The “True” Column Density Distribution In Star-Forming Molecular Clouds

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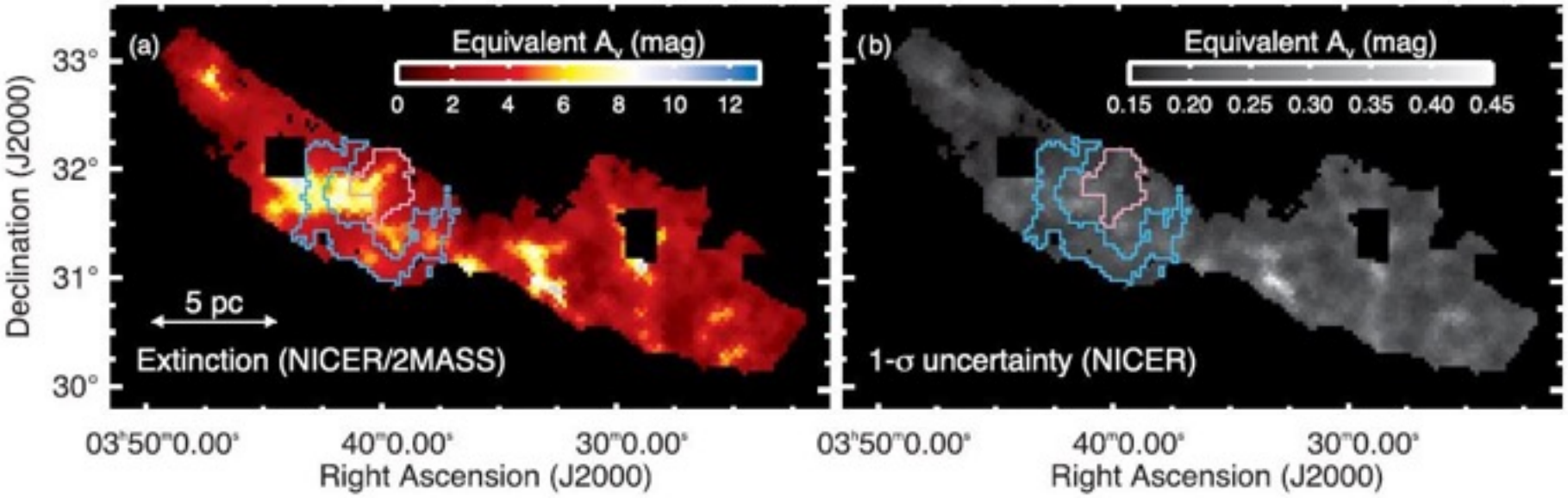
General Overview

- Interested in the structure of molecular clouds:
  - Clouds mostly composed of H_2
  - H_2 radiates very weakly hence Dark clouds.
  - Must find other tracers/methods to map clouds.

- Goal: Compare three different methods for mapping column density in molecular clouds by looking at Perseus cloud
  1. Near-infrared (NIR) extinction mapping
  2. Thermal Emission mapping in the Far-infrared (FIR)
  3. Intensity mapping of CO isotopologues

