Max-Planck-Institut für
extraterrestrische Physik

Dunlap Institute for Astronomy & Astrophysics
UNIVERSITY OF TORONTO

The Green Bank Ammonia Survey (GAS): First results of NH_3 mapping the Gould Belt

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A. Ginsburg (ESO), A. Goodman (Harvard), F. Heitsch (UNC),
J. Keown (UVic), H. Kirk (NRC Herzberg), P. Martin (Toronto),
C. Matzner (Toronto), P. C. Myers (Harvard), S. Offner (UMass),
A. Punanova (MPE), E. Rosolowsky (Alberta),
Y. Seo (Arizona), and Y. Shirley (Arizona)

From Molecular Cloud to Dense Cores

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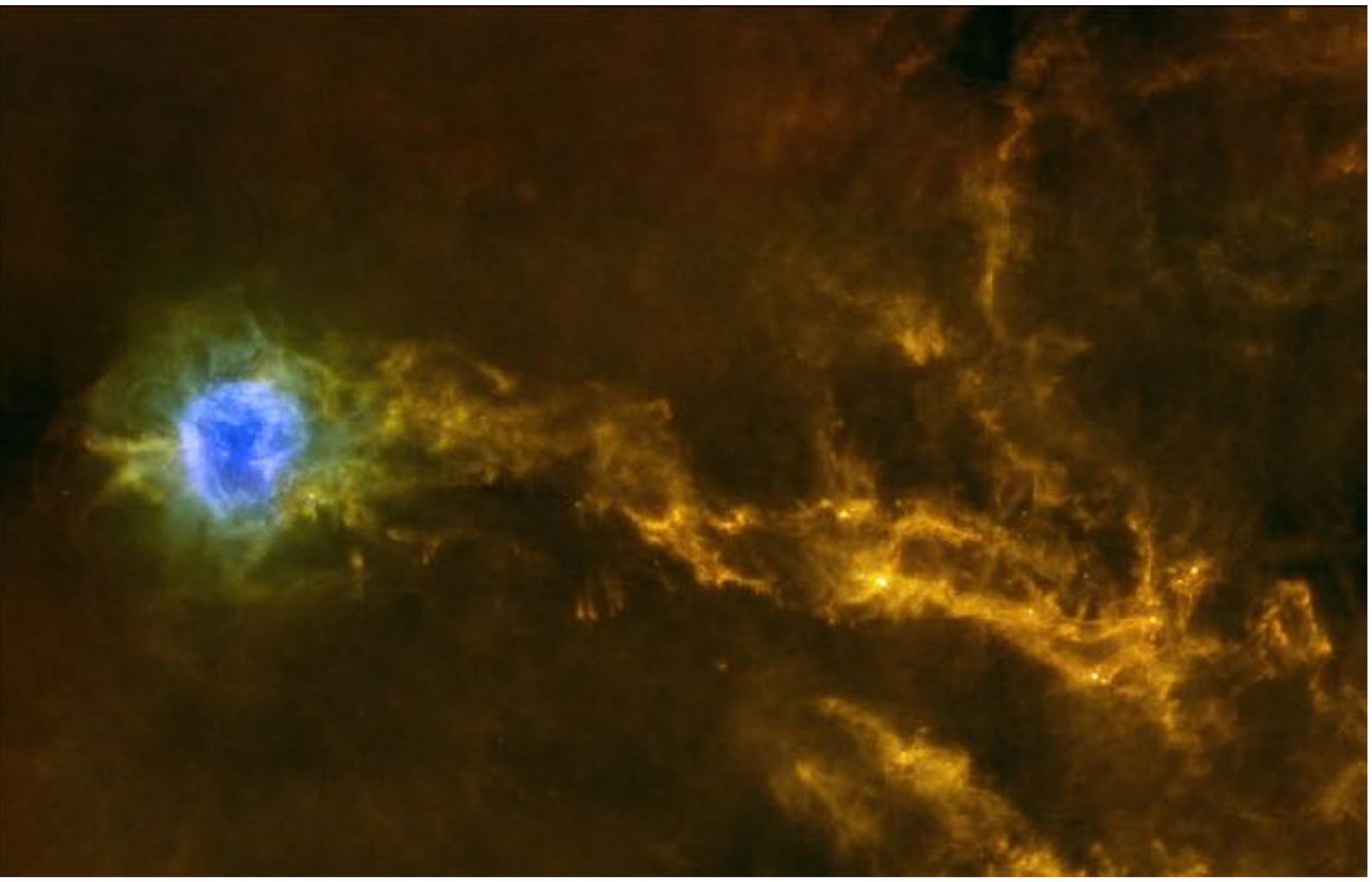
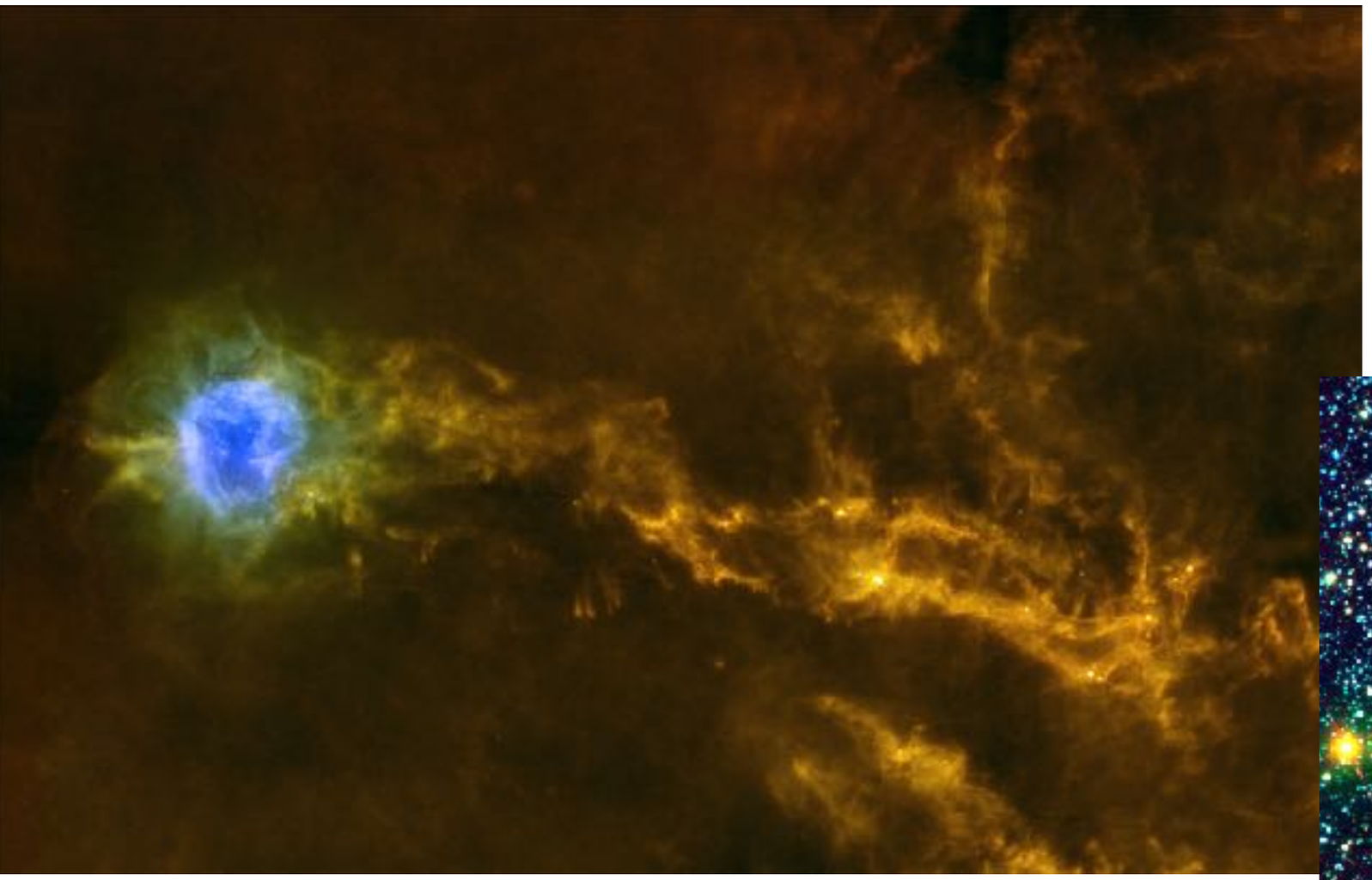


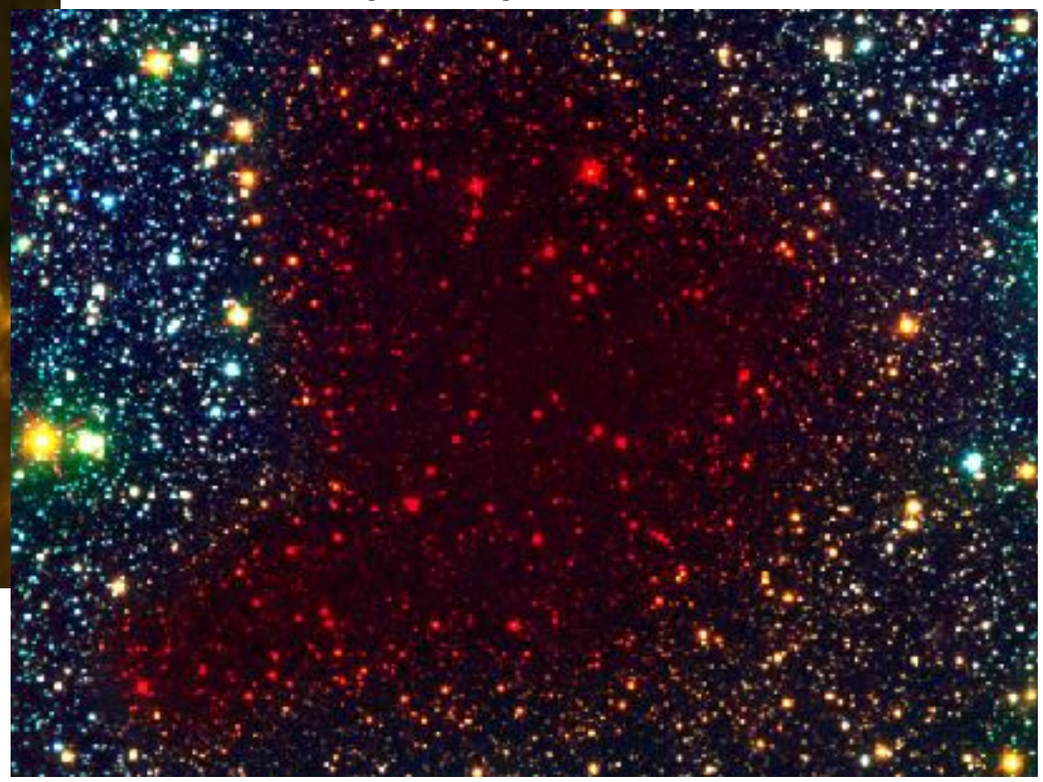
Herschel shows presence of filamentary structures in nearby clouds (Andre et al., 2014)

From Molecular Cloud to Dense Cores



Herschel shows presence of filamentary structures in nearby clouds (Andre et al., 2014)

How do we connect to Cores?
What are Cores properties



What is the effect of the molecular cloud?

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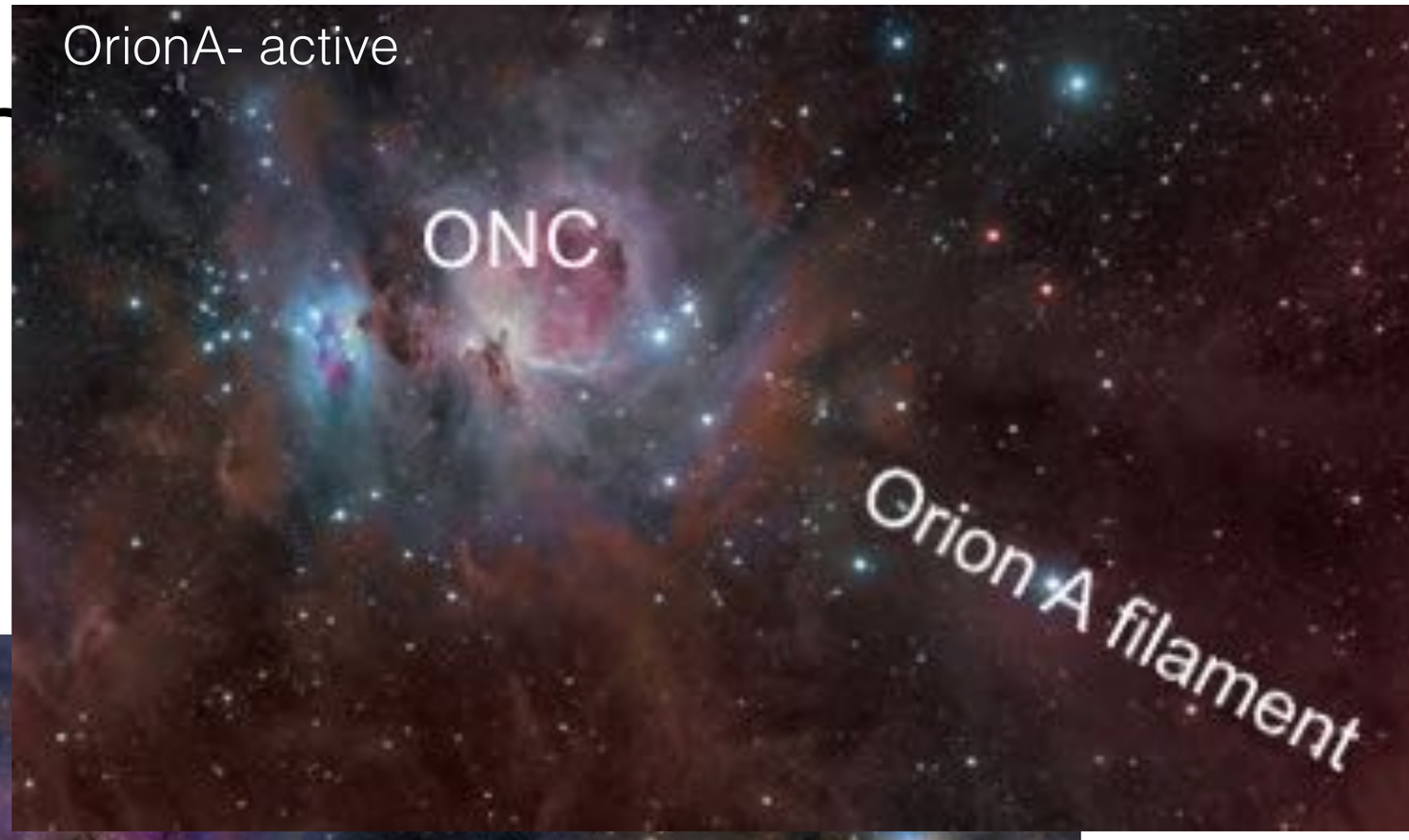
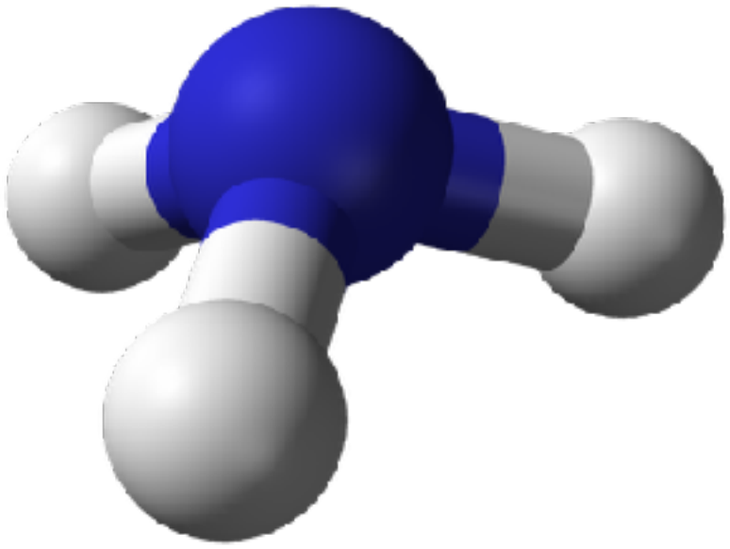
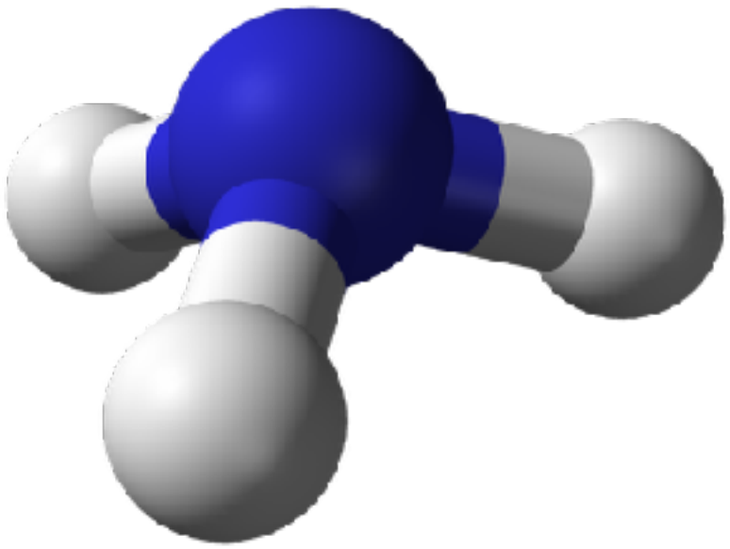
What is th
molec





