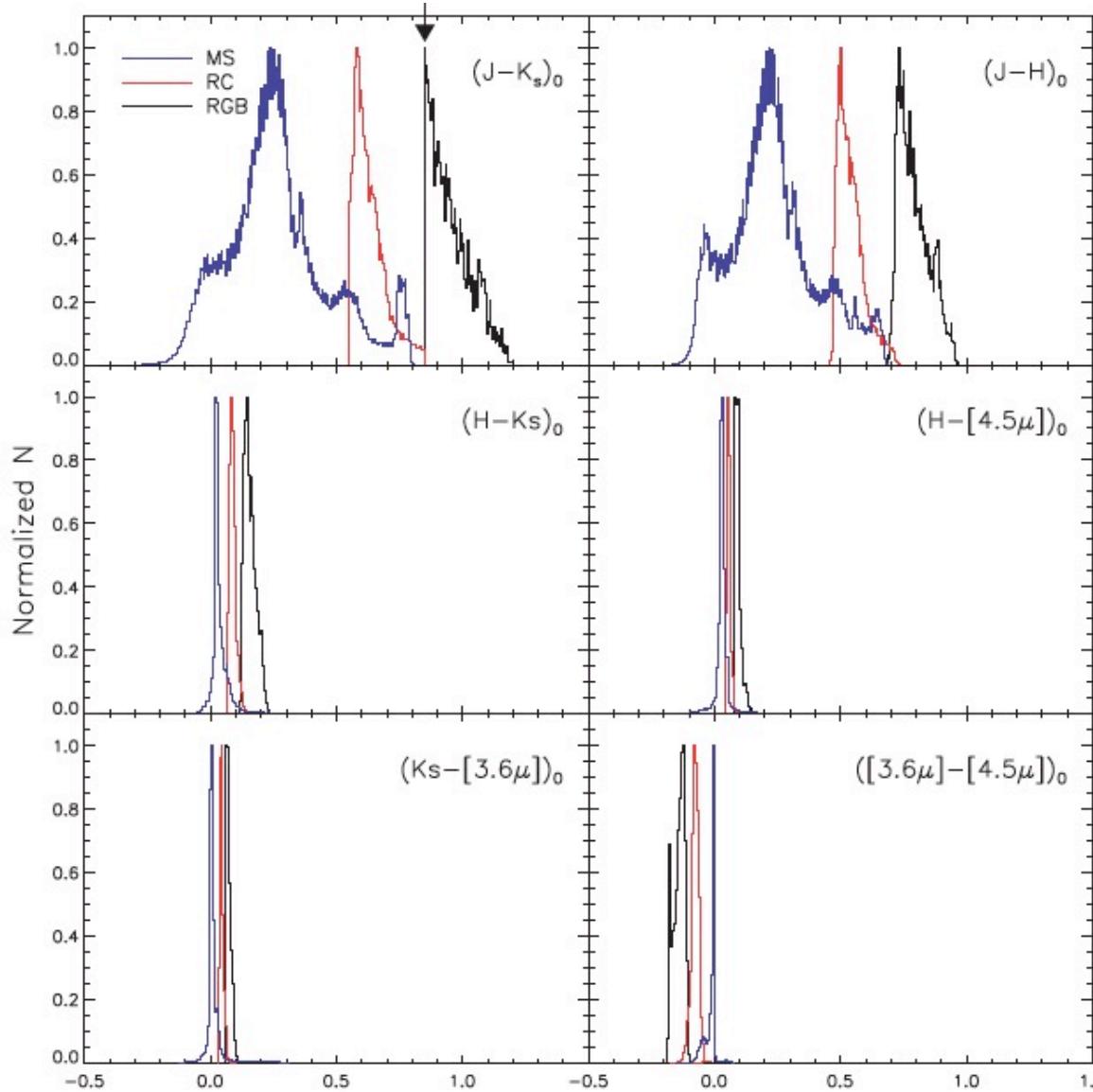
$$P(\rho_{new} \mid \{A_n\})$$

Rezaei Kh. et al. 2017, 2018b

Input data

- Gaia DR2 → 3D position
- 2MASS + WISE → extinction (RJCE, Majewski+2011)

