On the Luminosity of AGB Stars As Observed in the IR From Space and From the Ground.

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ABSTRACT

Main Topics:

•Introduction on AGB stars and mass loss	p. 3-7
•Why to select C-rich stars	p. 8-9
•Results for C-rich stars	p. 10-16
•Preliminary results for S stars	p. 17-18
•Ground-based observations (TIRCAM2)	p. 19-22

Main Results

•Estimates of bolometric magnitude for Galactic AGB C-rich stars are in agreement with the main theoretical models. The problem of underluminous C-rich stars, that is 20 years old, is not real according to our results and to other works on LMC data (p. 13-14).

•There is no clear correlation between mass loss and bolometric magnitude in C-rich AGB stars. Other parameters must be involved. Different mass loss mechanisms are also possible (p.15).

•Preliminary results of our analysis of a sample of 600 S stars (p.17-18).

•Mid-IR observations from the ground (TIRCAM2) of AGB stars with different chemical composition fit well with space-borne observations (ISO-MSX) of the same sources (p.20-21).

AGB stars:
Open Problems

There are still many unclear points in the study of the AGB evolution…

Uncertain Parameters…

- **Stellar LUMINOSITY** (whose uncertainty influences estimates of other parameters…);
- **Stellar MASS;**
- **MASS LOSS rates as a function** of the **evolutionary stage and of total mass;**
- **Production of CHEMICAL ELEMENTS.**

AGB stars:

Open Problems – Mass Loss

Mass Loss Evolution still uncertain!!

The knowledge of its efficiency is **fundamental** to understand crucial properties of the AGB phase (like its duration and the chemical composition of the matter ejected by mass loss phenomena).

There is not yet a theoretical model fully explaining mass loss processes during the AGB phase, only semi-empirical studies….

Mass Loss Estimates

Nowadays several semi-empirical methods are used to derive mass loss rates of AGB stars from observations of other fundamental parameters.

Le Bertre et al. (2001,2003) showed that the mass loss rates of AGB stars are correlated with the near-IR colors; this method probes the most internal layers of the circumstellar envelope and is expected to fit closely the **present** characteristics of the central star.

We have chosen the procedures suggested by **Knapp & Morris (1985)** for CO lines, that consider the gaseous phase at long wavelengths (mm or radio) where the contribution of the central variable star is negligible.

Mass Loss Estimates: Our Choices

The approaches for the mass loss estimates with the CO lines can be of different types, in particular we adopt:

$$\dot{M}_g = 1.4 \times \frac{T_{mb}\, v_e^2\, D^2\, B^2}{2 \times 10^{19}\, f_{CO}^{0.85}\, s(J)}, \qquad (3)$$

is used, where $\dot{M}_g$ is in solar masses per year, T_{mb} is the main-beam peak temperature in Kelvin, v_e is the gas expansion velocity in km s^{-1}, D is the distance in parsec, B is the FWHM size of the telescope beam in arcsec, f_{CO} is the CO abundance relative to H_2, and $s(J)$ is a correction factor, equal to unity for the $J = 1-0$ transition and 0.6 for the $J = 2-1$ transition.

Olofsson et al. (1993), adopted by **Groenewegen et al. (2002)**

The limits of this technique include the adoption of a *constant size for the CO envelope* and of a *treatment formally valid only for optically thick CO emission*.

$$\dot{M} = \frac{V_e^2\, d^2\, T_{MB}}{2\ 10^9\ f^{0.85}} \times F^{-1}(R_{CO})\, M_\odot \cdot \mathrm{yr}^{-1} \qquad (6a)$$

$$\dot{M} = 10^{-6} \left(\frac{R_{CO}}{7.3\ 10^{16}}\right)^{1/0.58} \left(\frac{V_e}{10}\right)^{1/1.45} \times \qquad (6b)$$

$$\times \left(\frac{4\ 10^{-4}}{f}\right)^{1/1.16} M_\odot \cdot \mathrm{yr}^{-1}$$

Loup et al. (1993), adopted by **Winters et al. (2003)** and in several other cases.

This is a **more general analysis** in which the assumptions of a constant value for the CO envelope and of an optically thick CO emission are dropped.

The Task

To perform an **analysis of AGB stars** of different chemical compositions looking for quantitative correlations between their basic parameters (**Bolometric Luminosity, Mass Loss, Photometric Colors**……).

First step

collect a sample as large as possible of AGB stars of classes M, S, C with: good ***near-IR photometry***

ground-based surveys (2MASS, DENIS)

reliable ***measurements of mass loss***

already existing or that can be easily compiled.