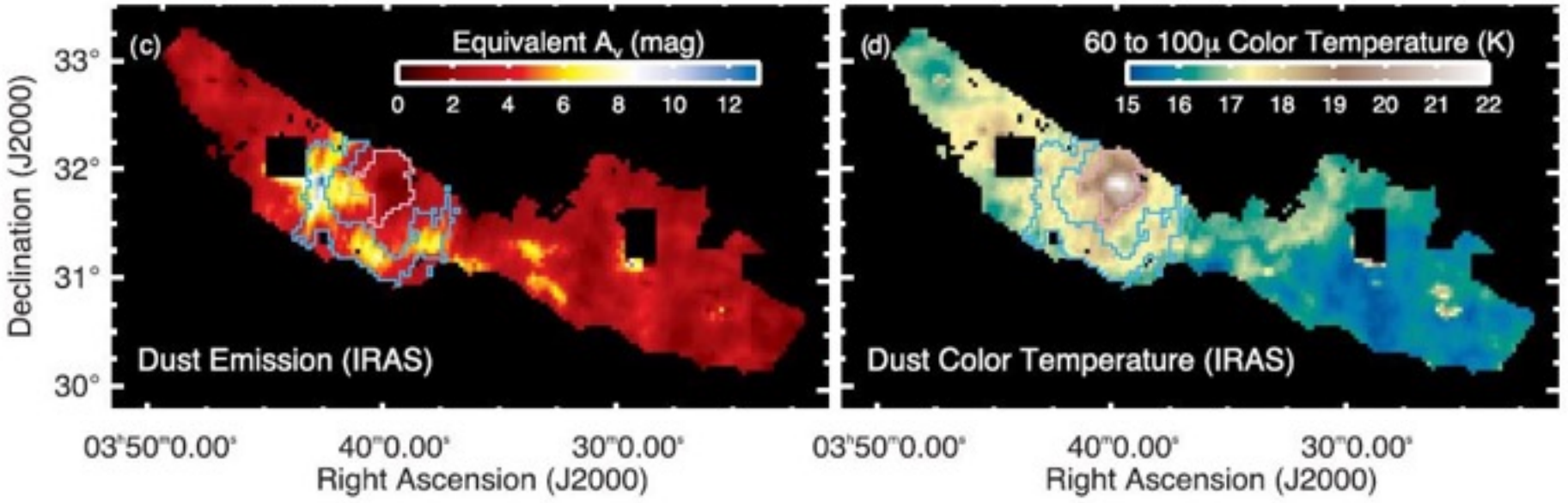
NIR Extinction Mapping

- Technique:
  - Relies on background stars behind the cloud.
  - Calculate extinction rates by comparing observed NIR color of stars to the star intrinsic color.
  - Bright stars embedded in cloud can obscure data
    - Fix: remove all stellar densities larger than 10 stars per pixel.



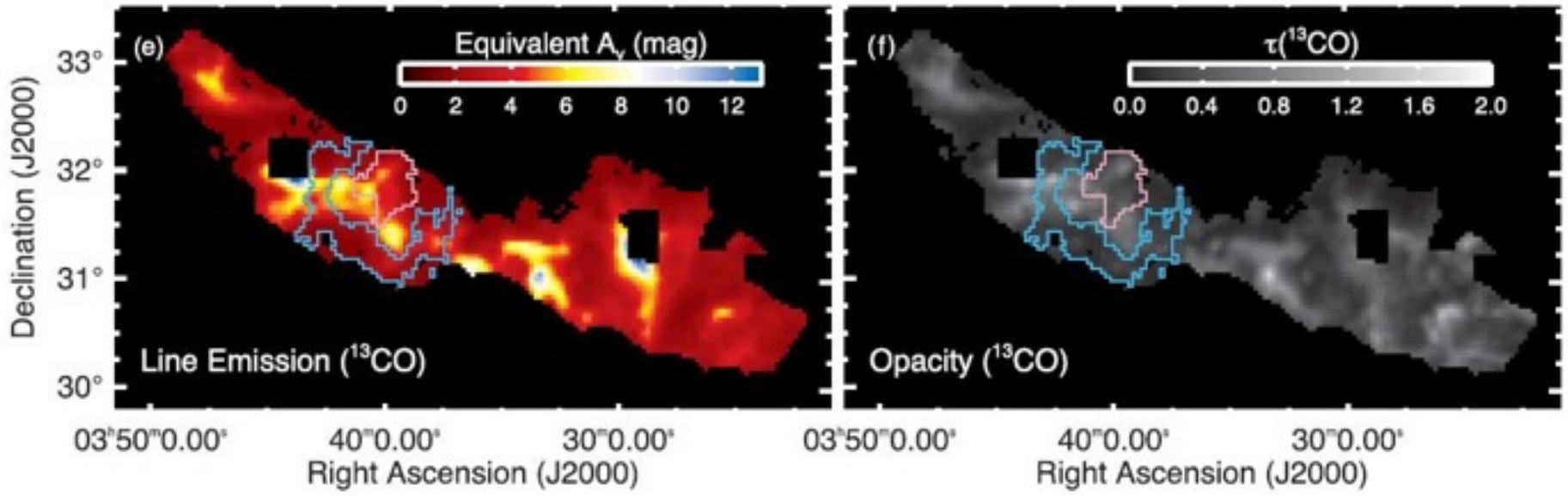
FIR Emission Mapping

- Technique:
  - Measures wavelengths of 60 μm and 100 μm
  - Maps of the wavelength flux are used to derive dust temperature and FIR optical depth maps.
  - Column density map from NIR is used to calibrate and convert the FIR optical depth map to an extinction map.