RJCE extinction

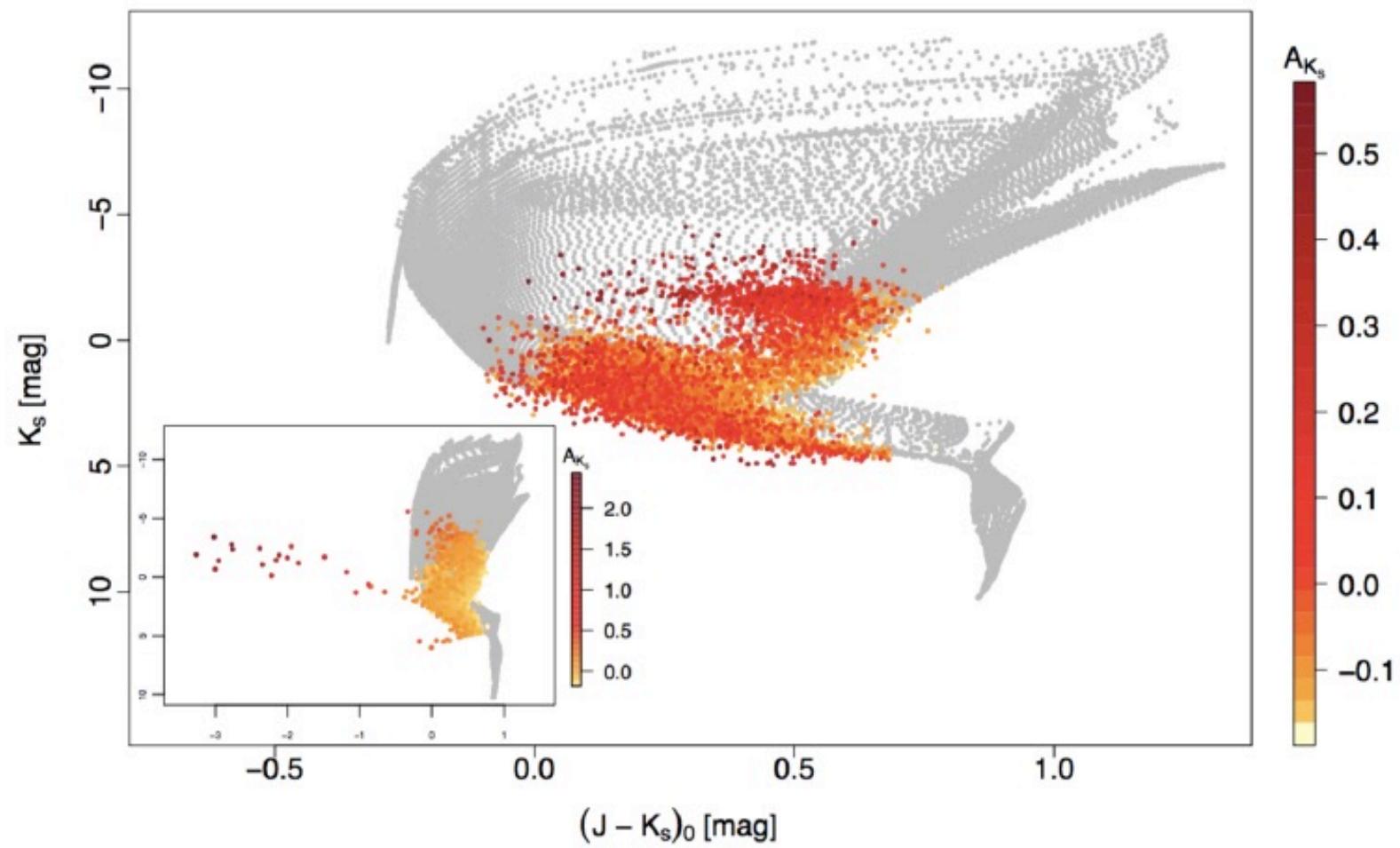


$$A_K = 0.918(H - [4.5\mu] - 0.08)$$

(Majewski et al. 2011)

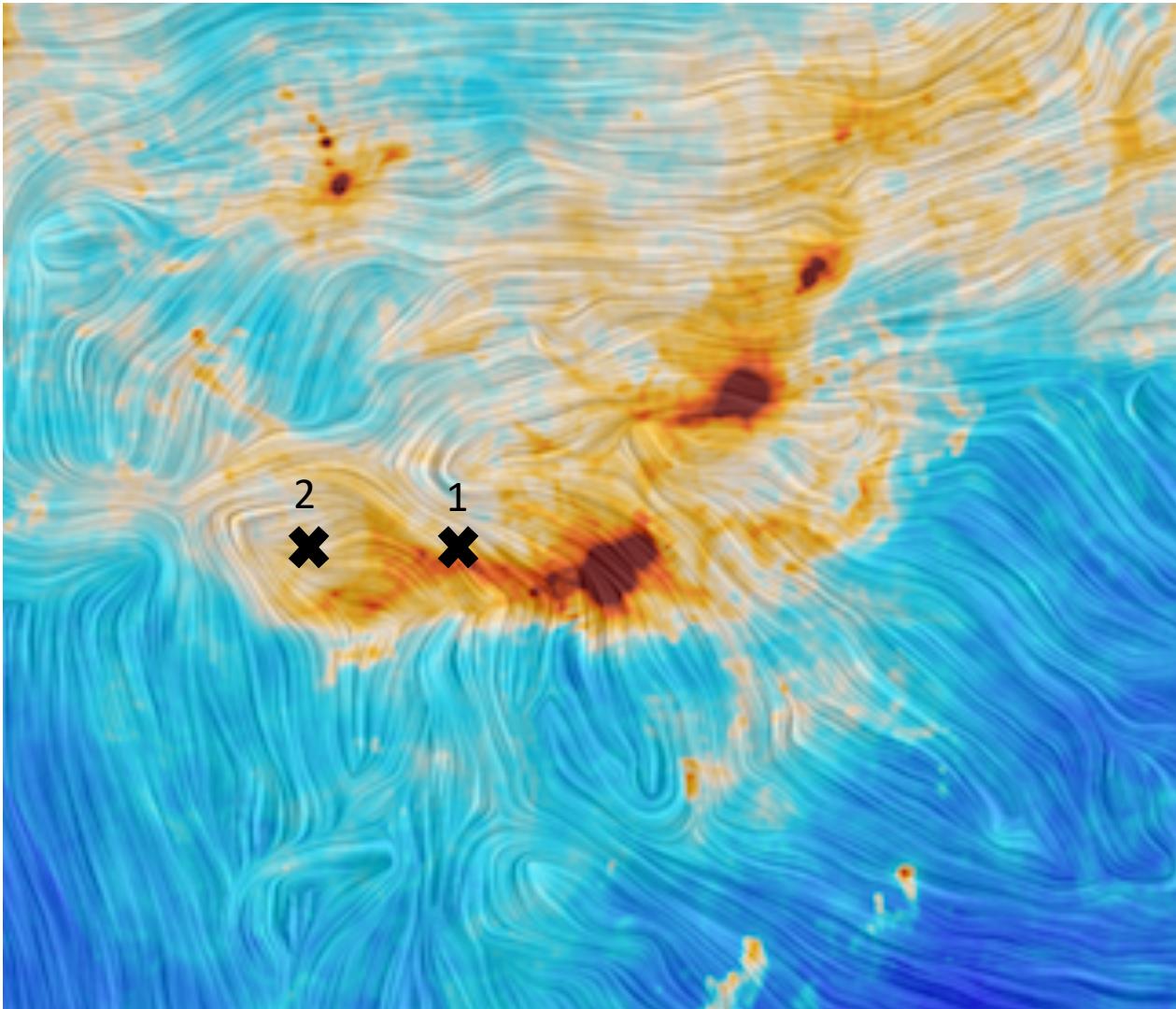
Input data

- Gaia DR2 → 3D position
- 2MASS + WISE → extinction (RJCE, Majewski+2011)
- Final selection on the CMD