NH_3 as a tool



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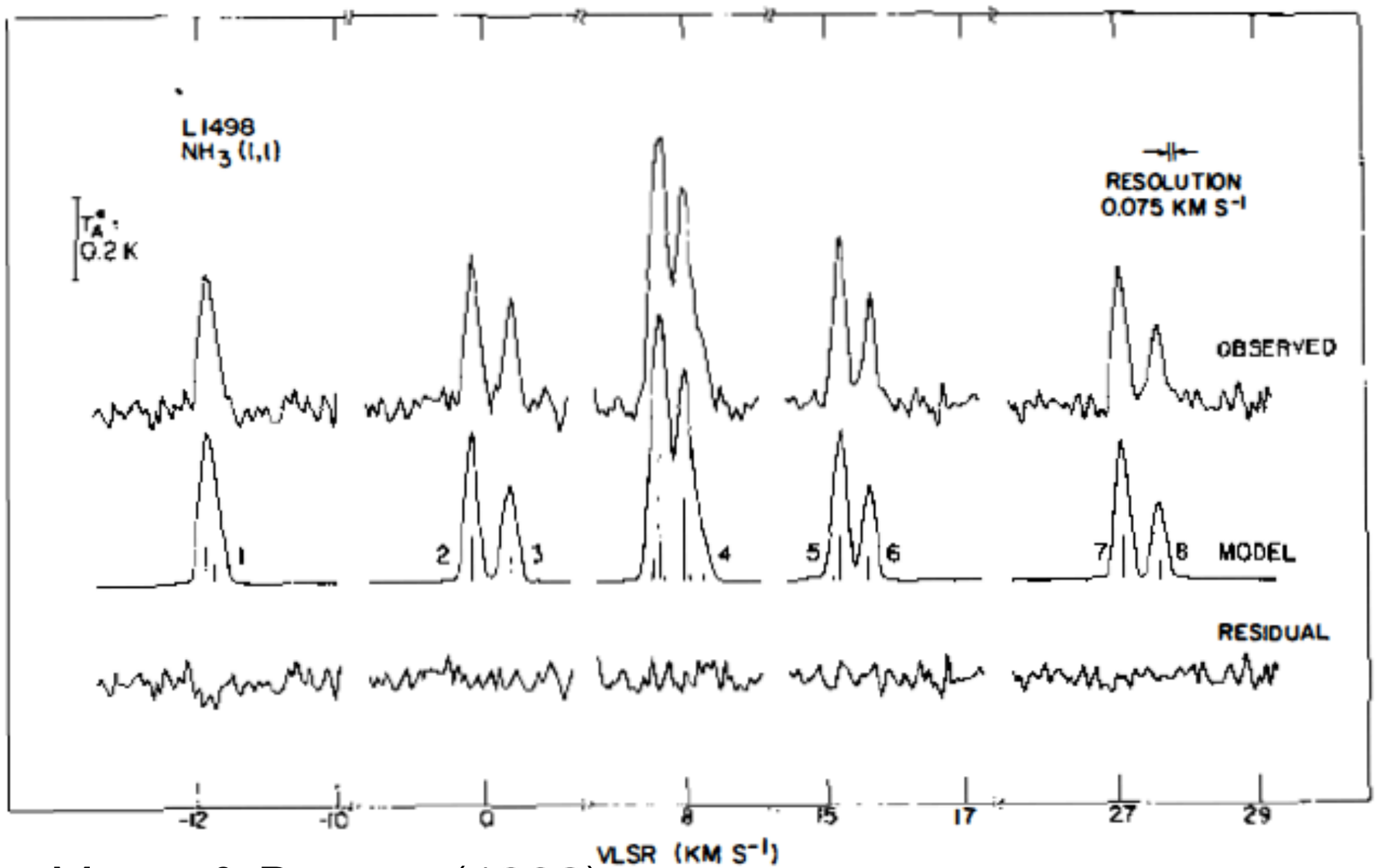
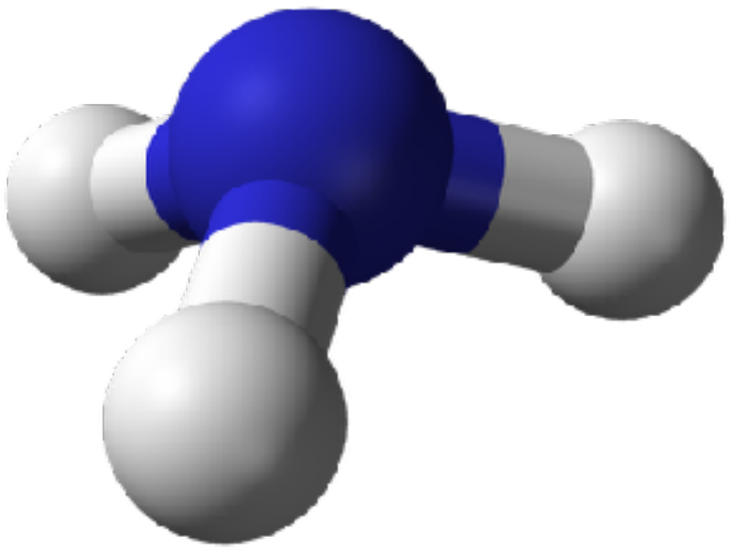
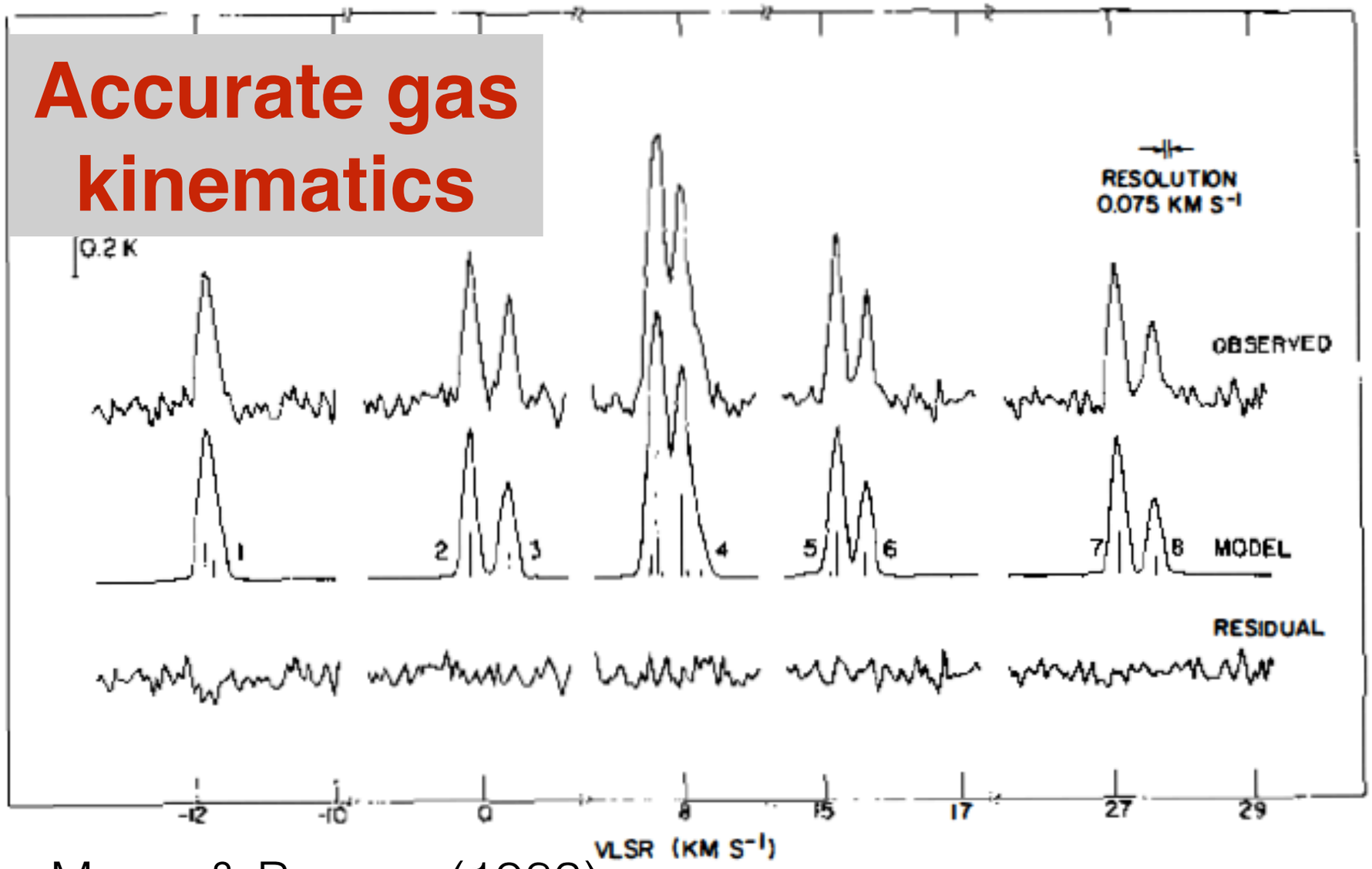


Myers & Benson (1983)



NH_3 as a tool

Accurate gas kinematics



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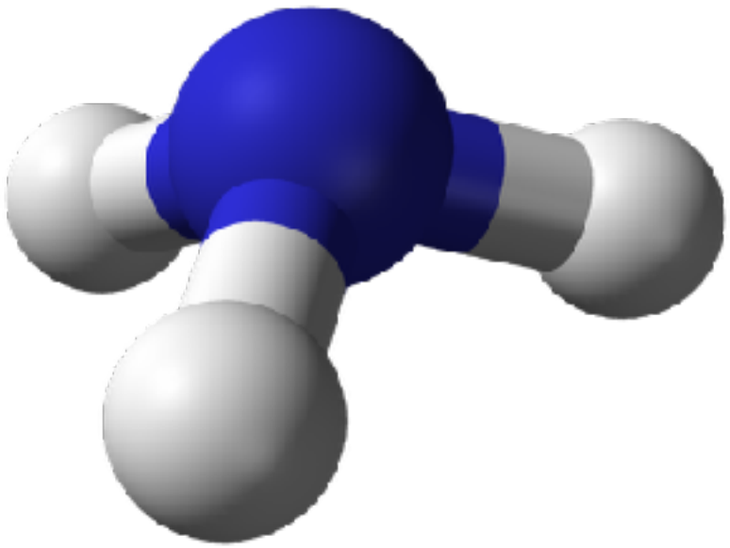

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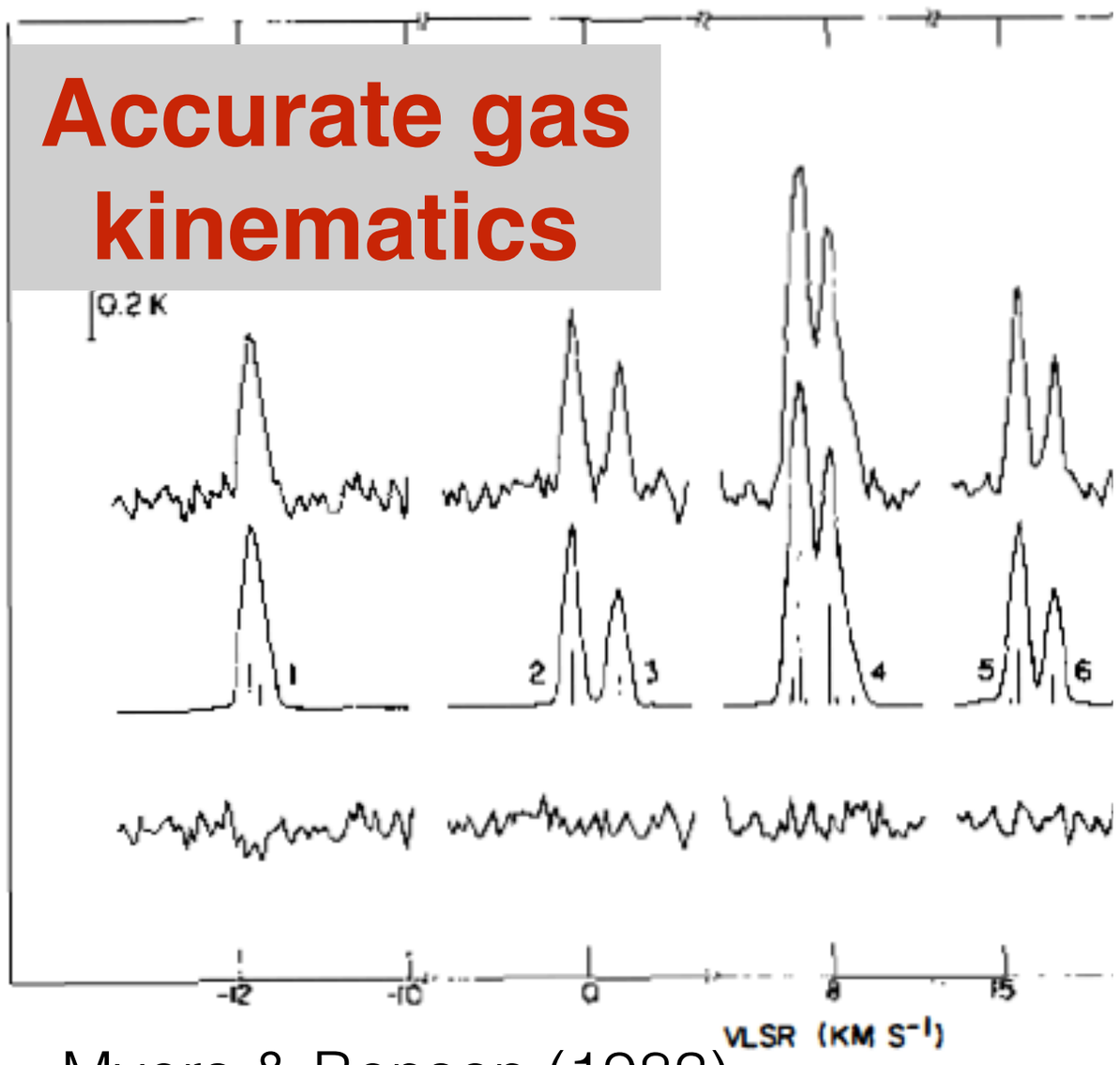

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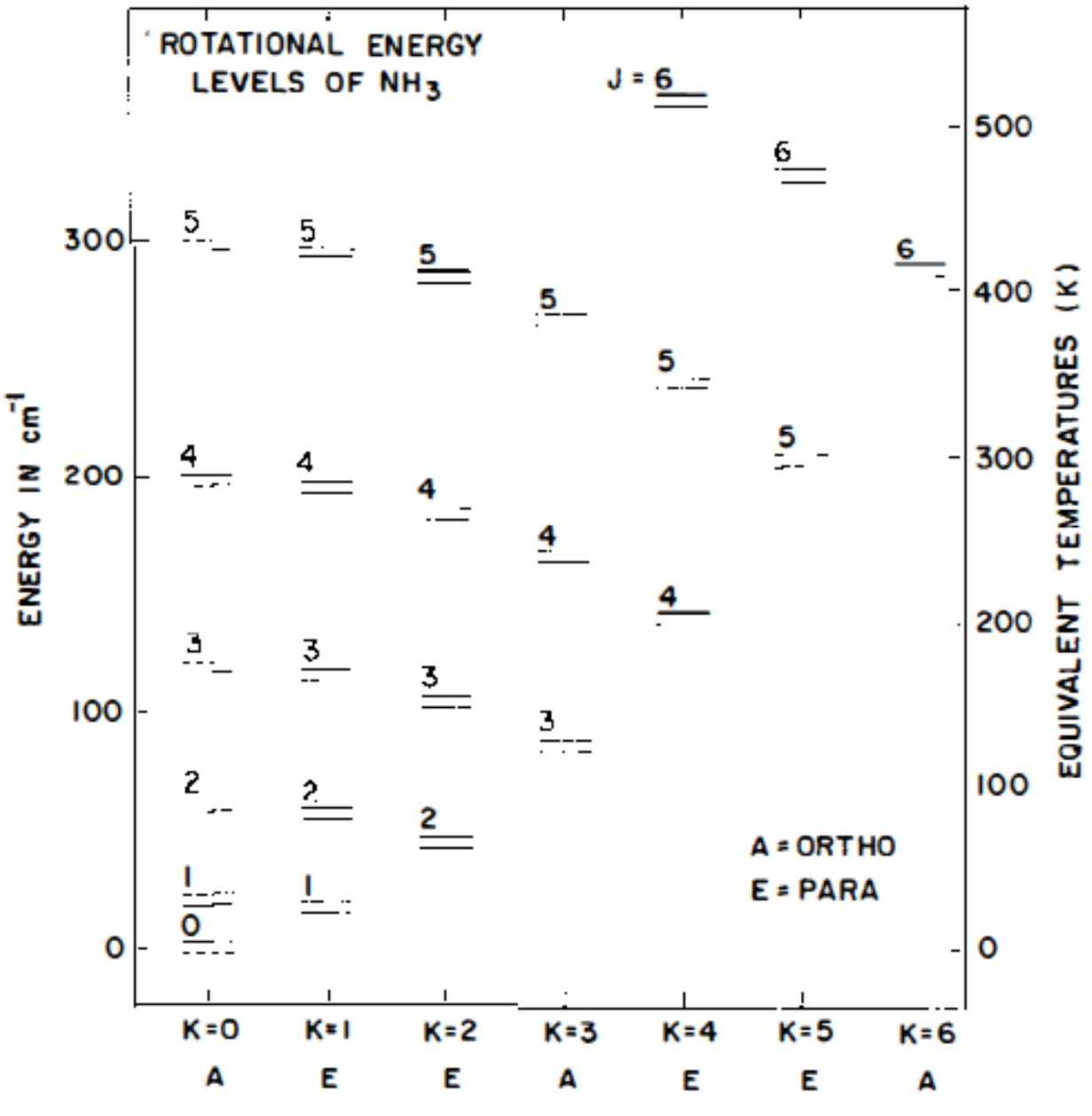
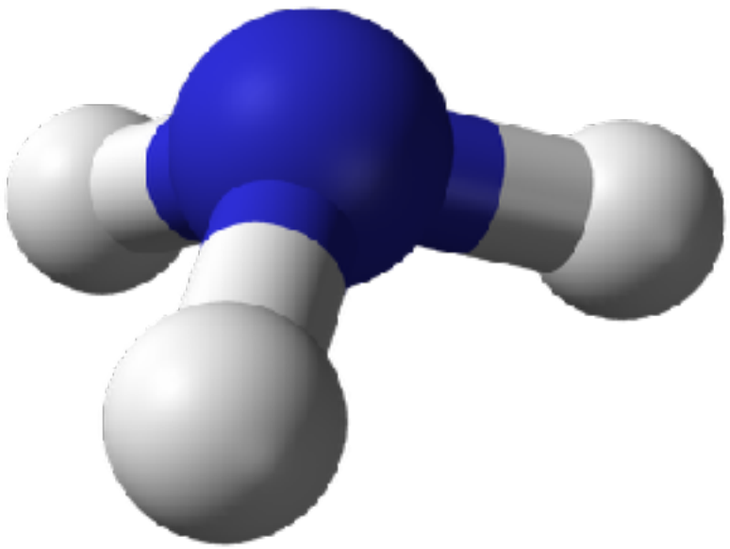


Ho & Townes (1983)