Whenever possible we have also ***collected mid-IR photometric data*** in the 8-25 (45) μm window. (ISO, MSX).

Comparison with ground-based observations in the mid-IR (TIRCAM2).

The Sample:
Selection Rules

Important parameters

1. **Mid-IR observations (ISO-SWS and MSX)**
2. ***Distance estimates (type of measurements….)***
3. **Mass loss estimates (various models)**
4. **Knowledge of variability type**
5. **Mid-IR ground-based observations (TIRCAM).**

The C-rich Star Sample

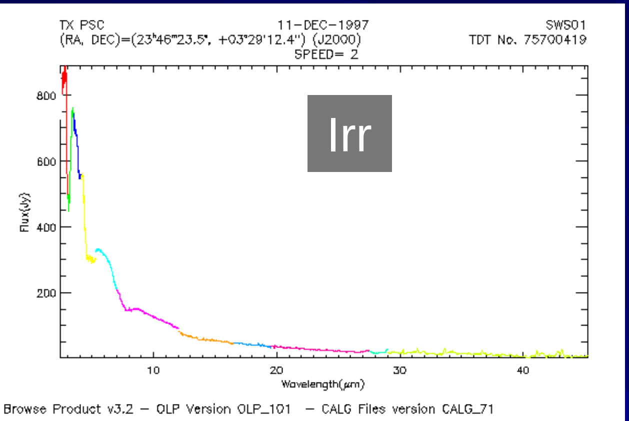
Our first interest is the study of the **sub-sample of Carbon-rich AGB stars** because they present **a higher level of homogeneity** **and** **may require a simpler analysis**.

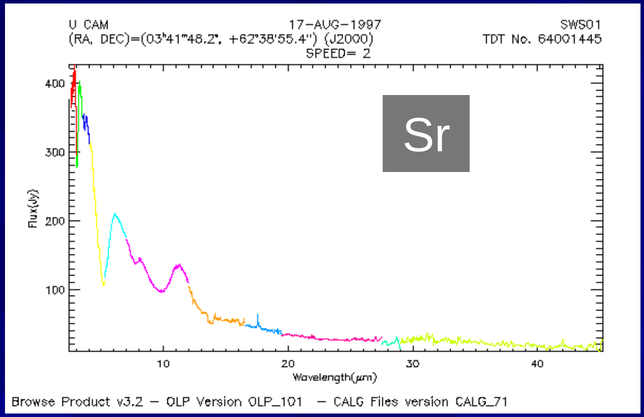
Property of **AGB Carbon-rich stars**:

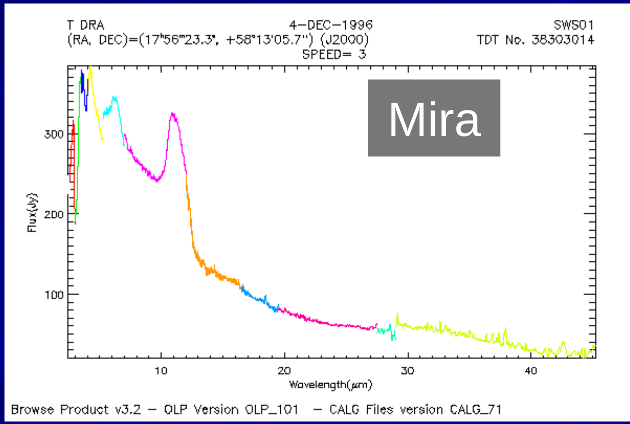
Limited to a **non-enormous interval of mass**

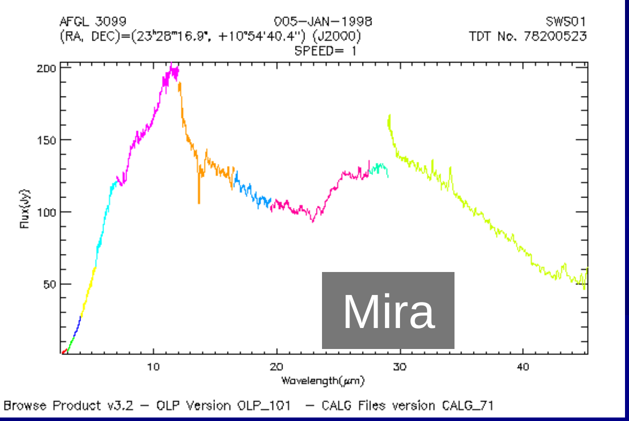
(but even so their *mass loss* estimates *cover a wide range*).