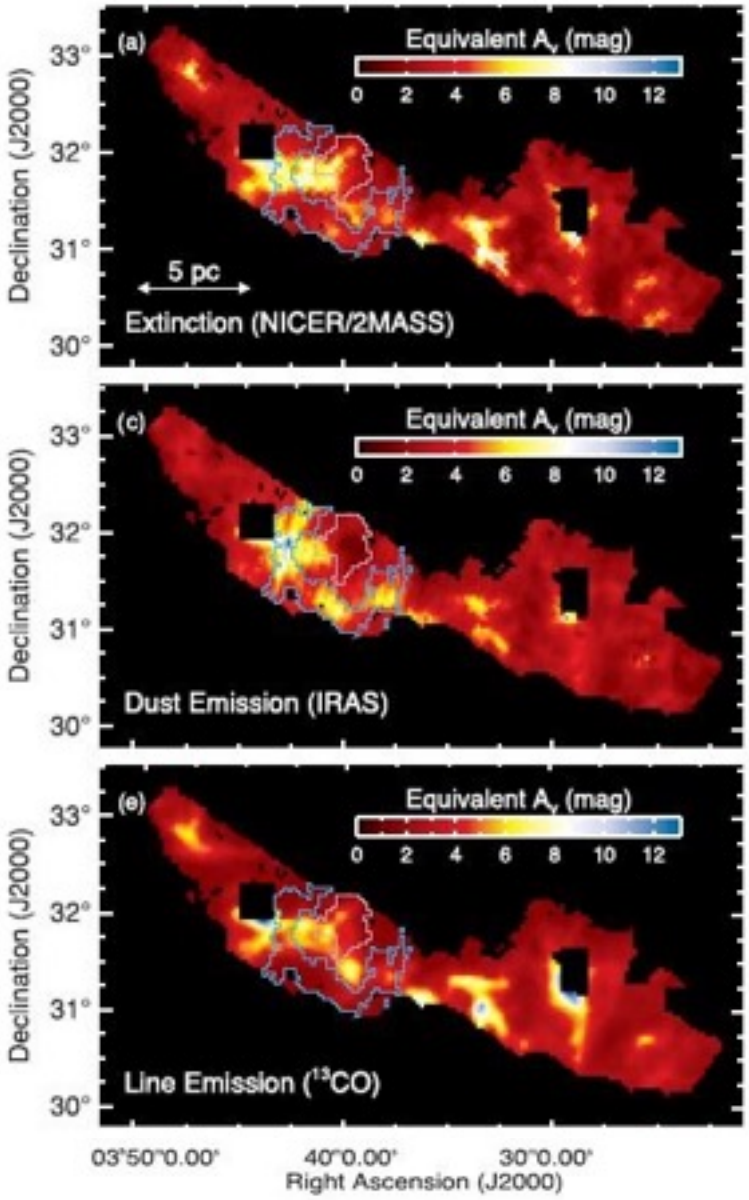


^{13}CO and ^{12}CO Emission Mapping

- Technique:
  - Measure the j(1→0) transitions for ^{13}CO and ^{12}CO
  - Integrating emission of ^{13}CO over all velocities and the multiplying by abundance of H_2 relative to ^{13}CO yields column density.
  - Use measured kinetic temperatures and optical depths from ^{12}CO to increase accuracy