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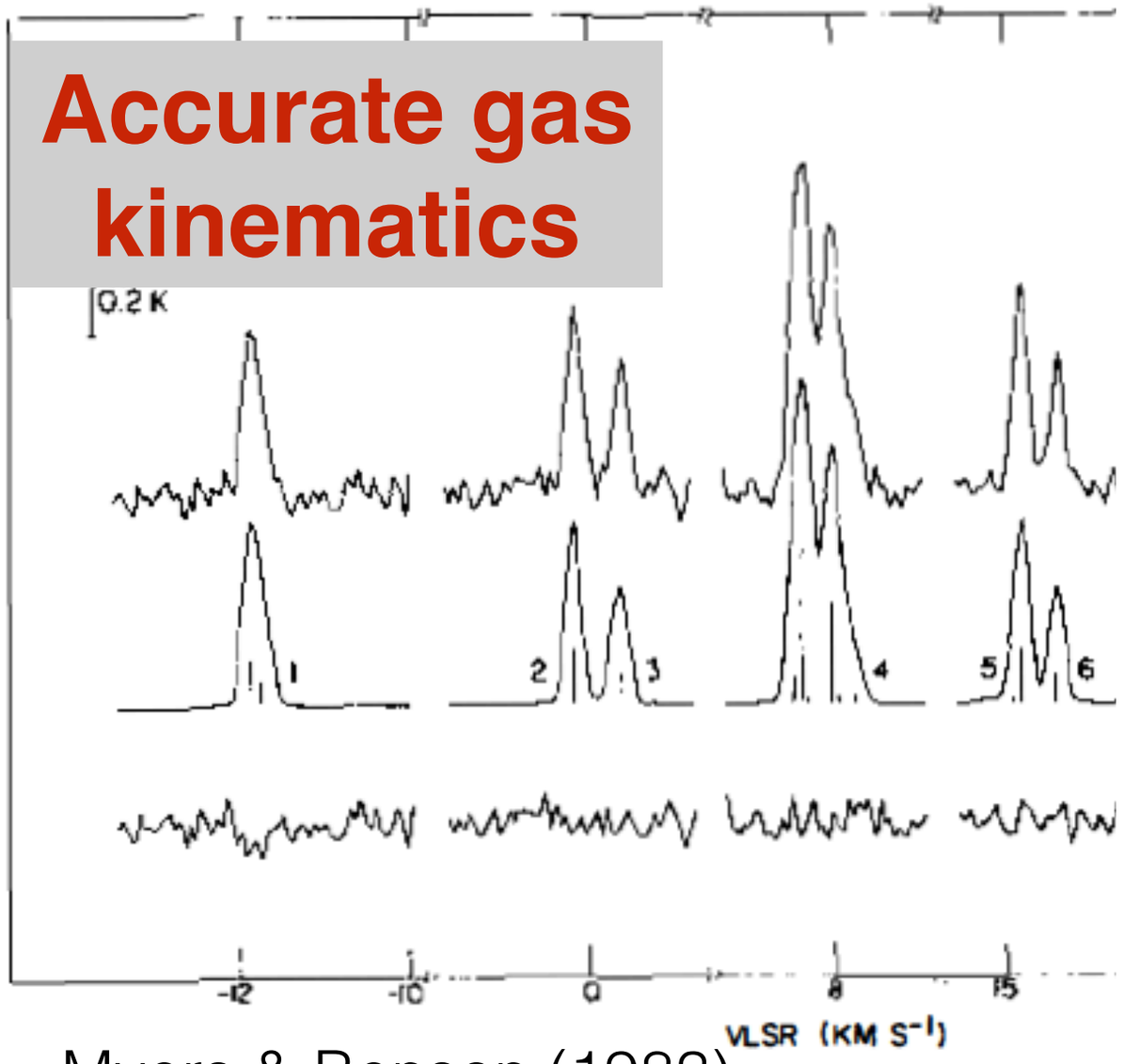

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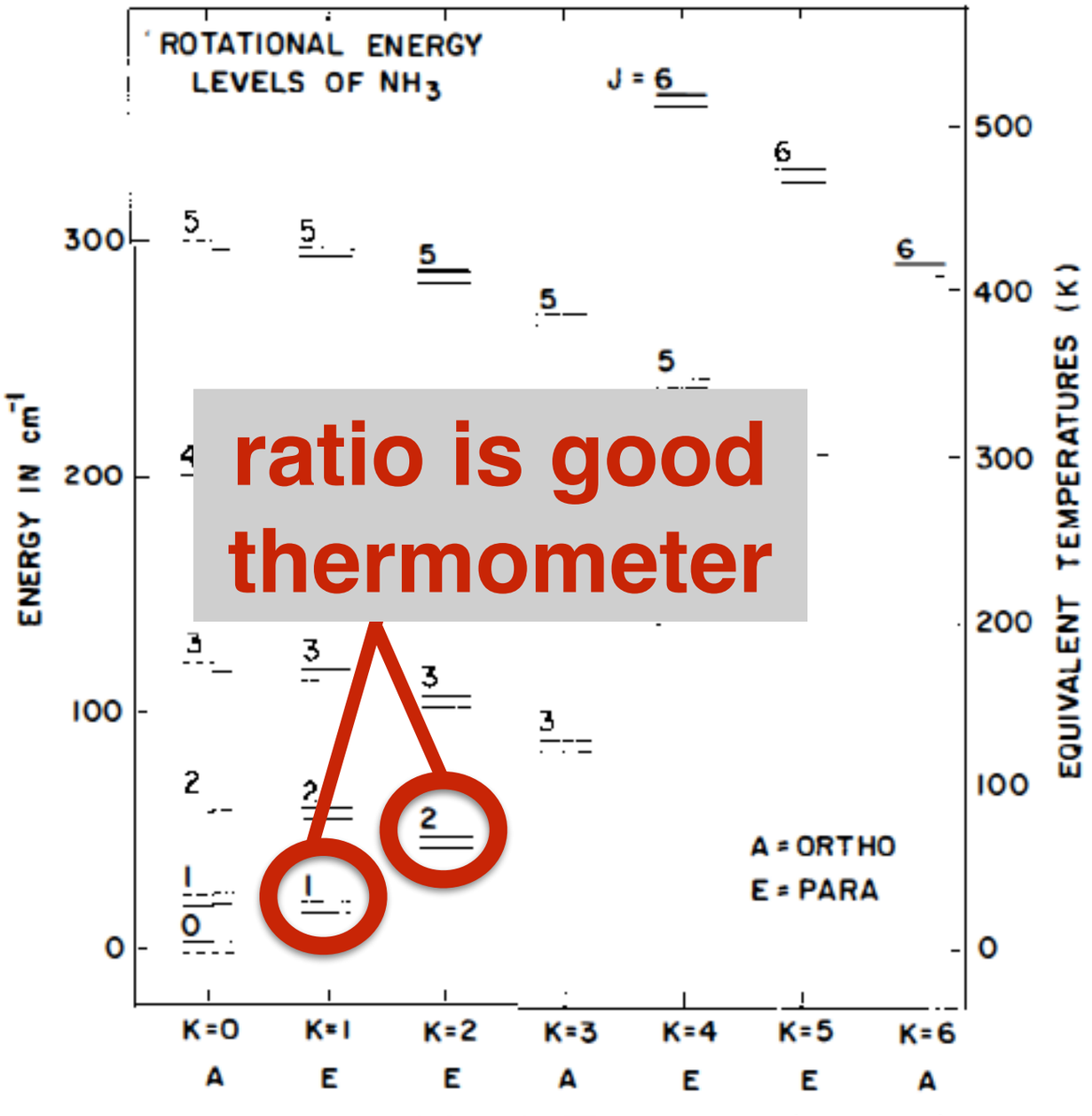

ratio is good thermometer

Ho & Townes (1983)

Why should you care?

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- From E. Herbst's talk: Density and temperature are key for setting up models

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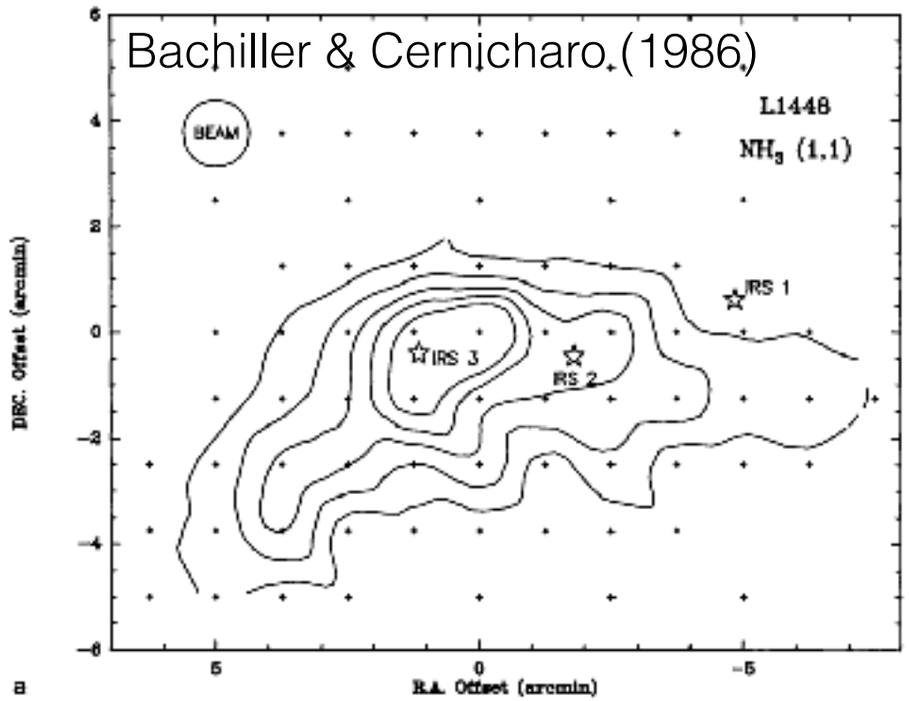
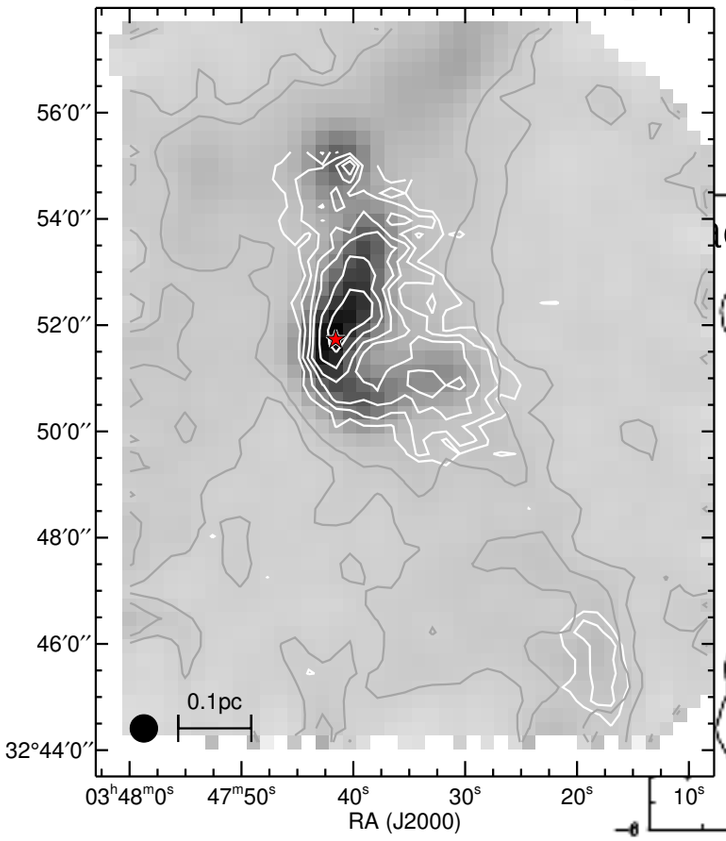
- From E. Herbst's talk: Density and temperature are key for setting up models
- Good test for simple chemical models (NH_3 is easy) from low-density clouds to dense cores

Previous maps

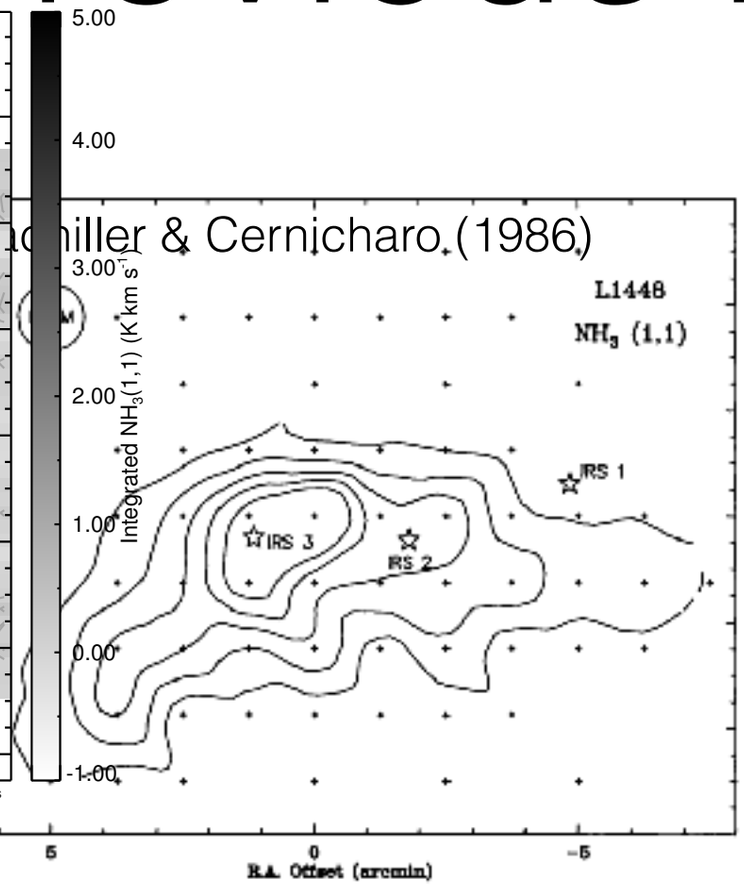


Previous maps

Pineda et al. (2010)



Perseus



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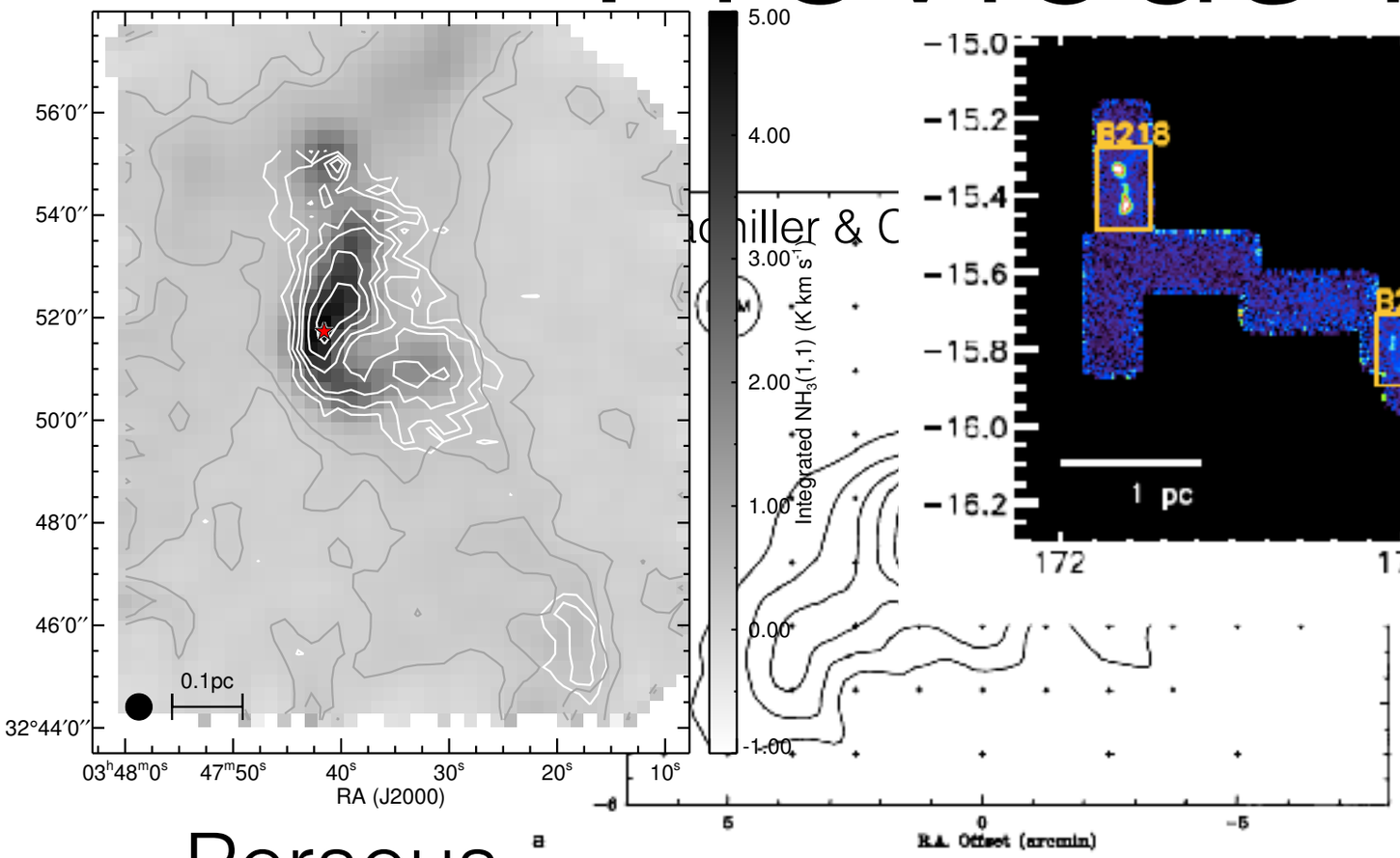
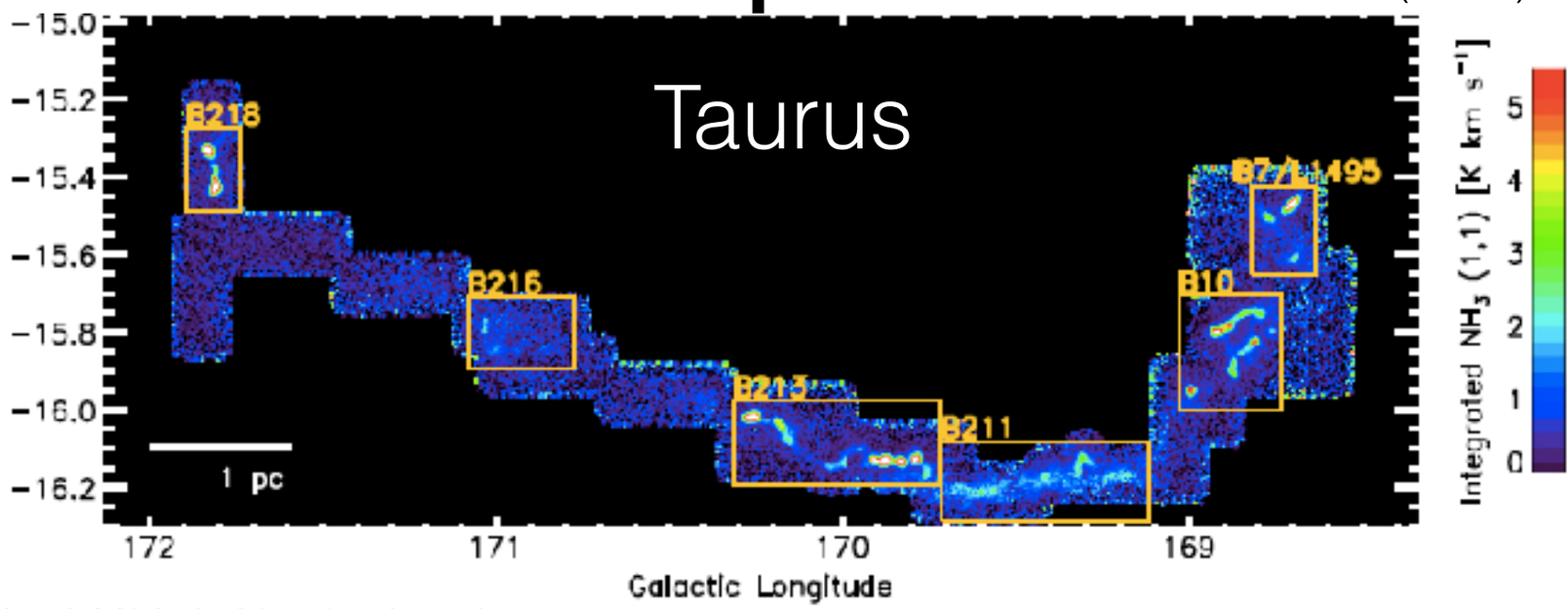