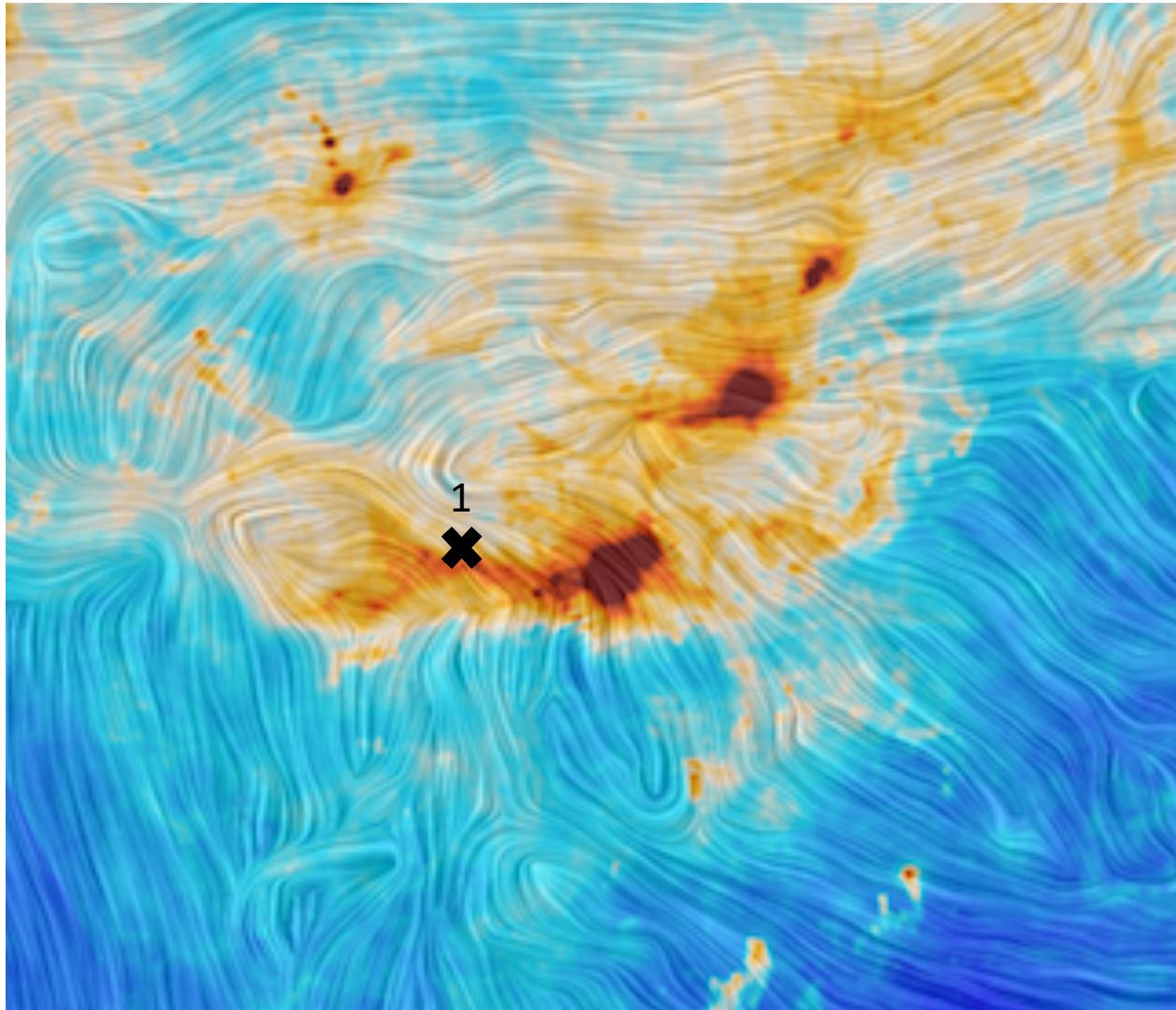
Rezaei Kh. et al. 2018a

Results / Orion



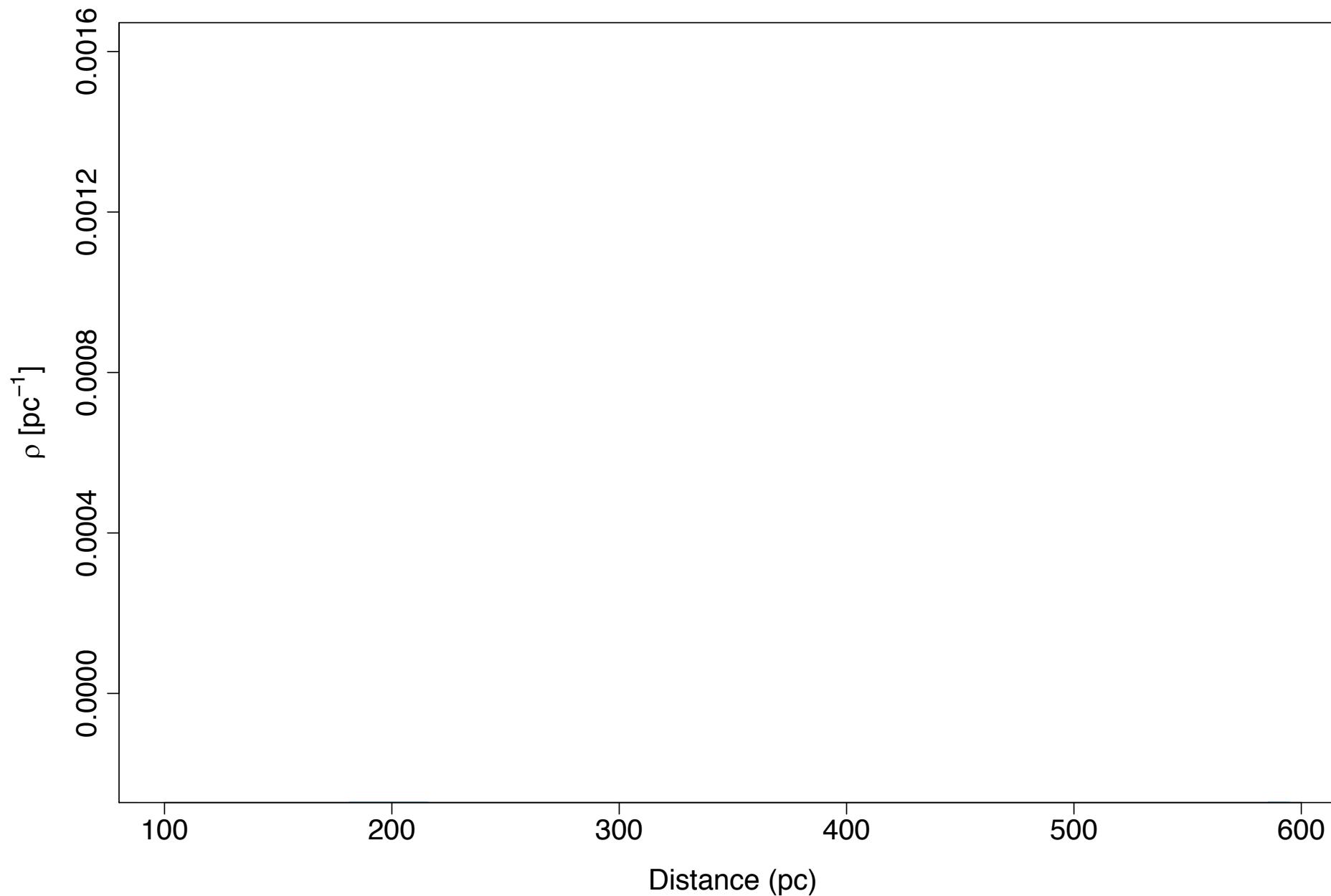