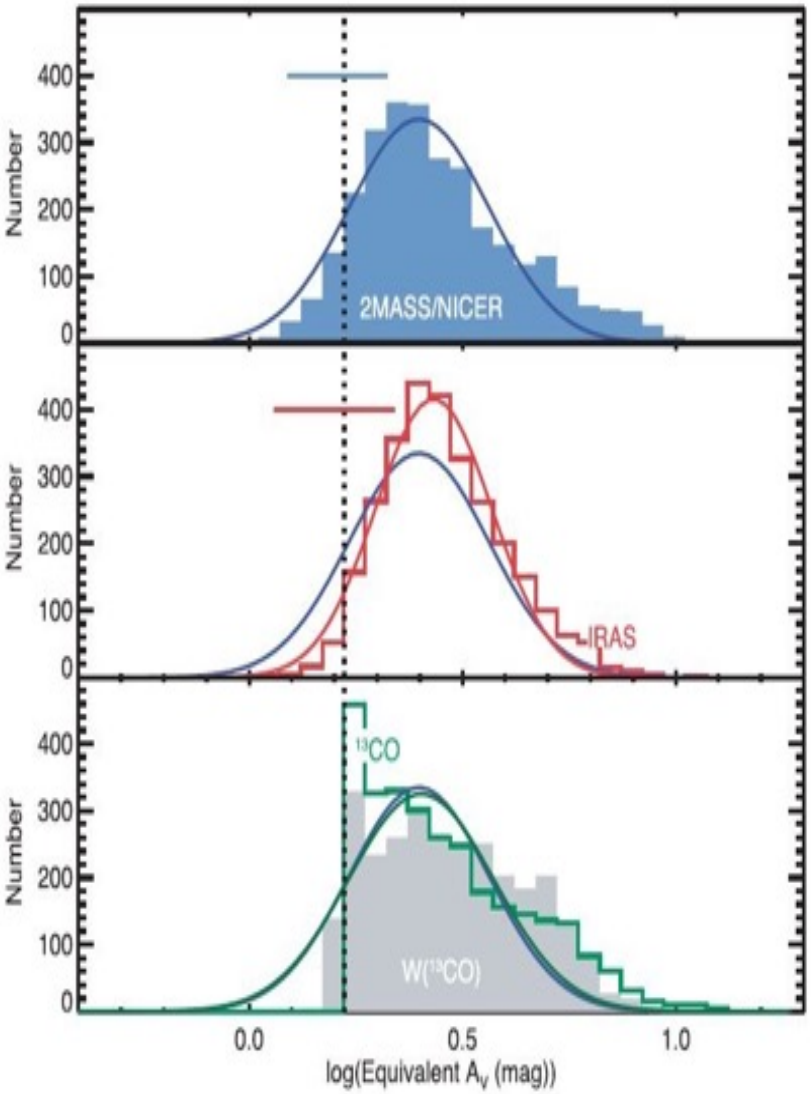
Model Comparison



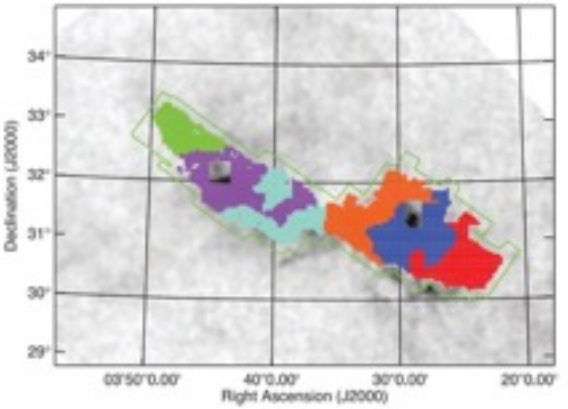
NIR Extinction

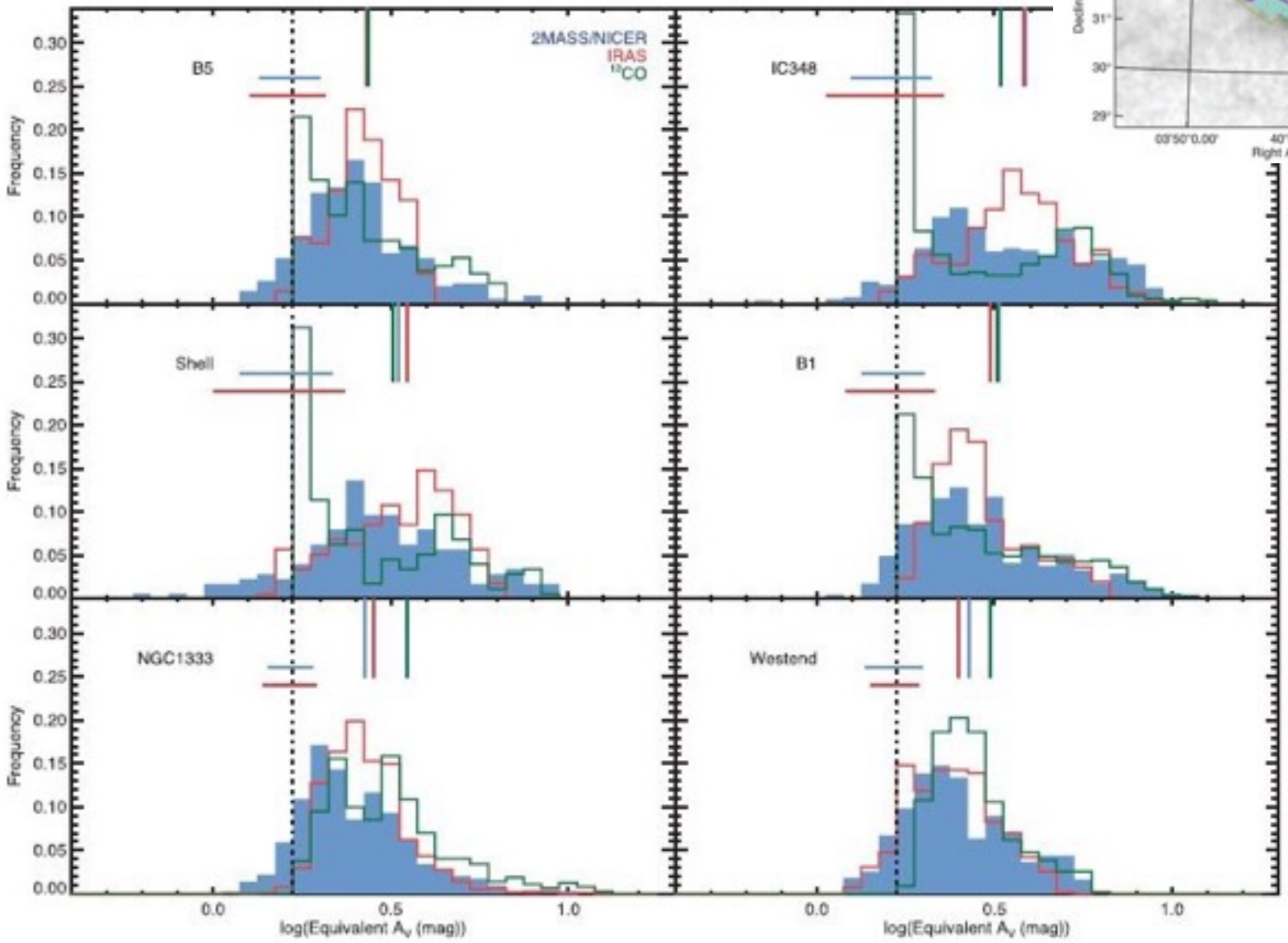
FIR Emission

^{13}CO Trace



Region Comparison





Conclusion

- Difference between NIR-FIR methods is due to temperature
  - Dust emission dependent on temperature, extinction does not.
- Difference between ^{13}CO-Dust methods is due to change in ratio of gas-to-dust along sight line.
- ^{13}CO emissions are biased due to critical density and strongly influenced by stellar objects.
- Moral: All techniques have their associated errors.
- Authors recommended a “holistic” approach.
  - E.g. If dust-to-gas ratio is not varying in a region and there is no line of sight blending issues then use NIR extinction.
  - E.g. If dust-to-gas ratio is unknown then use ^{13}CO emissions.

References

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