Perseus

Seo et al. (2015)



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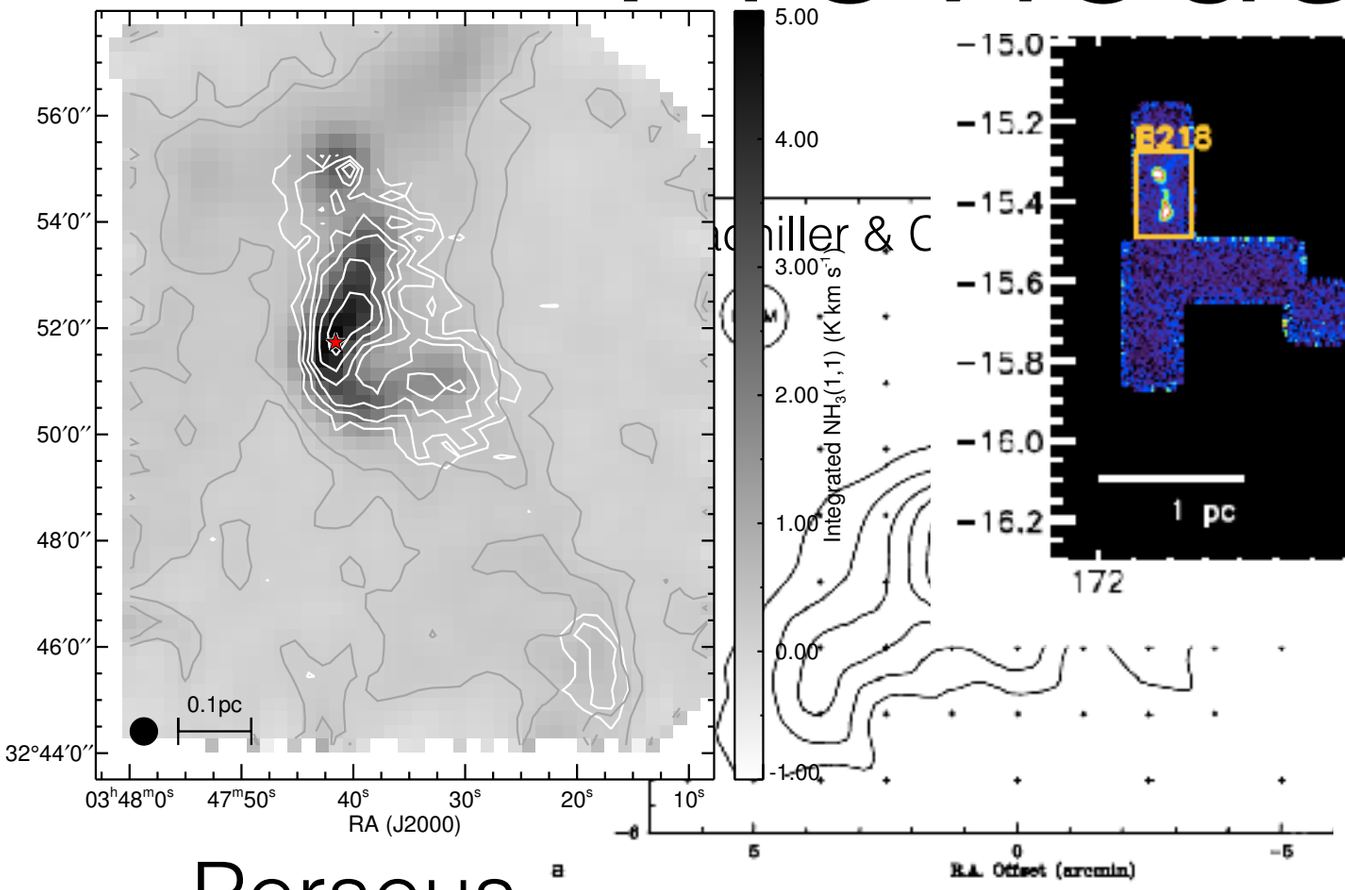

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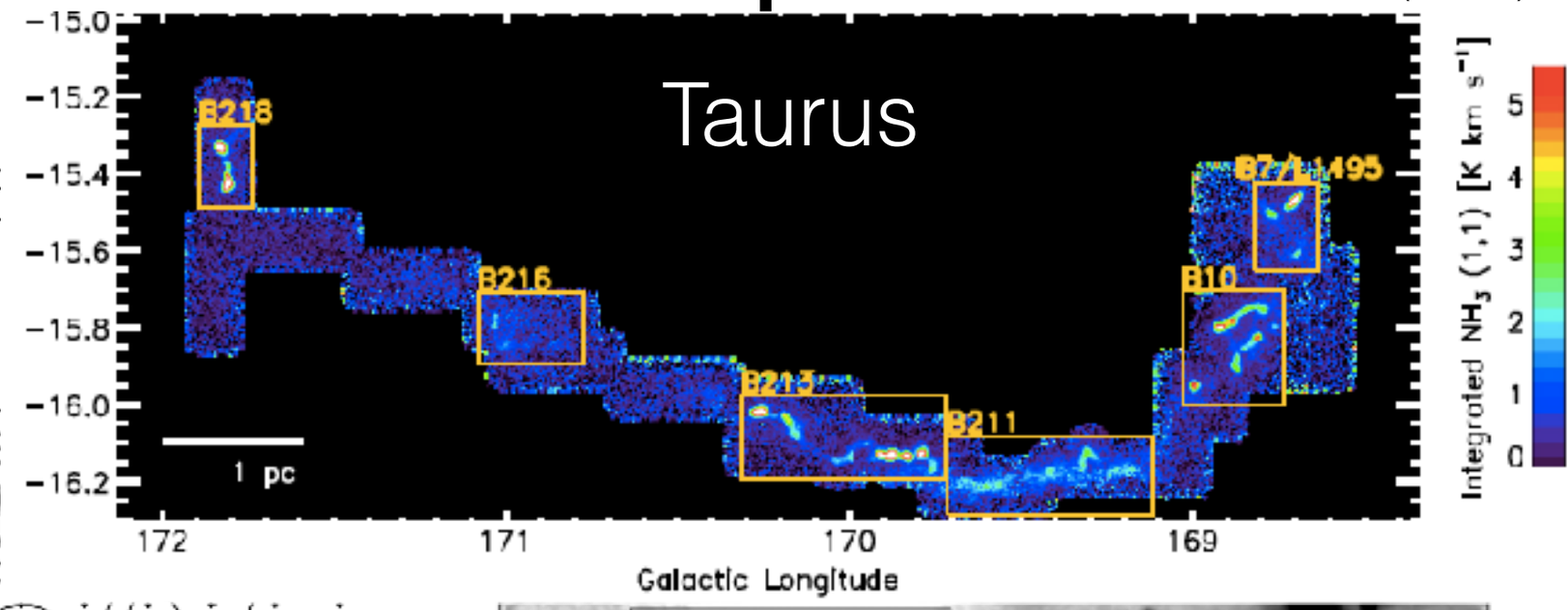
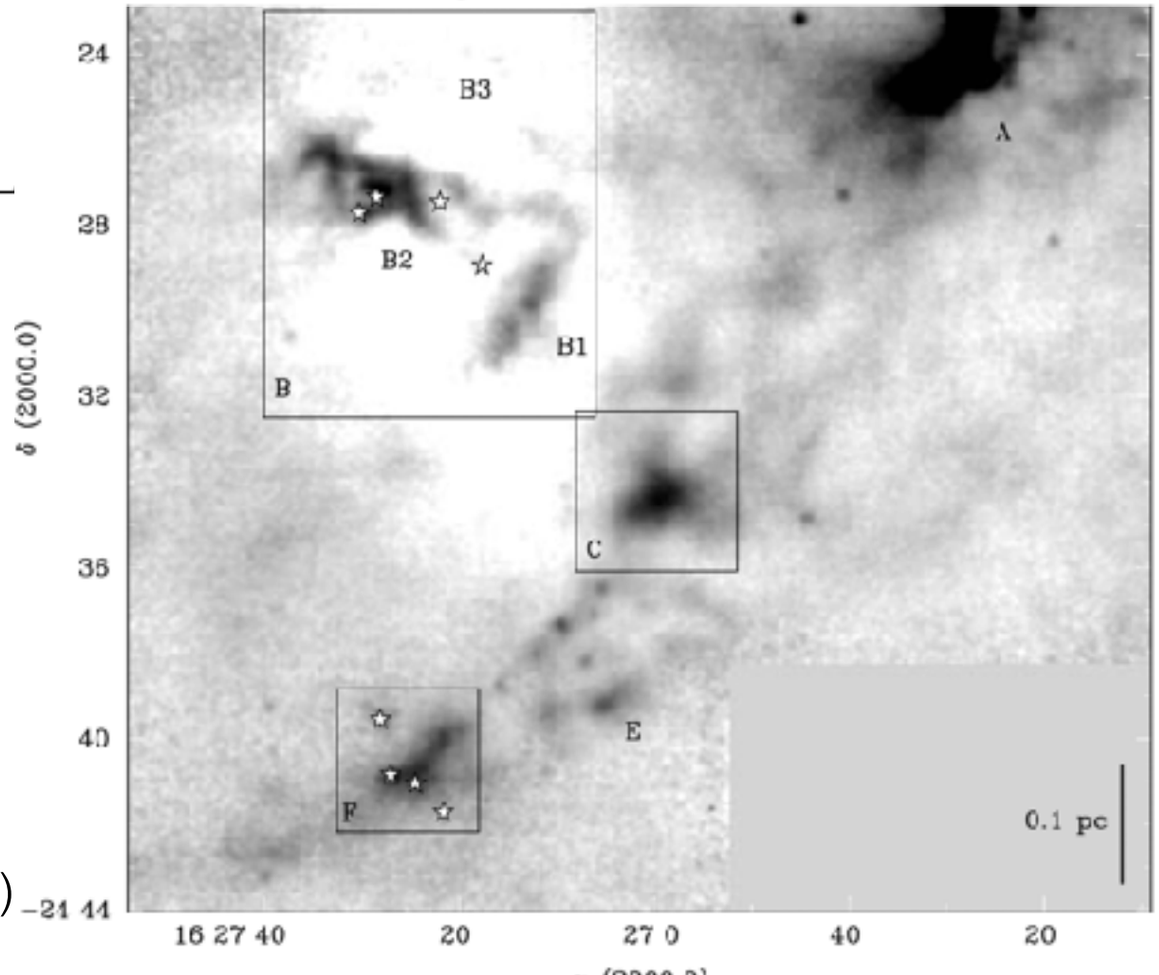


Oph



Friesen et al. (2009)

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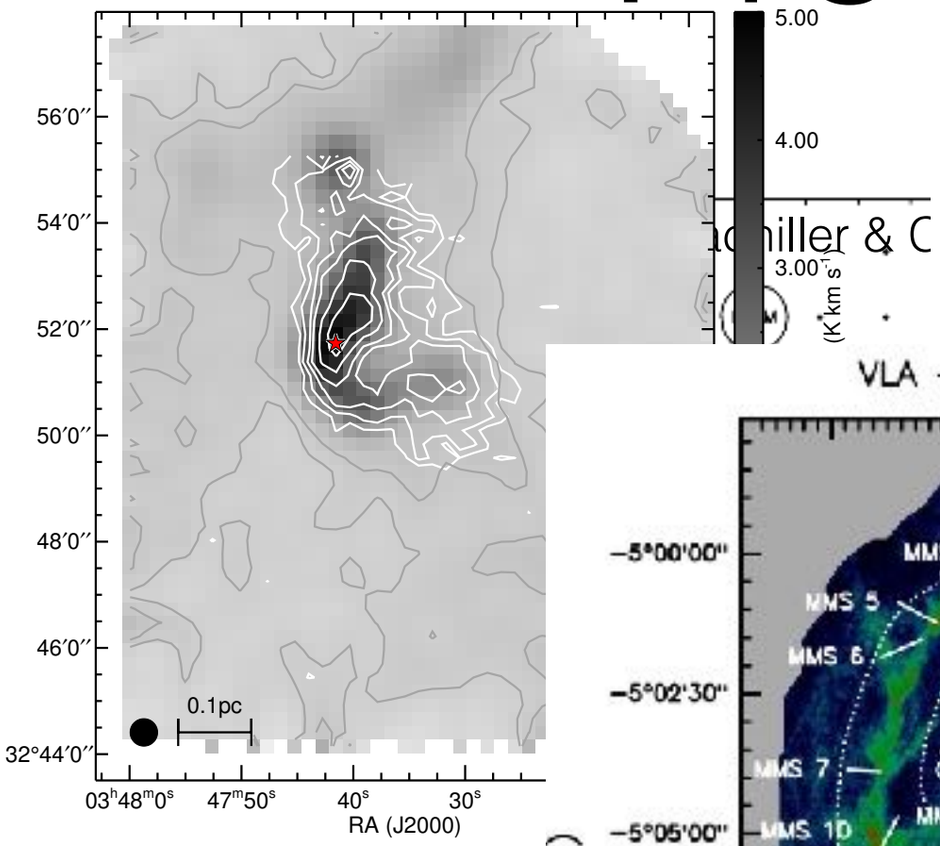
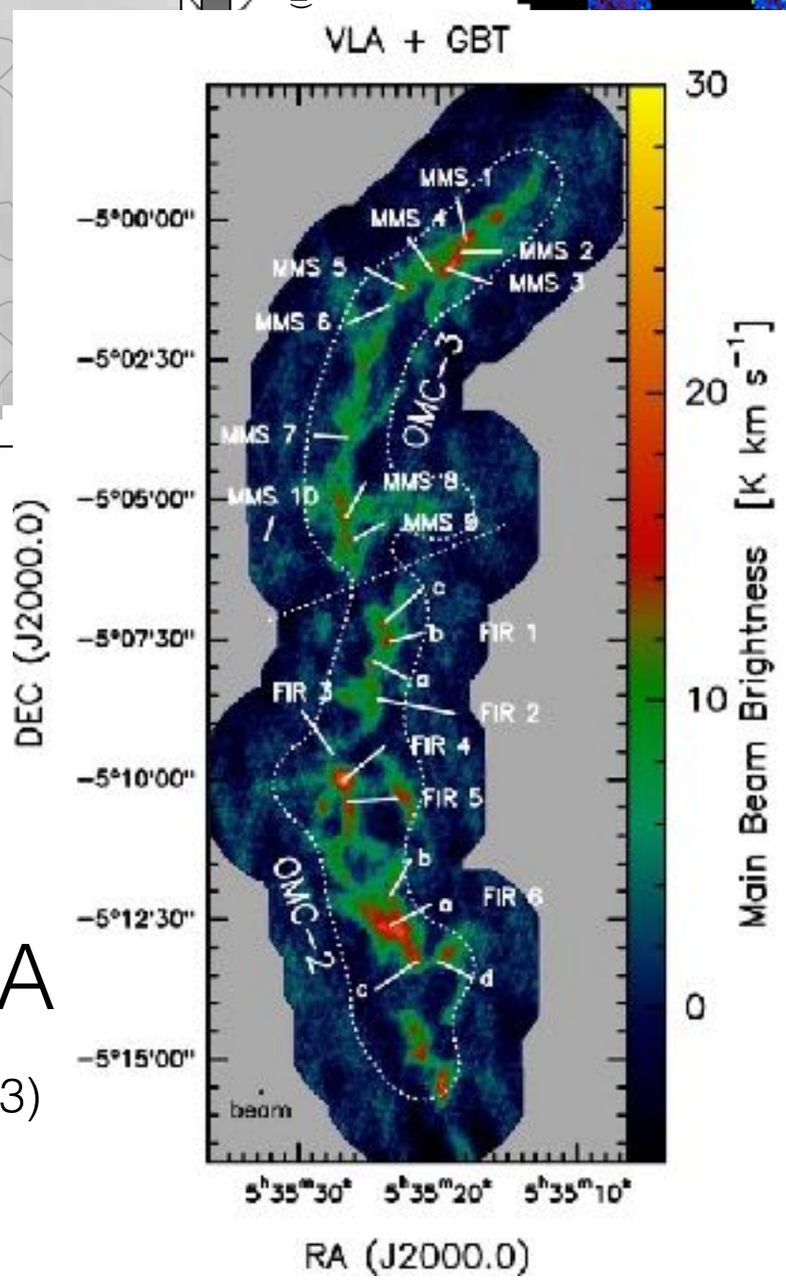