Credit: ESA / Planck collaboration

Results / Orion A

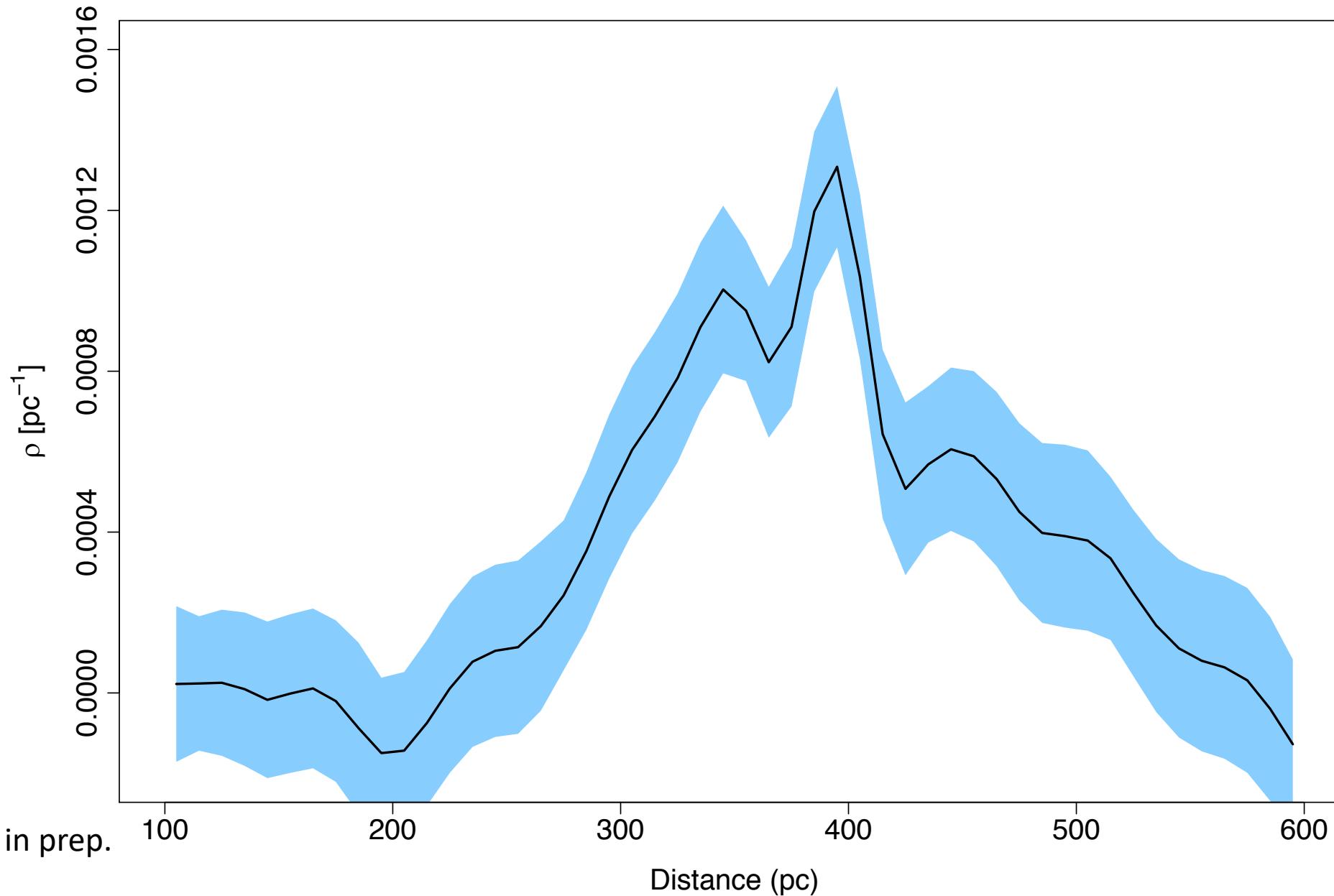