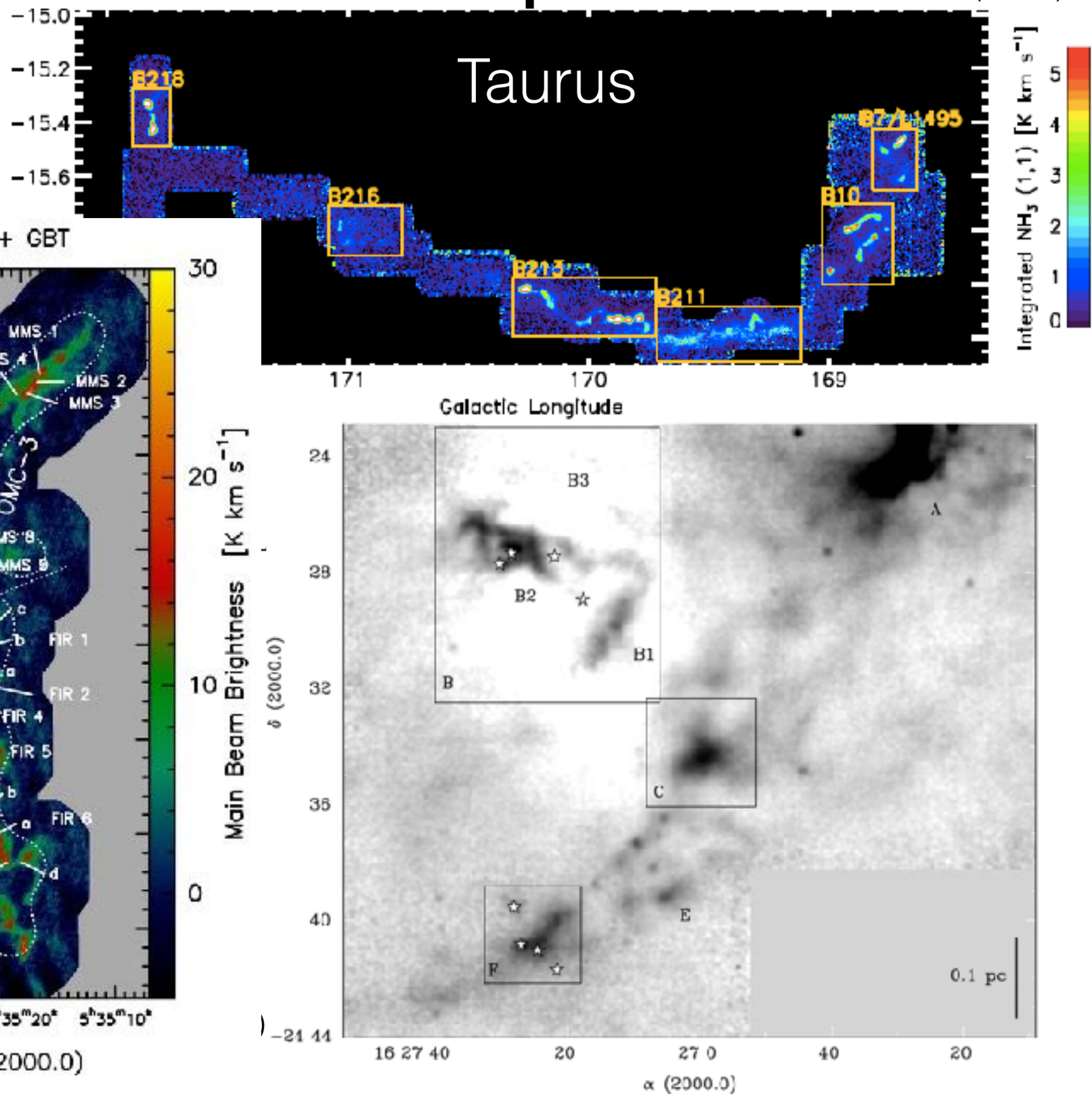
Perseus

OrionA

Li et al. (2013)



Seo et al. (2015)



NH_3 survey

- 244 hrs allocated

- lines targeted:

  ★ NH_3 (1,1), (2,2) and (3,3)

  ★ C_2S (2_1-1_0), HC_5N (9-8), HC_7N (21-20) and (22-21)

- maps of regions in Gould Belt clouds of A_v>7 mag: Perseus, OrionA, OrionB, Ophiuchus, IC5146, Pipe, Taurus, CrA, Cepheus, Serpens-Aquila

- Green Bank Telescope (100-m)

- K-Band Focal plane array (7-pixels)

Typical rms~0.1 K (T_{MB}) in a 0.07 km/s channel

http://dataverse.harvard.edu/dataverse/GAS_DR1

NH_3 survey

- **Data Release 1 in 2017**:
- NGC1333
- L1688
- B18 (in Taurus)
- OrionA-North

- 24 fields mapped
- lines targeted:
  - ★ NH_3 (1,1), (2,2) and (3,3)
  - ★ C_2S (2_1-1_0), HC_5N (9-8), HC_7N (21-20) and (22-21)
- maps of regions in Gould Belt clouds of A_v>7 mag: Perseus, OrionA, OrionB, Ophiuchus, IC5146, Serpens, Taurus, CrA, Cepheus, Serpens-Aquila
- Green Bank Telescope (100-m)
- KFPA: K-Band Focal plane array (7-pixels)

20.5 21.0 21.5 22.0 22.5 23.0

0.1$\overline{0}$ pc

48

36

24

12

+31:00

Dec (J2000)

NGC1333
log N(H_2)

30 30:00 30 29:00 30 3:28:00

RA (J2000)

Integrated Intensity (K km s^{-1})

0 3 6 12

0.1$\overline{0}$ pc

48

36

24

12

+31:00

NGC1333
NH_3(1,1)

30 30:00 30 29:00 30 3:28:0

RA (J2000)

6 7 8 9

0.10 pc

48

36

24

12

+31:00

Dec (J2000)

NGC1333

v_{LSR} (km s^{-1})

30 30:00 30 29:00 30 3:28:00

RA (J2000)

0.0 0.3 0.6 0.9 1.2 1.5 1.8

0.10 pc

48

36

24

12

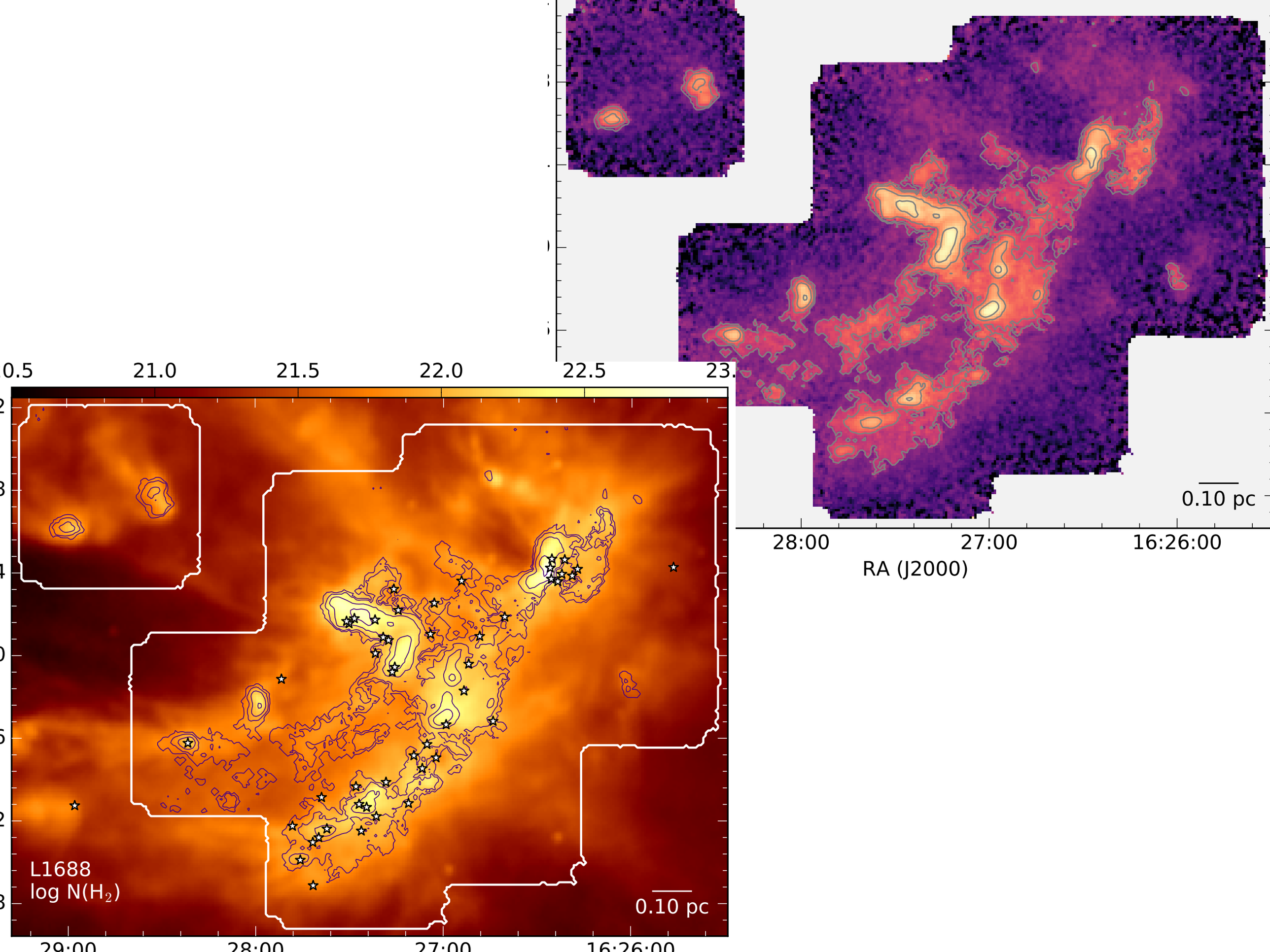
+31:00

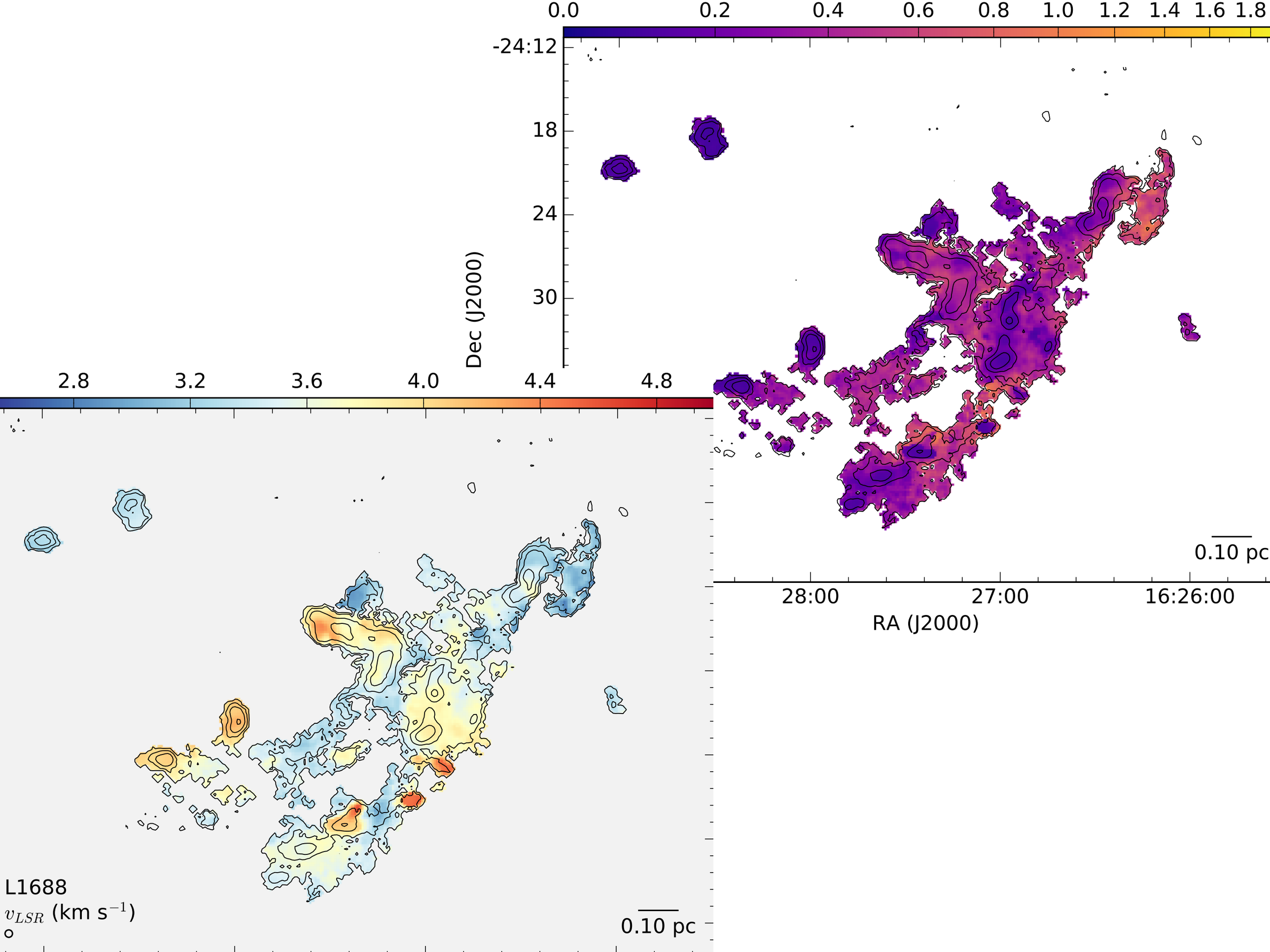
NGC1333

σ_v (km s^{-1})

30 30:00 30 29:00 30 3:28:00

RA (J2000)


0.5
21.0
21.5
22.0
22.5
23.
2
3
4
0
6
2
3
L1688
log N(H2)
0.10 pc
29:00
28:00
27:00
16:26:00
0.10 pc
28:00
27:00
16:26:00
RA (J2000)


0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
-24:12
18
24
30
Dec (J2000)
2.8
3.2
3.6
4.0
4.4
4.8
0.10 pc
28:00
27:00
16:26:00
RA (J2000)
L1688
v_{LSR} (km s^{-1})
0.10 pc

Integrated Intensity (K km s^{-1})

0

3

6

B18
NH_3(1,1)

Dec (J2000)

50

40

30

20

10

+24:00

0.10 pc

20.5

21.0

21.5

22.0

22.5

23.0

B18
log N(H_2)

Dec (J2000)

50

40

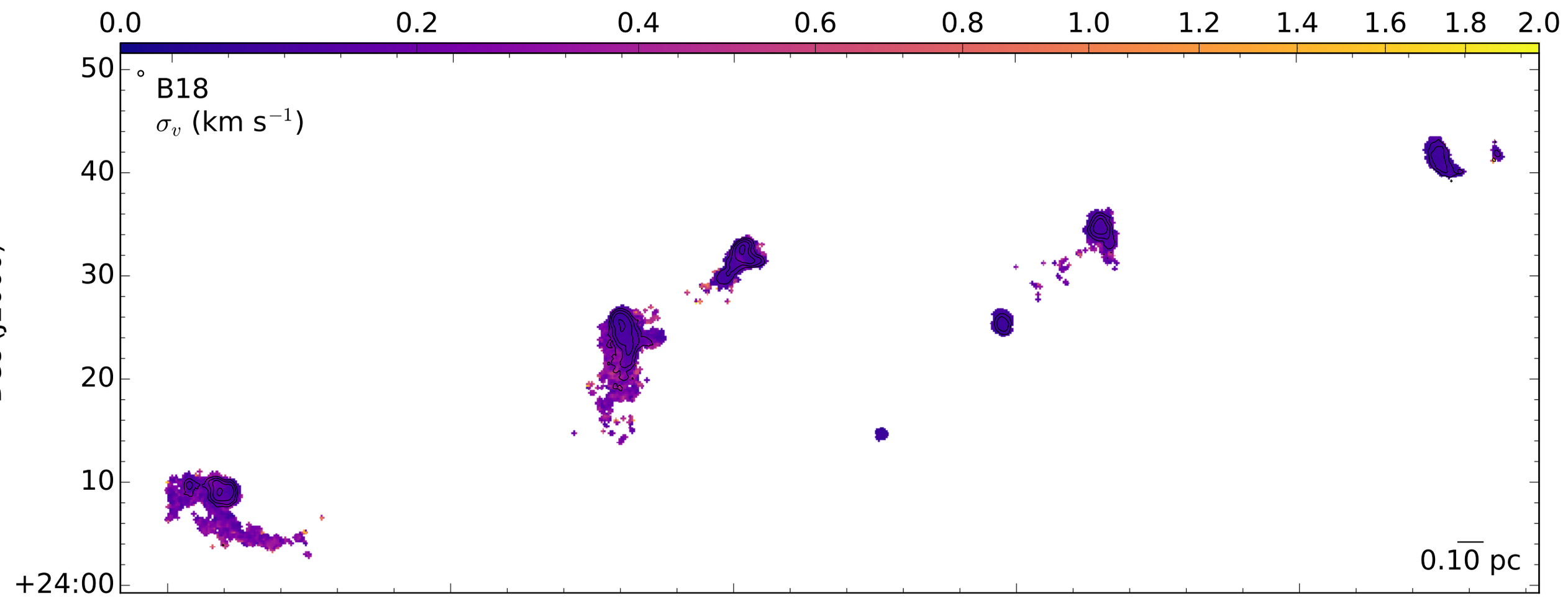
30

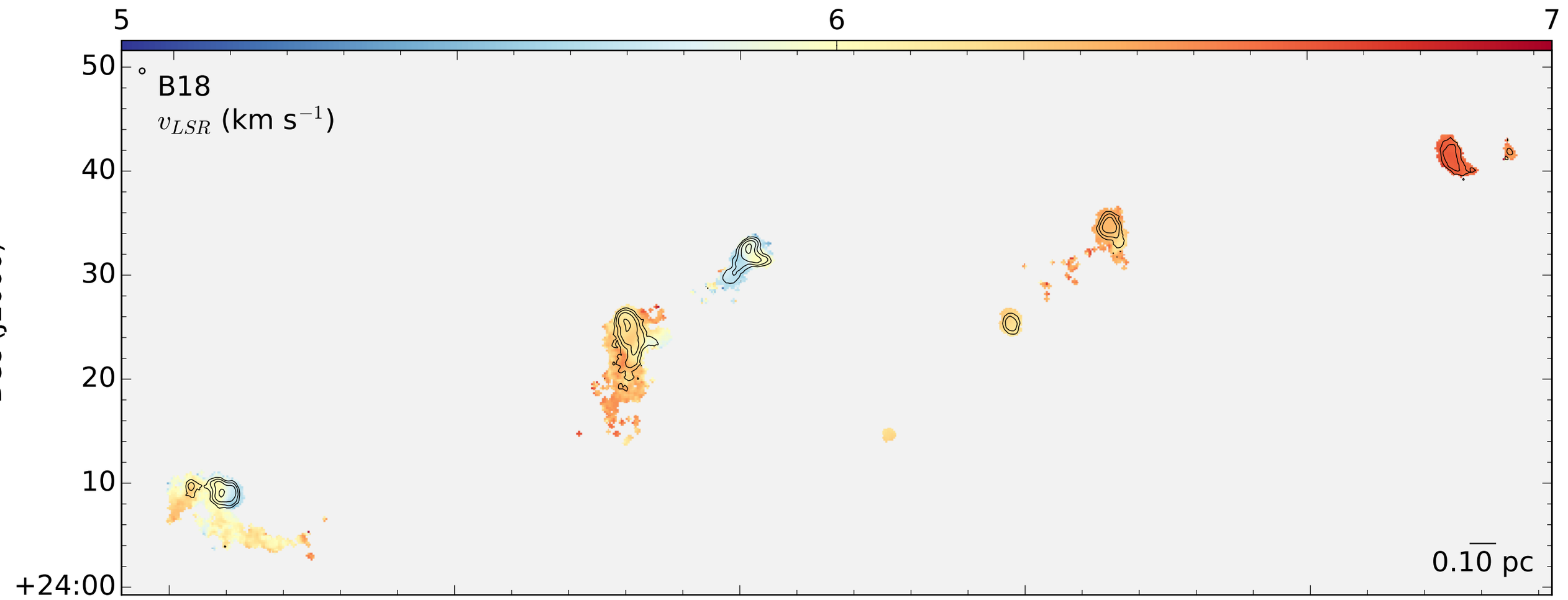
20

10

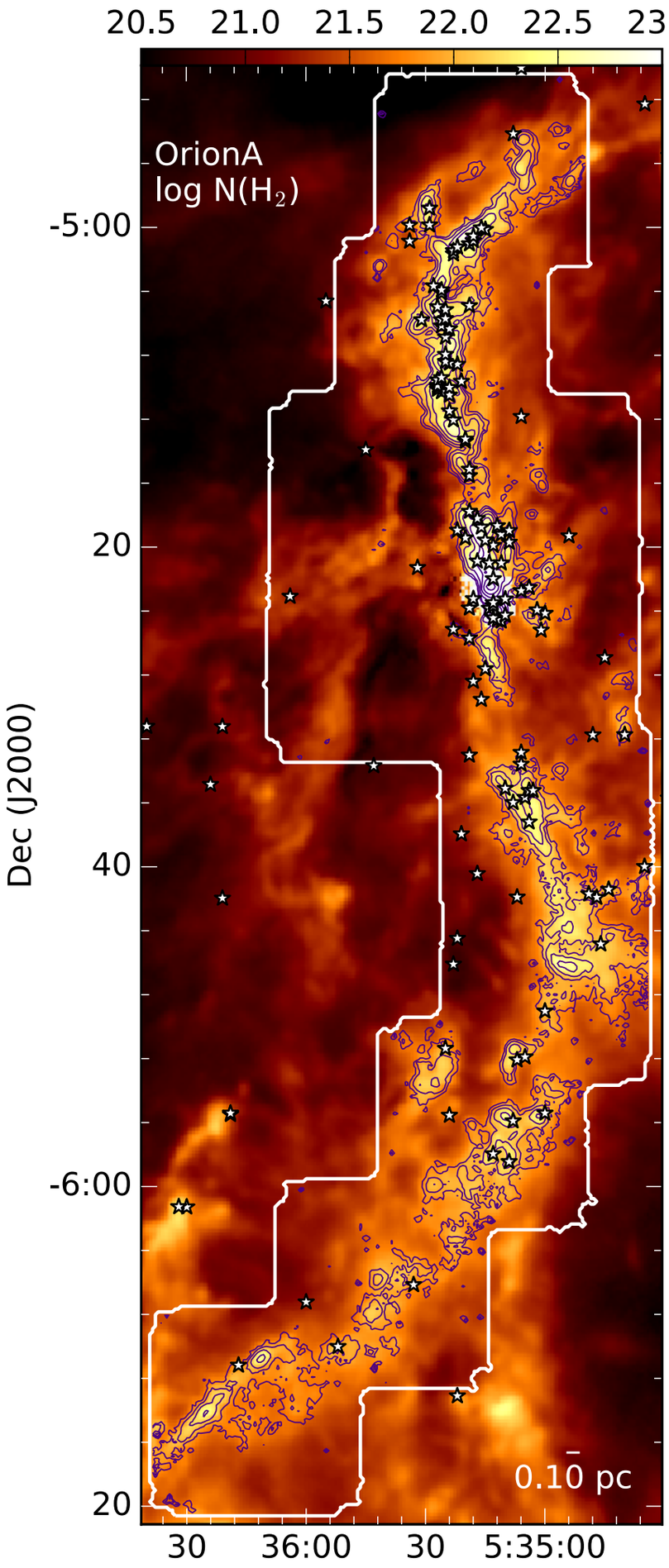
+24:00

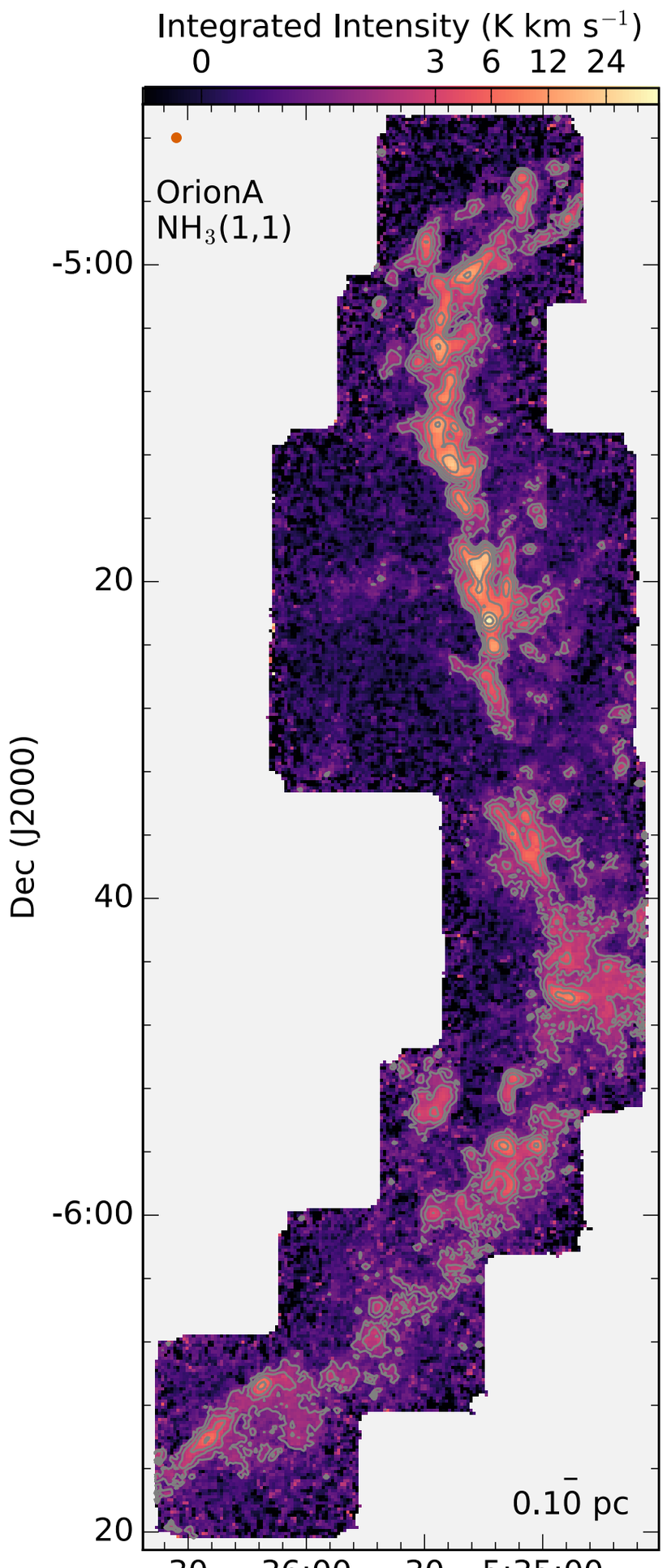
0.10 pc


0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
B18
σ_v (km s^{-1})
50
40
30
20
10
+24:00
0.1̄0 pc