Credit: ESA / Planck collaboration

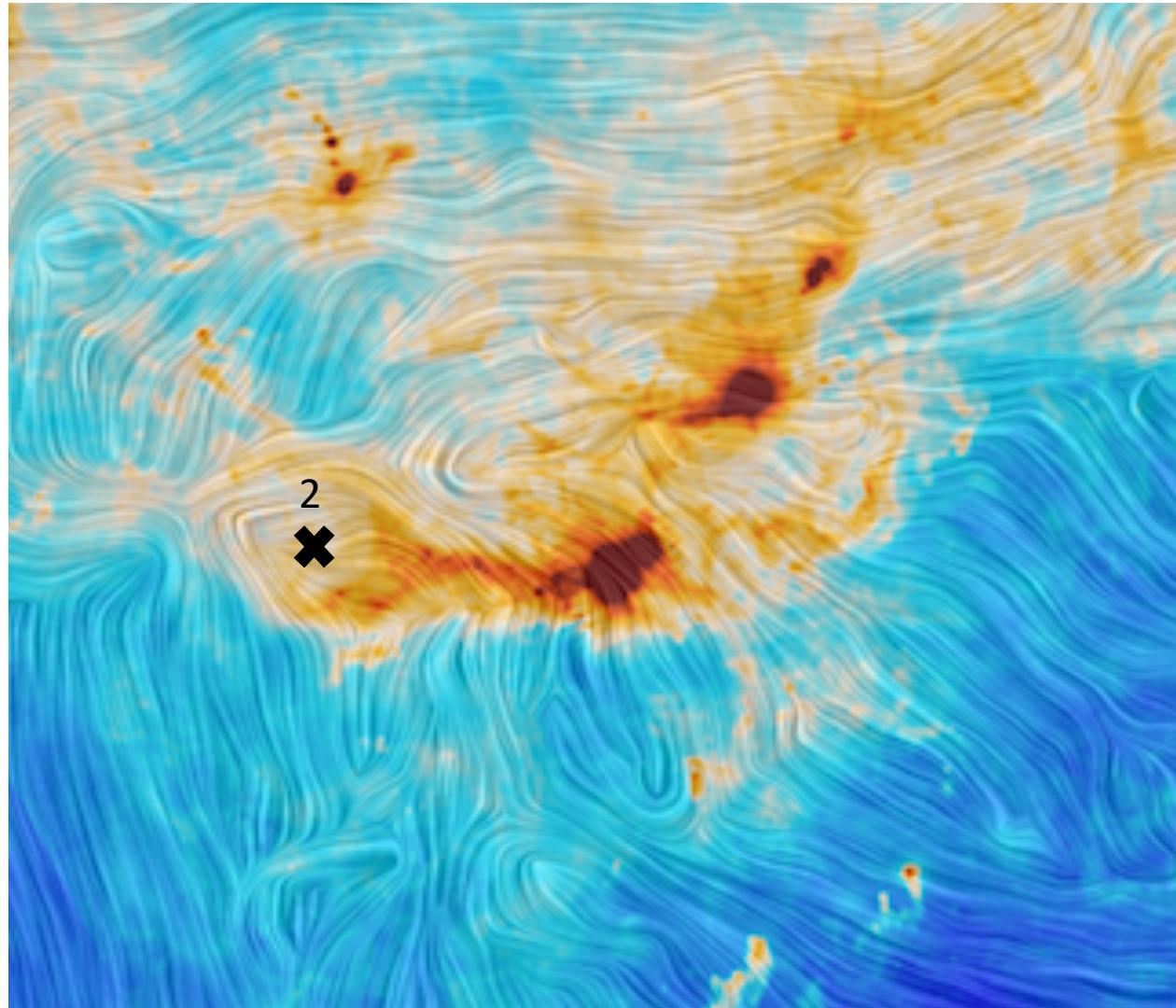
Orion A → (207° , -17°)



Orion A → (207° , -17°)

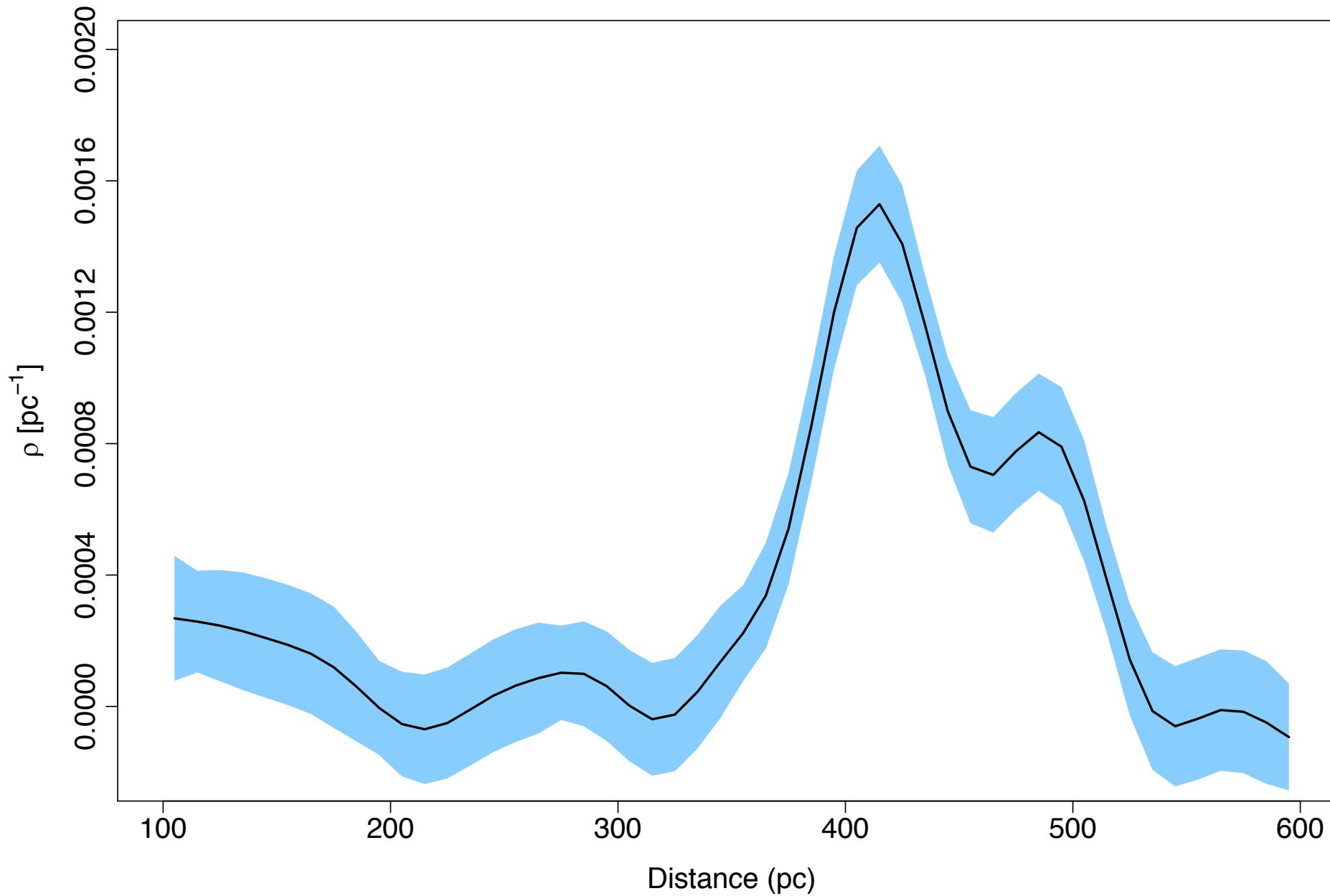


Results / κ Orionis

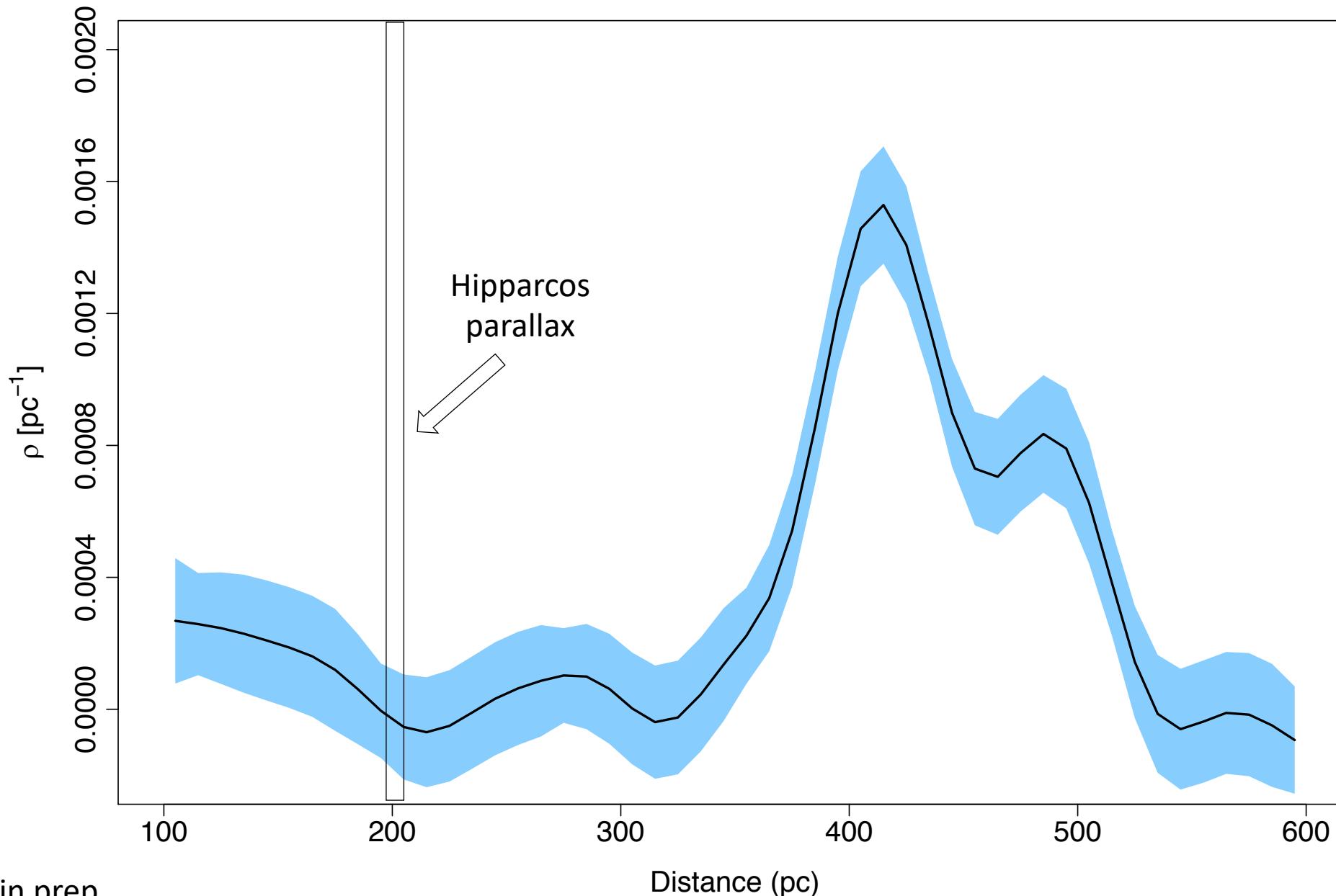


Credit: ESA / Planck collaboration

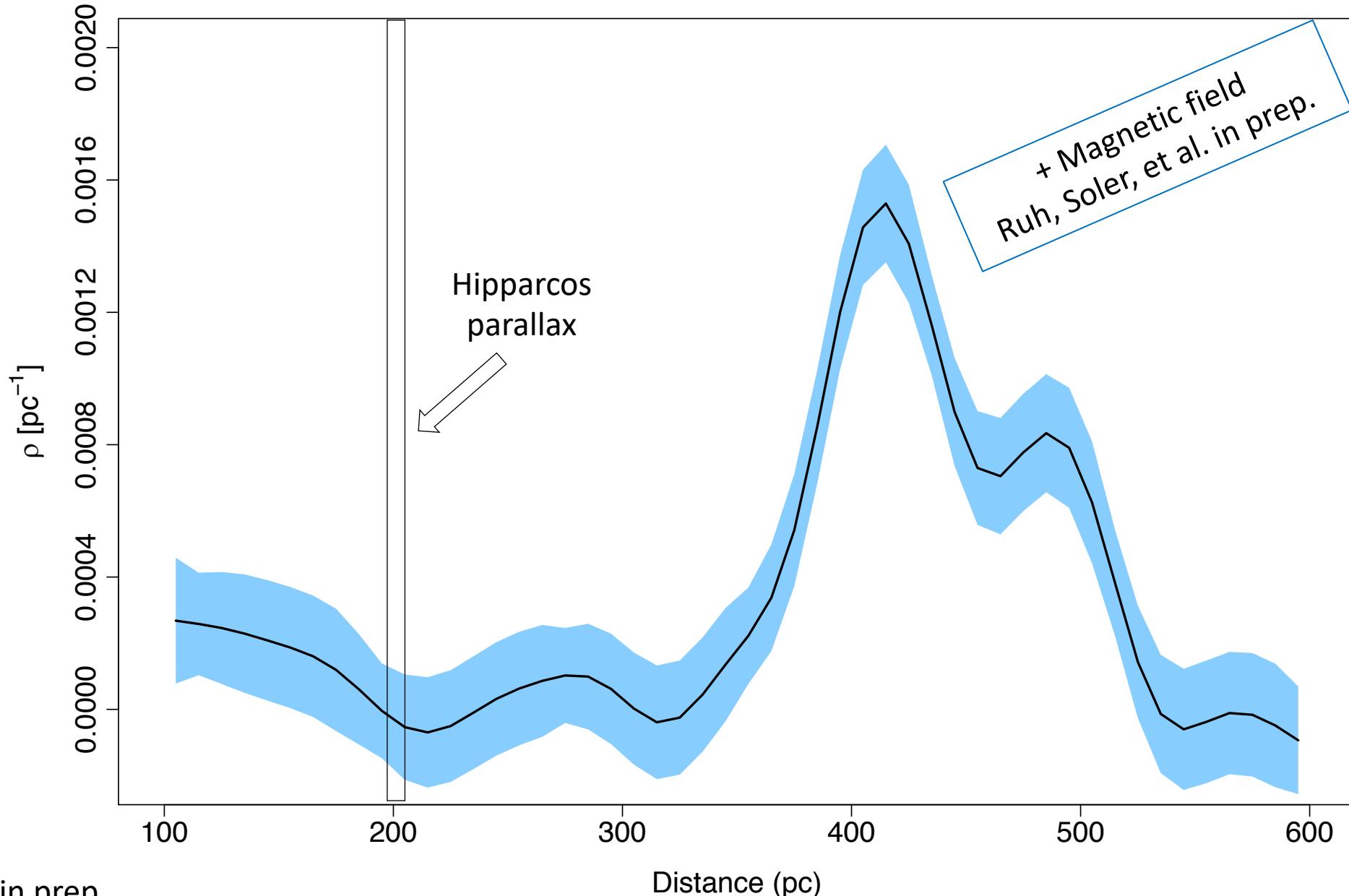
κ Orionis $\rightarrow (214.5^\circ, -18.5^\circ)$



κ Orionis $\rightarrow (214.5^\circ, -18.5^\circ)$



κ Orionis $\rightarrow (214.5^\circ, -18.5^\circ)$



Conclusion

- Robust 3D dust mapping technique without artefacts
 - Study ISM substructures

Conclusion

- Robust 3D dust mapping technique without artefacts
 - Study ISM substructures
- Foreground cloud to Orion A at \sim 350 pc

Conclusion

- Robust 3D dust mapping technique without artefacts
 - Study ISM substructures
- Foreground cloud to Orion A at \sim 350 pc
- Kappa Orionis distance at 400 pc in contrast to 200 pc Hipparcos parallax