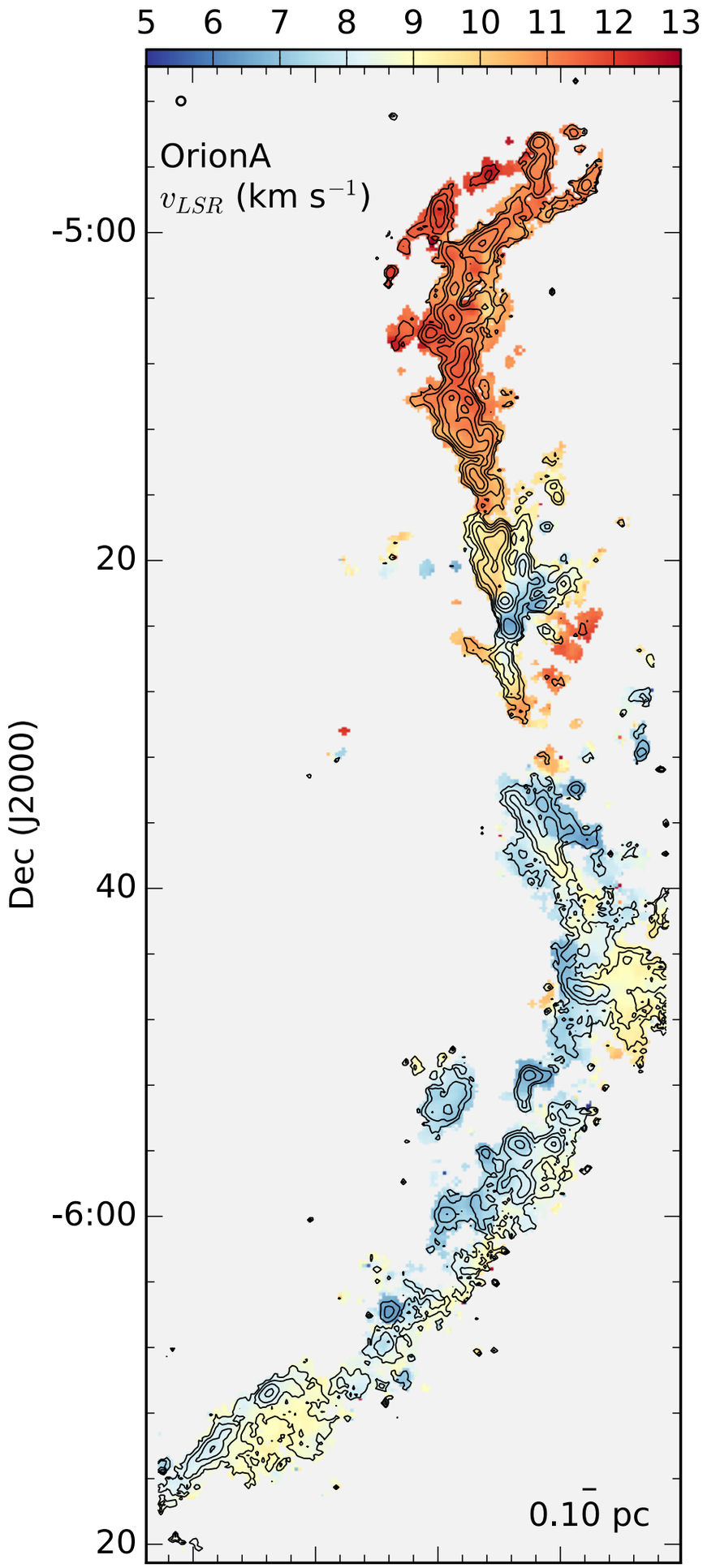

5
6
7
B18
v_{LSR} (km s^{-1})
50
40
30
20
10
+24:00
0.1̄0 pc

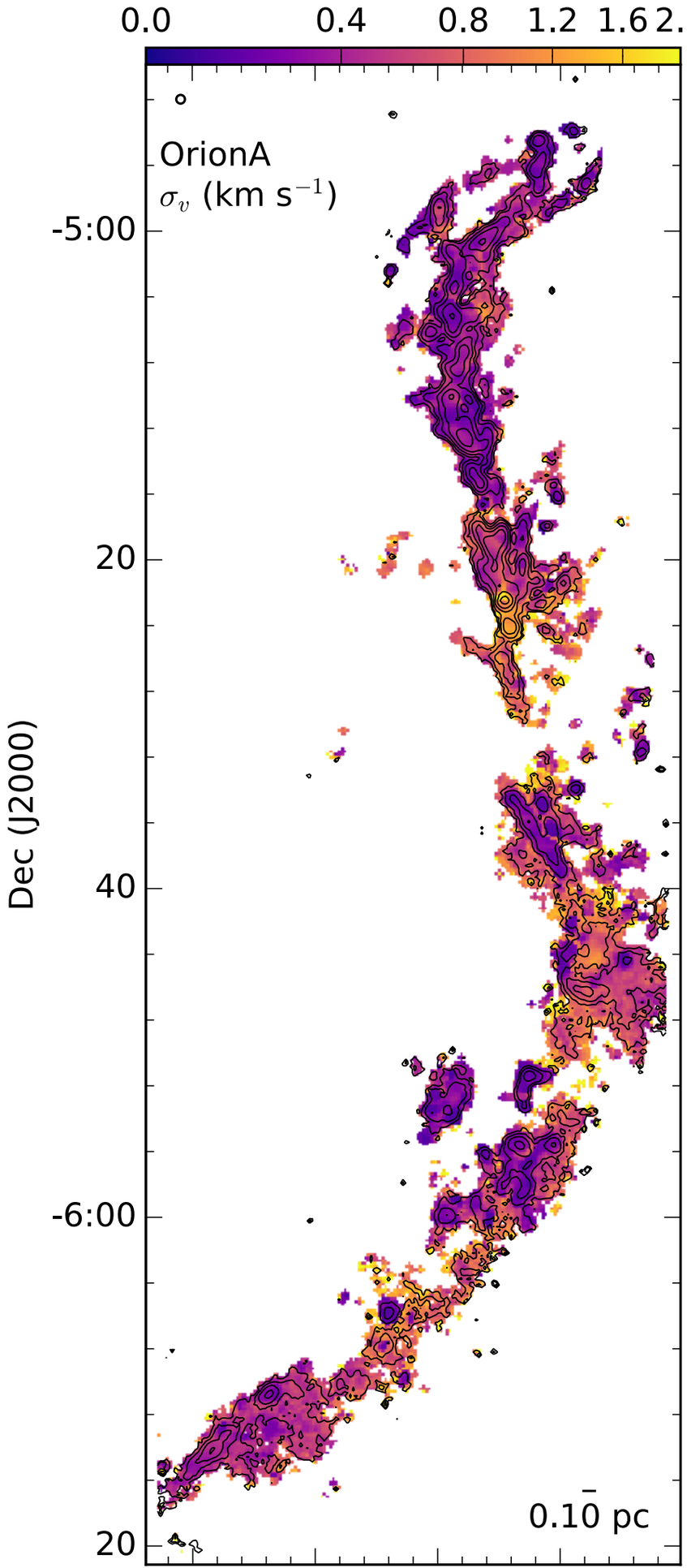
OrionA North



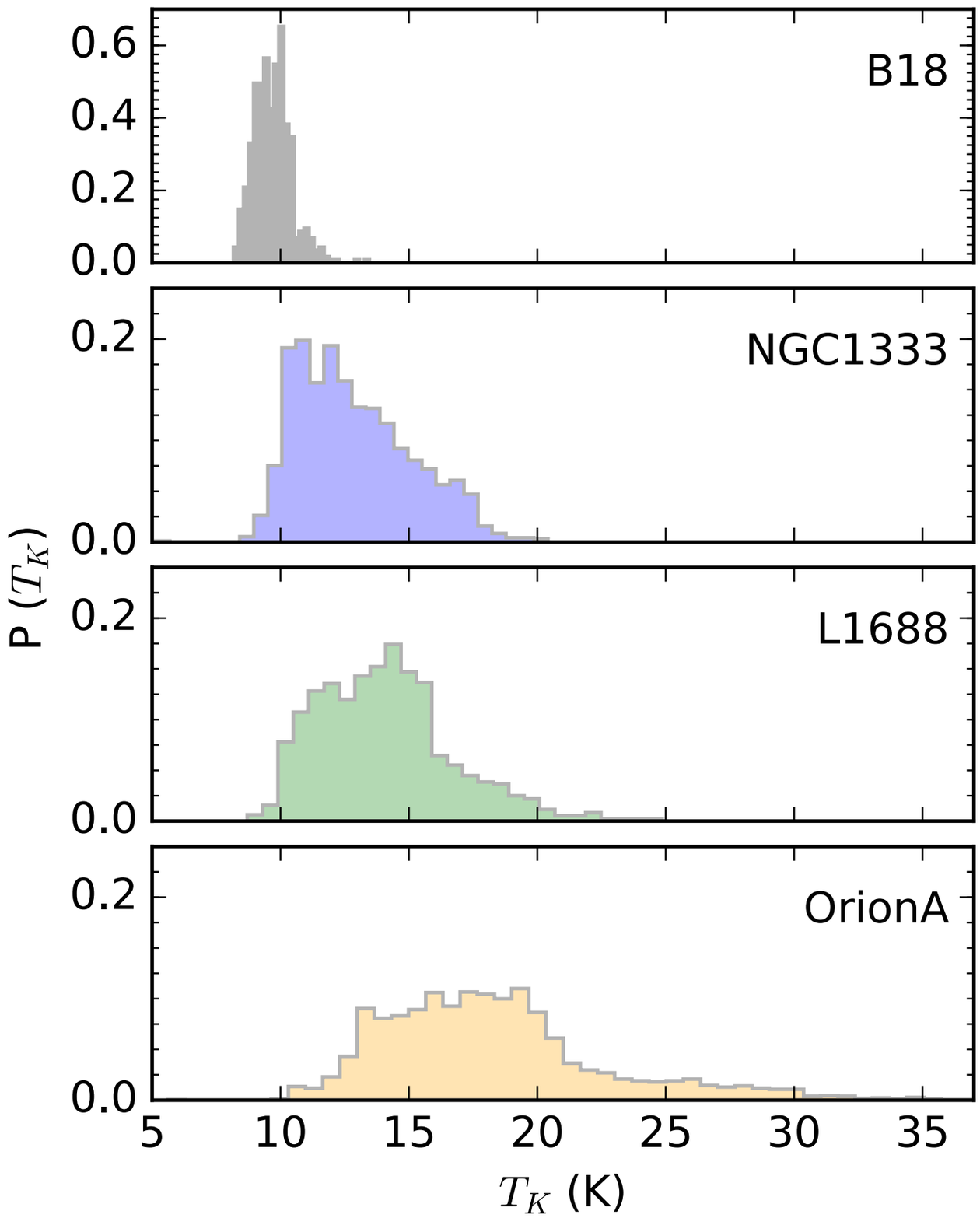


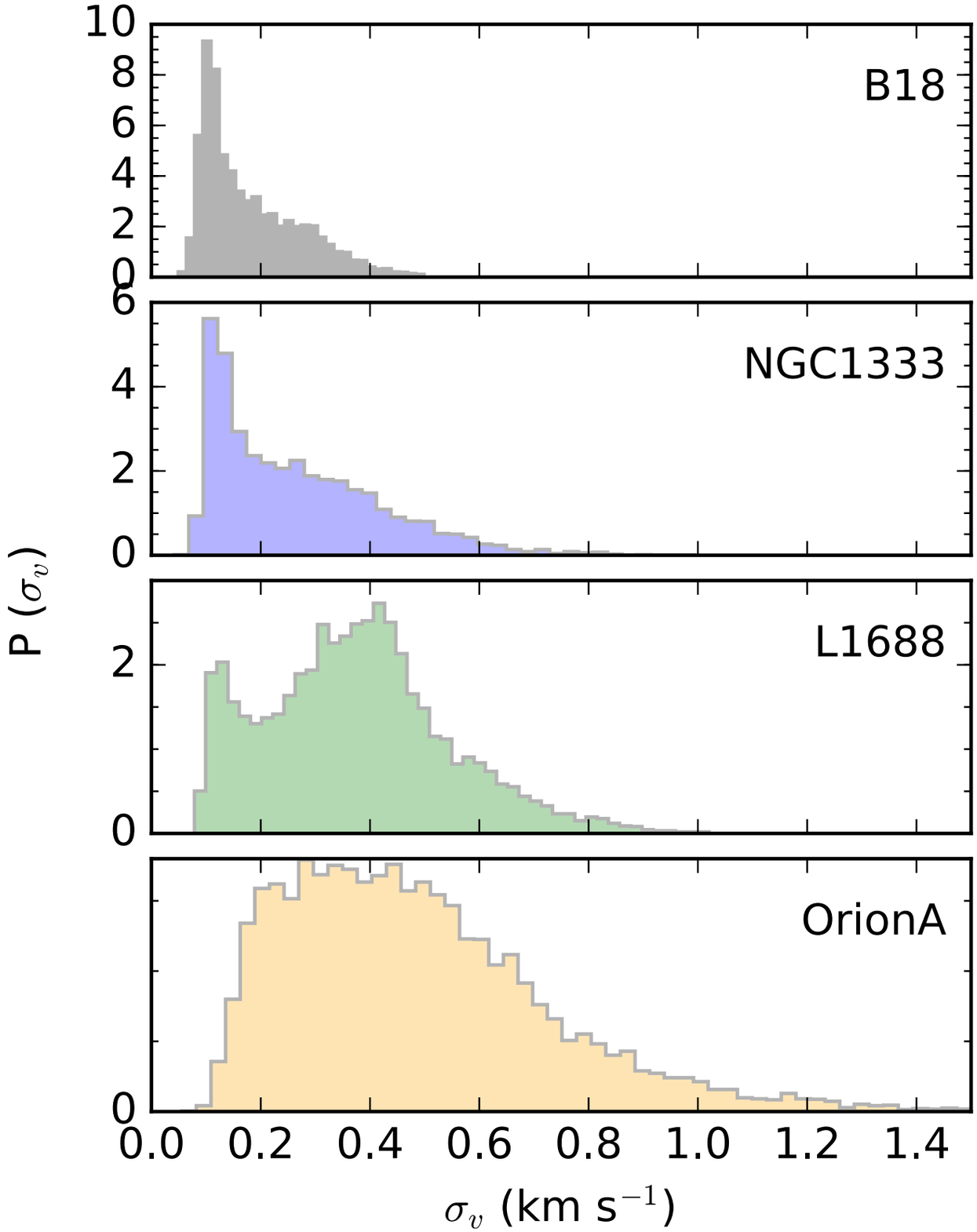
OrionA North



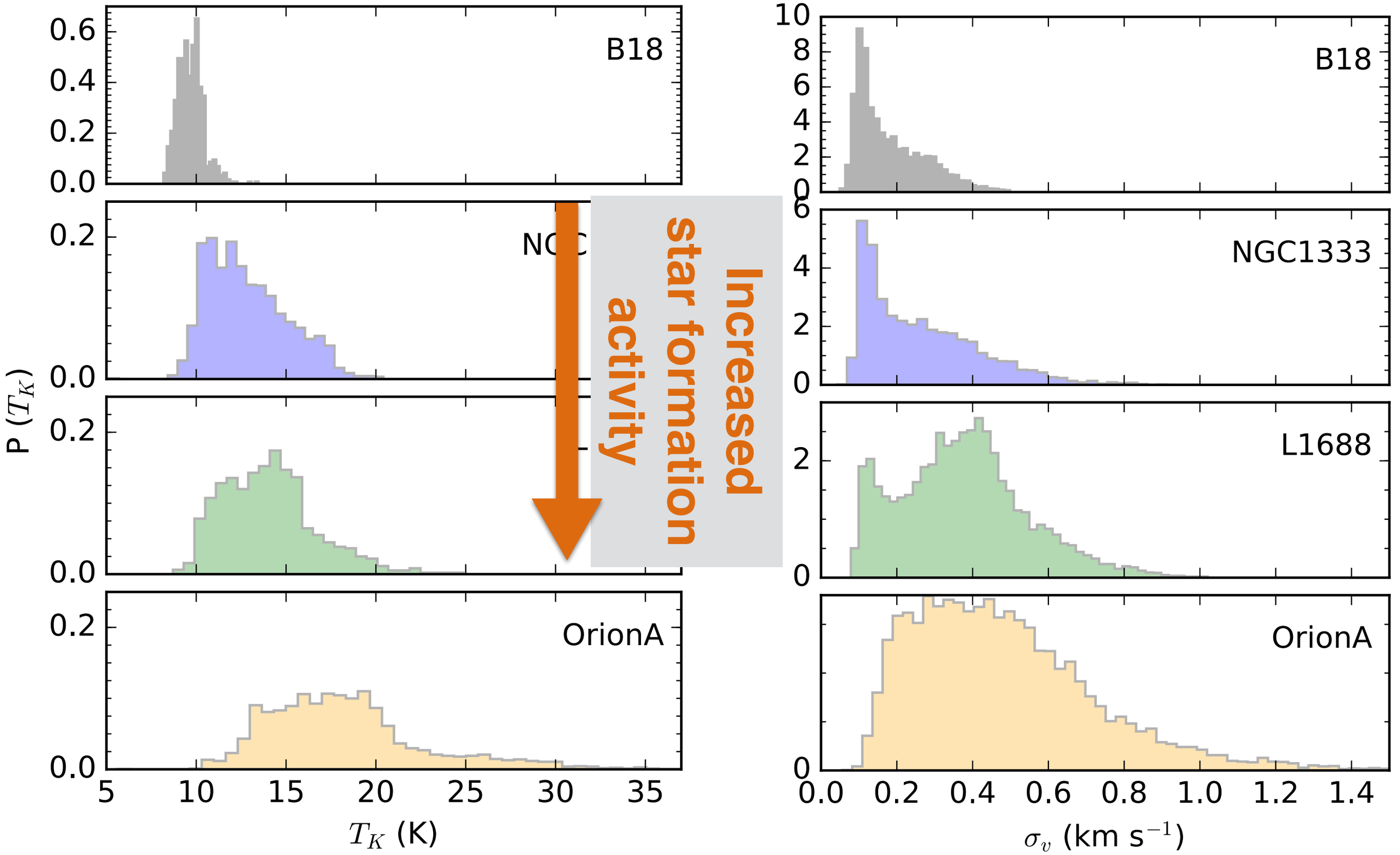


Distributions of properties

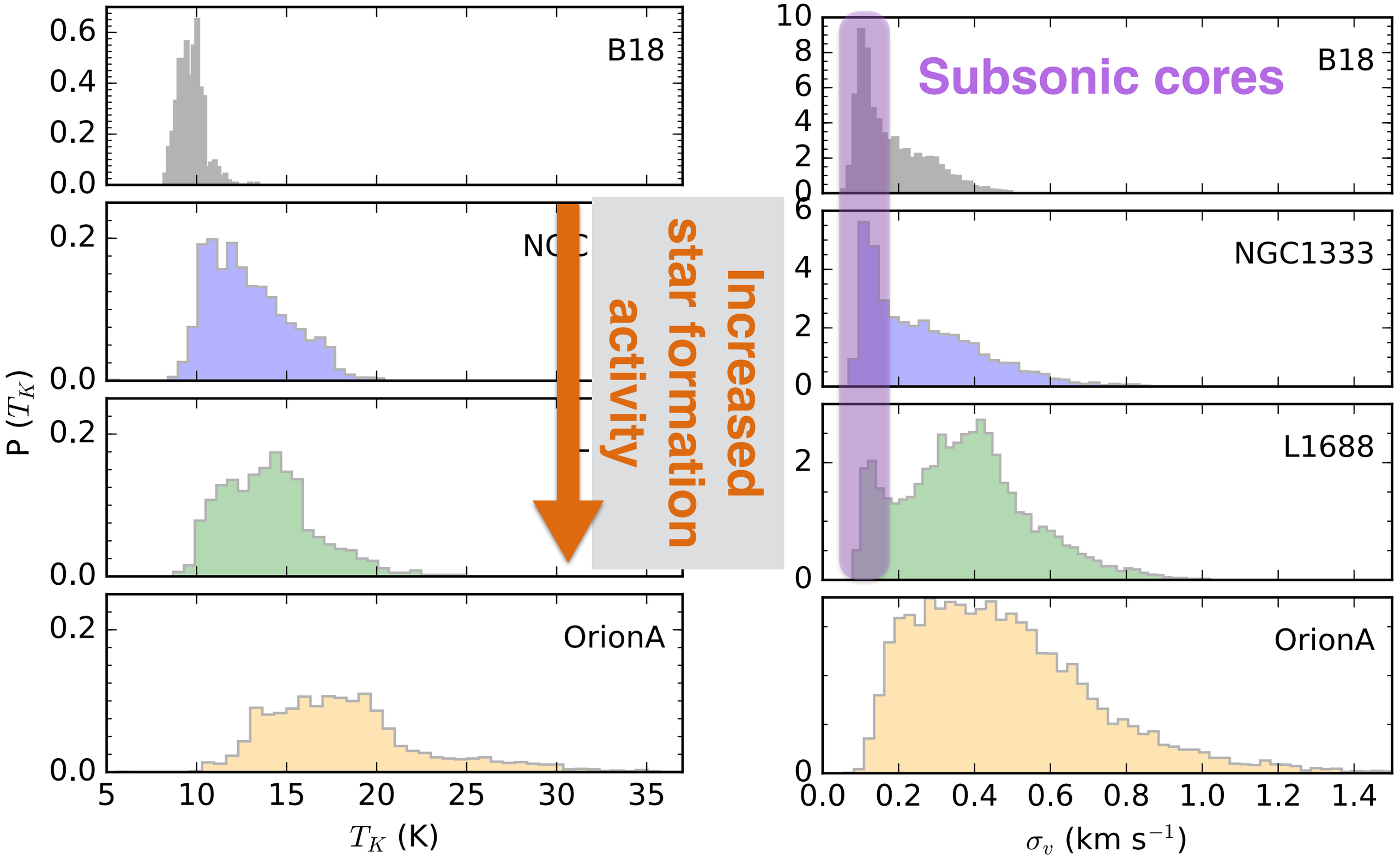




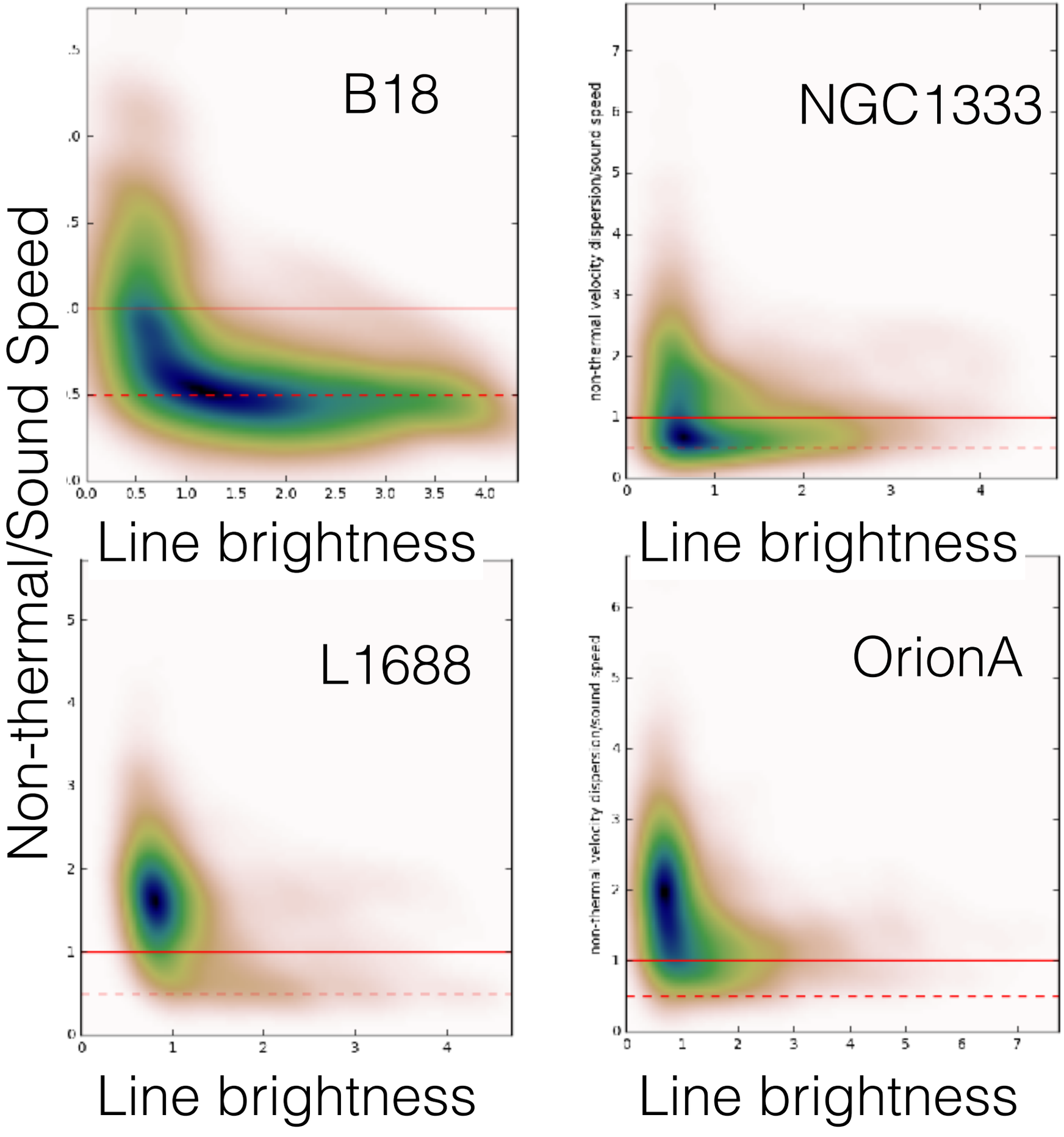
Distributions of properties

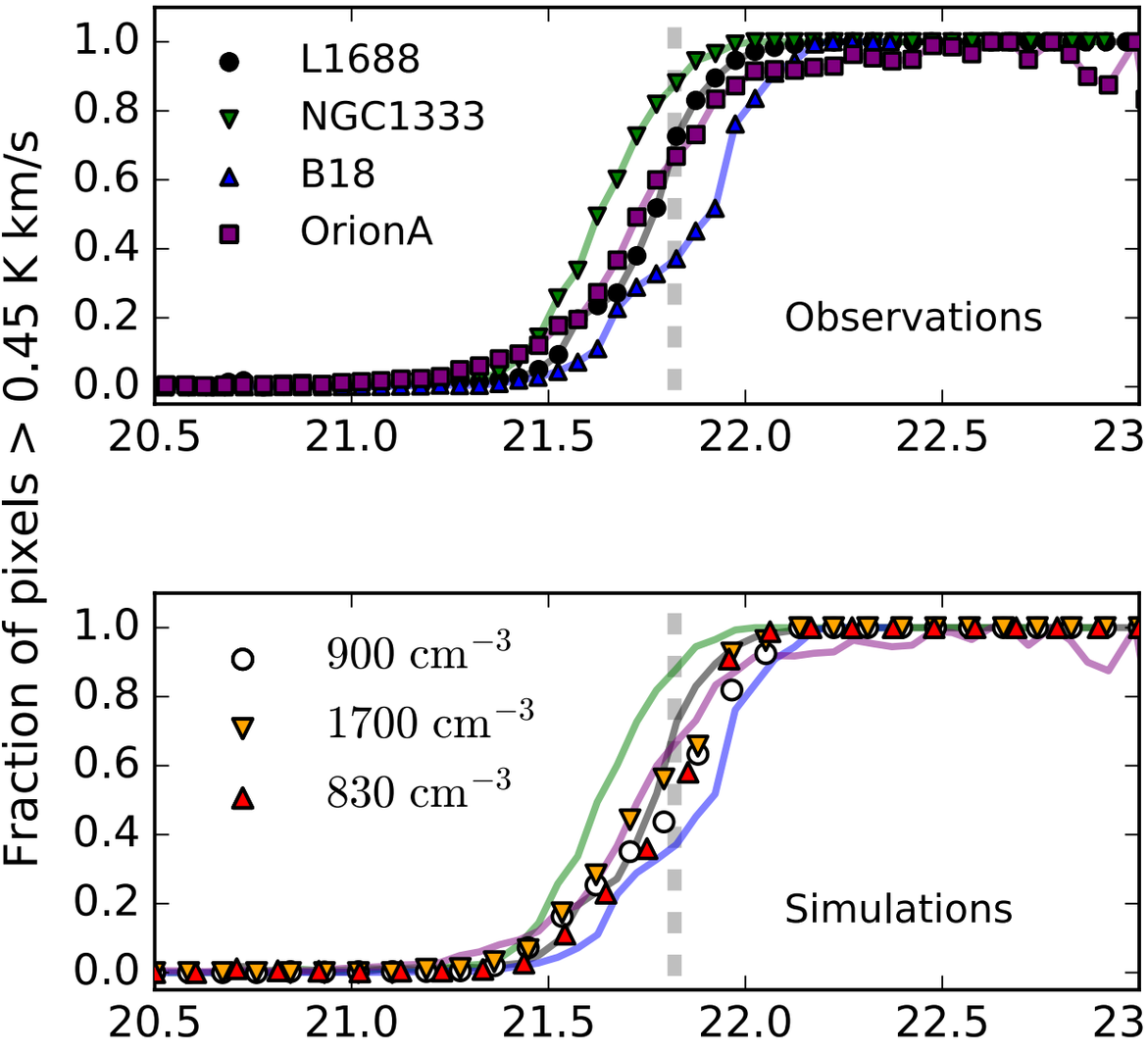


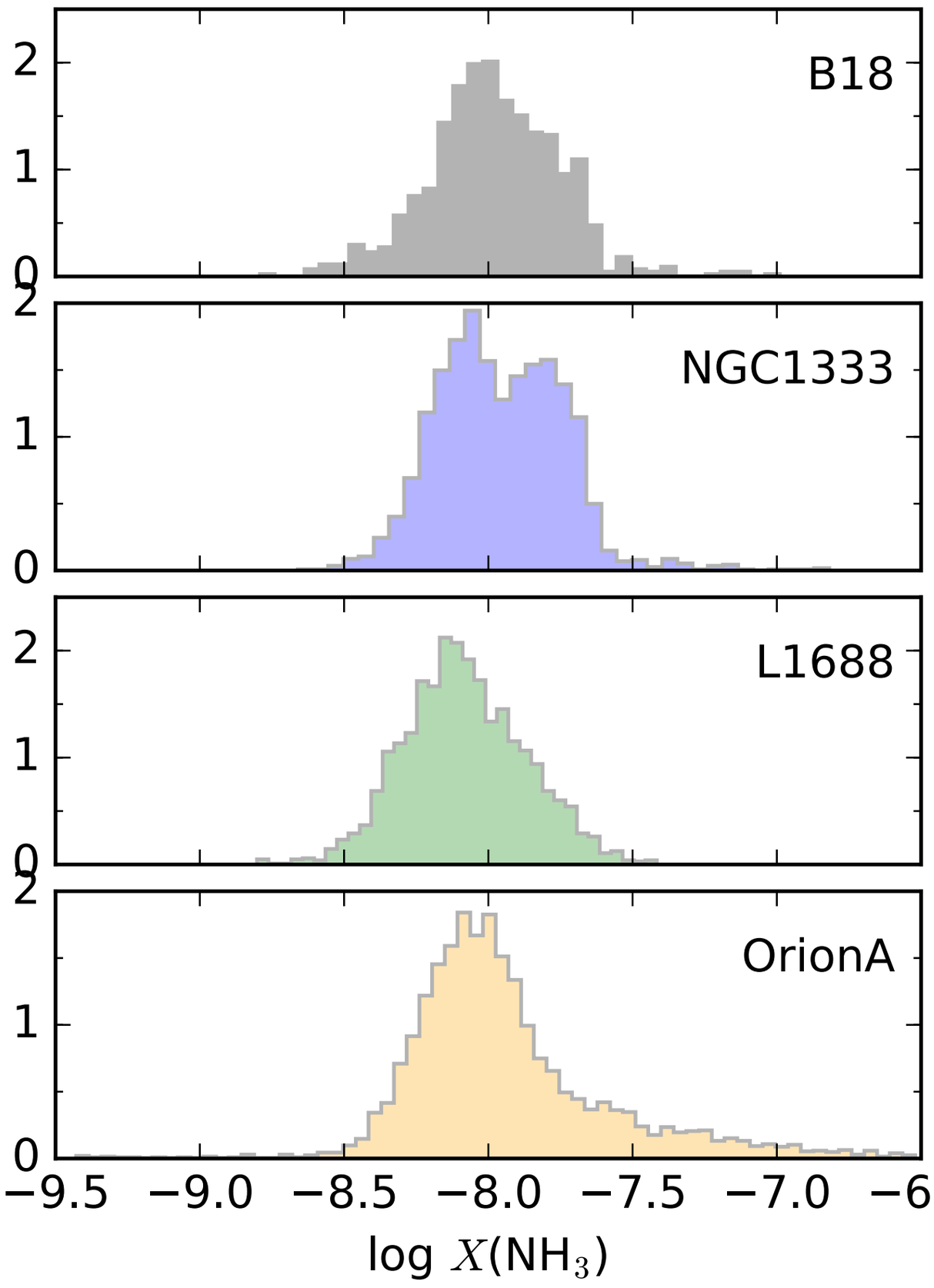
Distributions of properties



Subsonic Regions

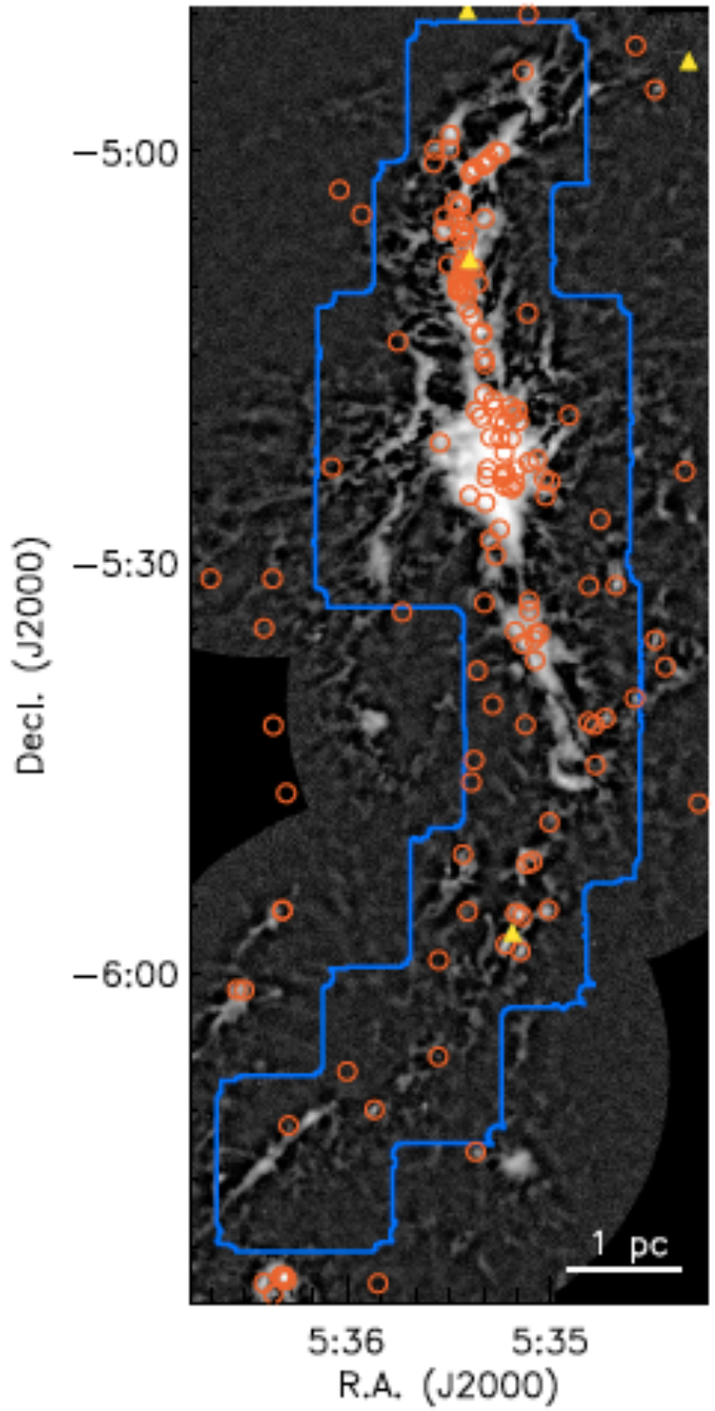


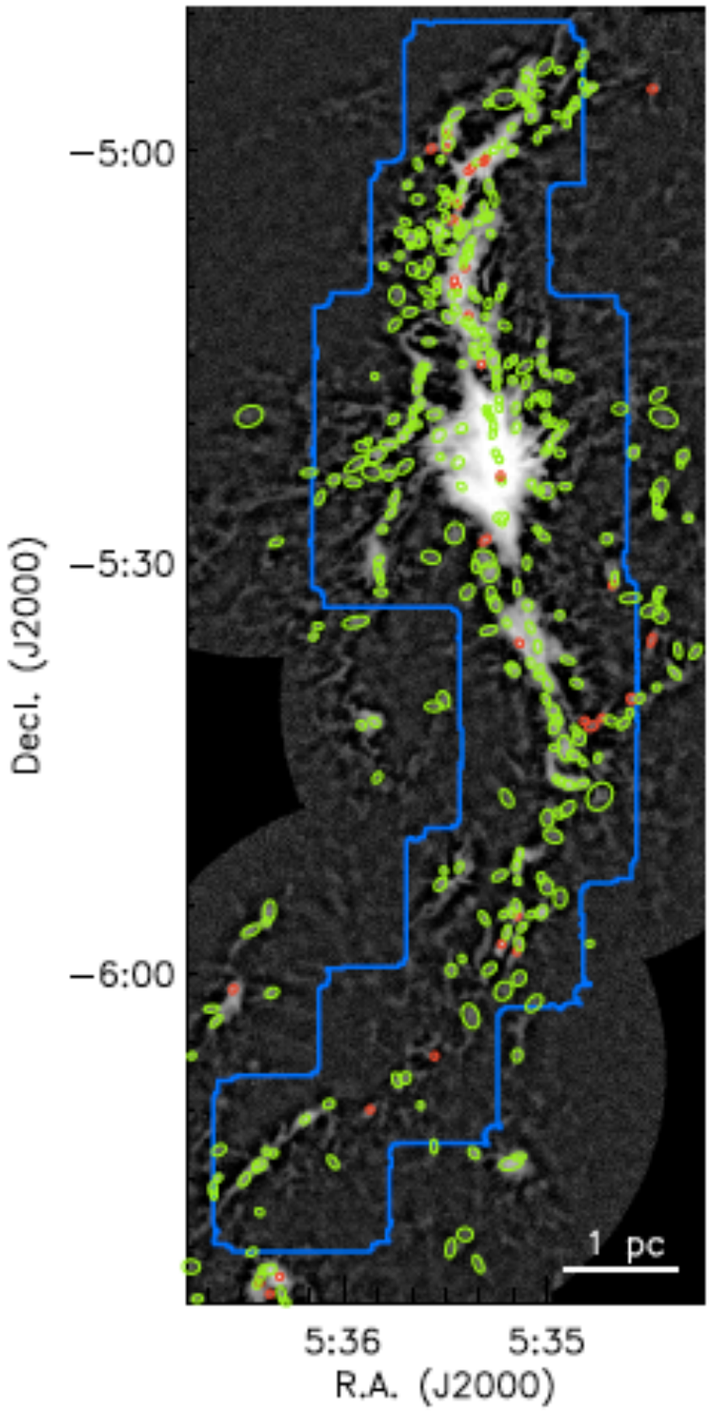

L1688
NGC1333
B18
OrionA
Observations
Simulations
900 cm^{-3}
1700 cm^{-3}
830 cm^{-3}
Fraction of pixels > 0.45 K km/s
log(N(H$_2$) cm^2)


B18
NGC1333
L1688
OrionA
P(X(NH$_3$))
log X(NH$_3$)

Are Dense Cores gravitationally bound?

- Cores from SCUBA2
- Kinematics from NH_3
- Virial analysis





Kirk et al. (2017)

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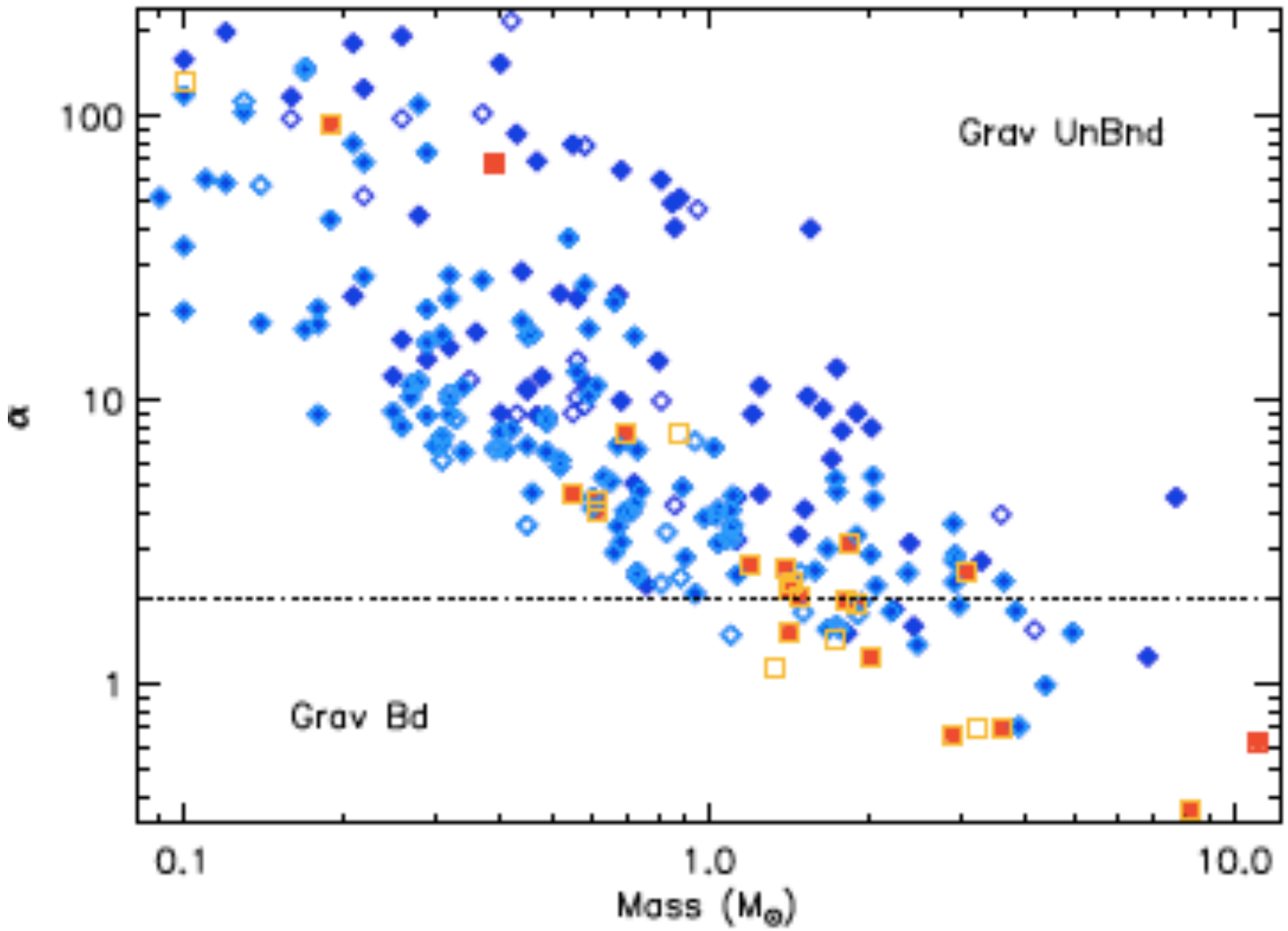

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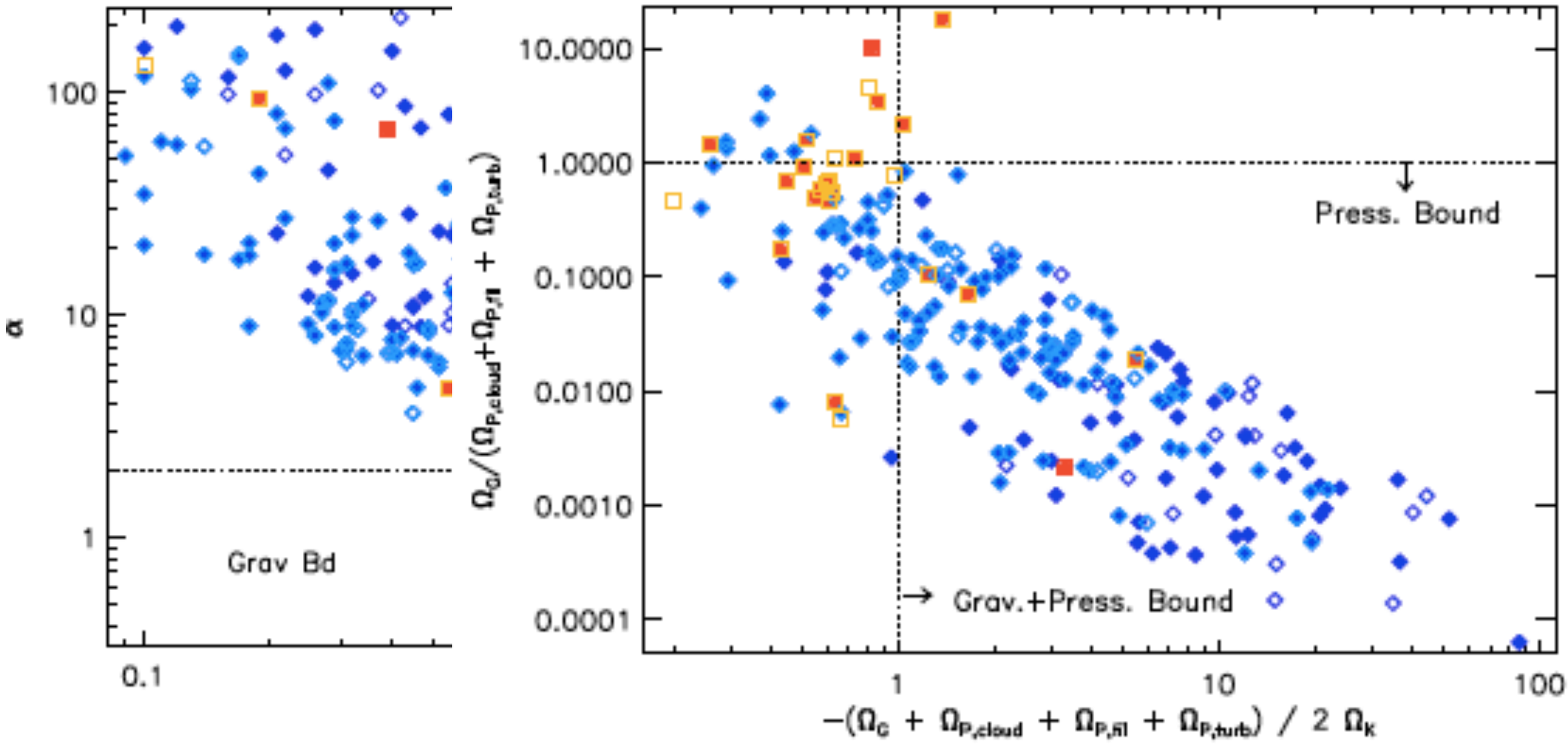

Kirk et al. (2017)

Summary

- Large area maps in NH_3 for Gould Belt Clouds
- Initial release in March 2017
- NH_3 (1,1) is quite extended -> different abundance at low column density?
- Transition between subsonic and supersonic turbulence is observed in most Regions
- A large fraction of the dense gas (NH_3) traces supersonic turbulence
- Why is NH_3 detected in Taurus only at higher column densities?