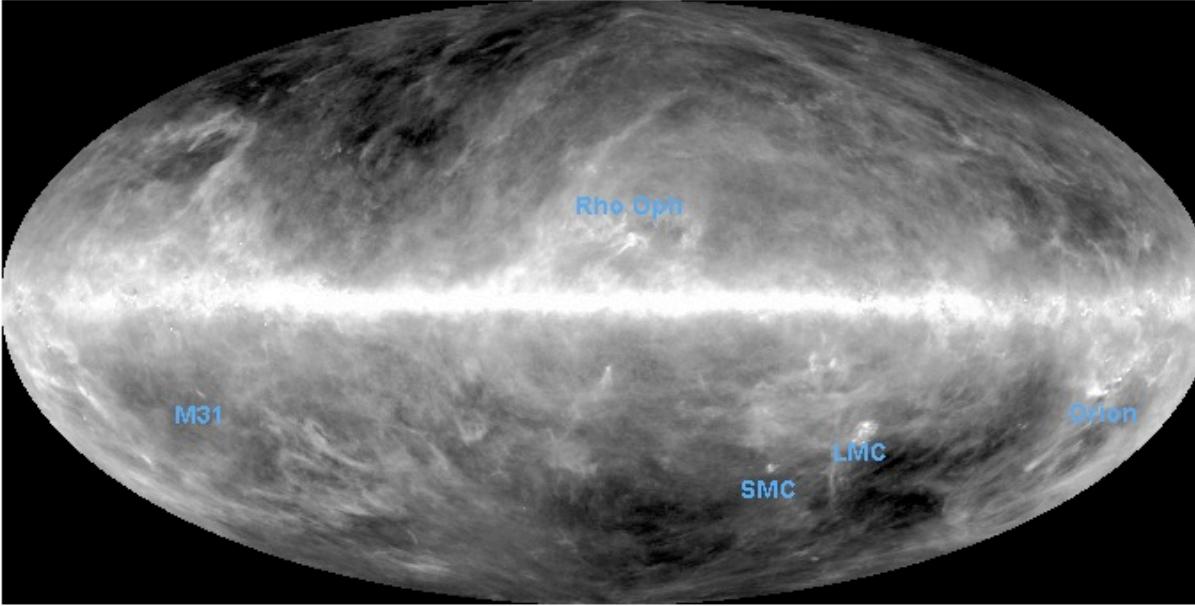
Conclusion

- Robust 3D dust mapping technique without artefacts
 - Study ISM substructures
- Foreground cloud to Orion A at \sim 350 pc
- Kappa Orionis distance at 400 pc in contrast to 200 pc Hipparcos parallax
- Kappa Orionis ring connected to the tail of Orion A

2D emission maps

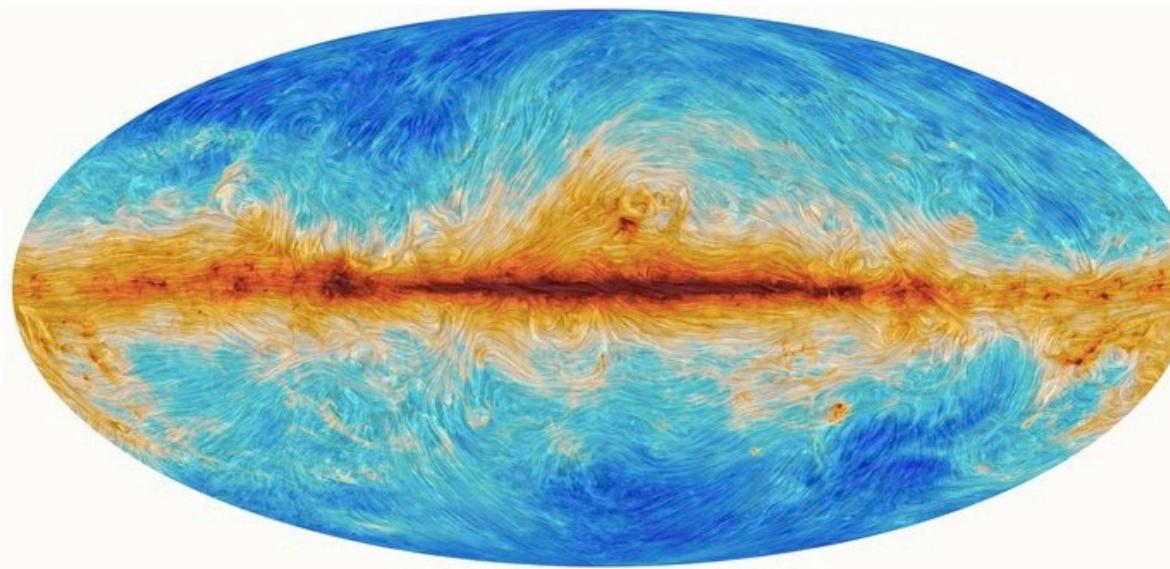
2D emission maps

Schlegel, Finkbeiner, and Davis
(SFD, 1998)

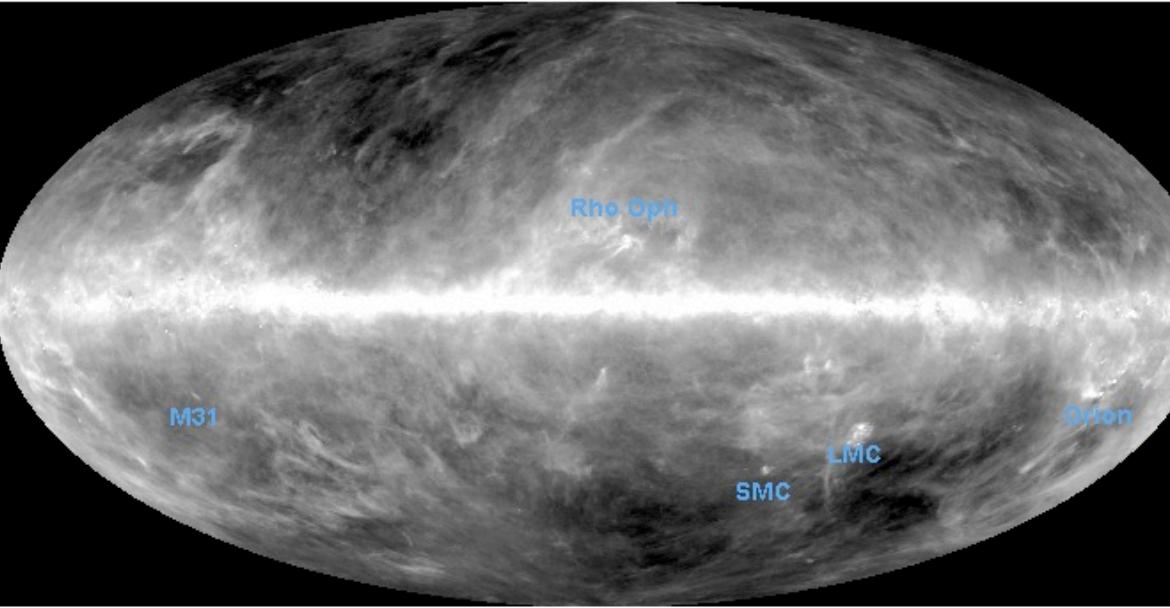


2D emission maps

Planck Collaboration
(2015)



Schlegel, Finkbeiner, and Davis
(SFD, 1998)



2D emission maps



3D maps