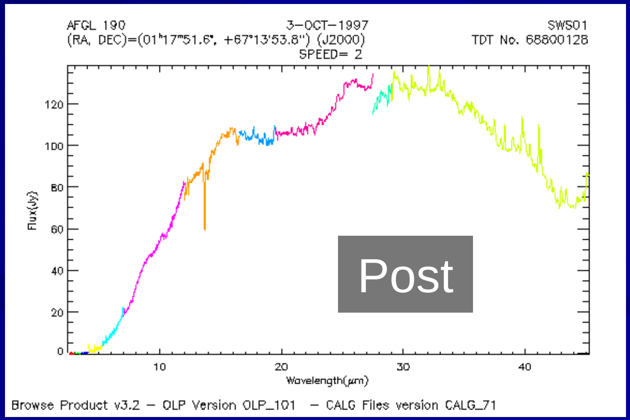
Results:
Mid-IR Observations with ISO(SWS)

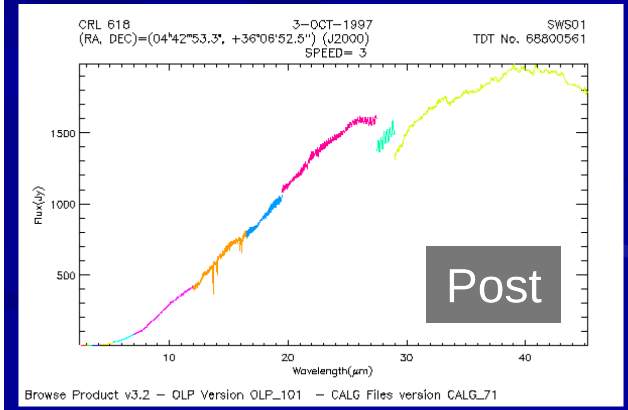








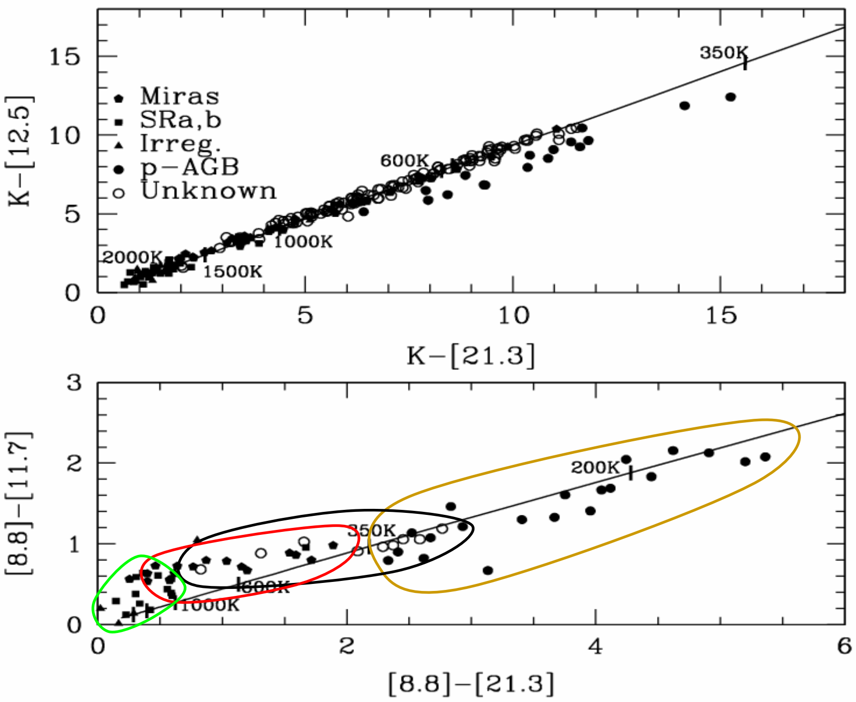




Results :
Color-Color Diagram

Different variability types are well distinguished by IR colors.

Distance does not cause uncertainty in these diagrams.



Guandalini et al. 2006

AGB stars:

Open Problems - Luminosity

- CONVECTIVE EQUILIBRIUM characterizes the envelope on the AGB:
- Dredge-up repeated phenomena: chemical enrichment.
- Expansion of stellar radius (over 1 AU): external layers of the envelope become relatively cool (2500 – 3000 K), formation of dust grains origin of mass loss phenomena.

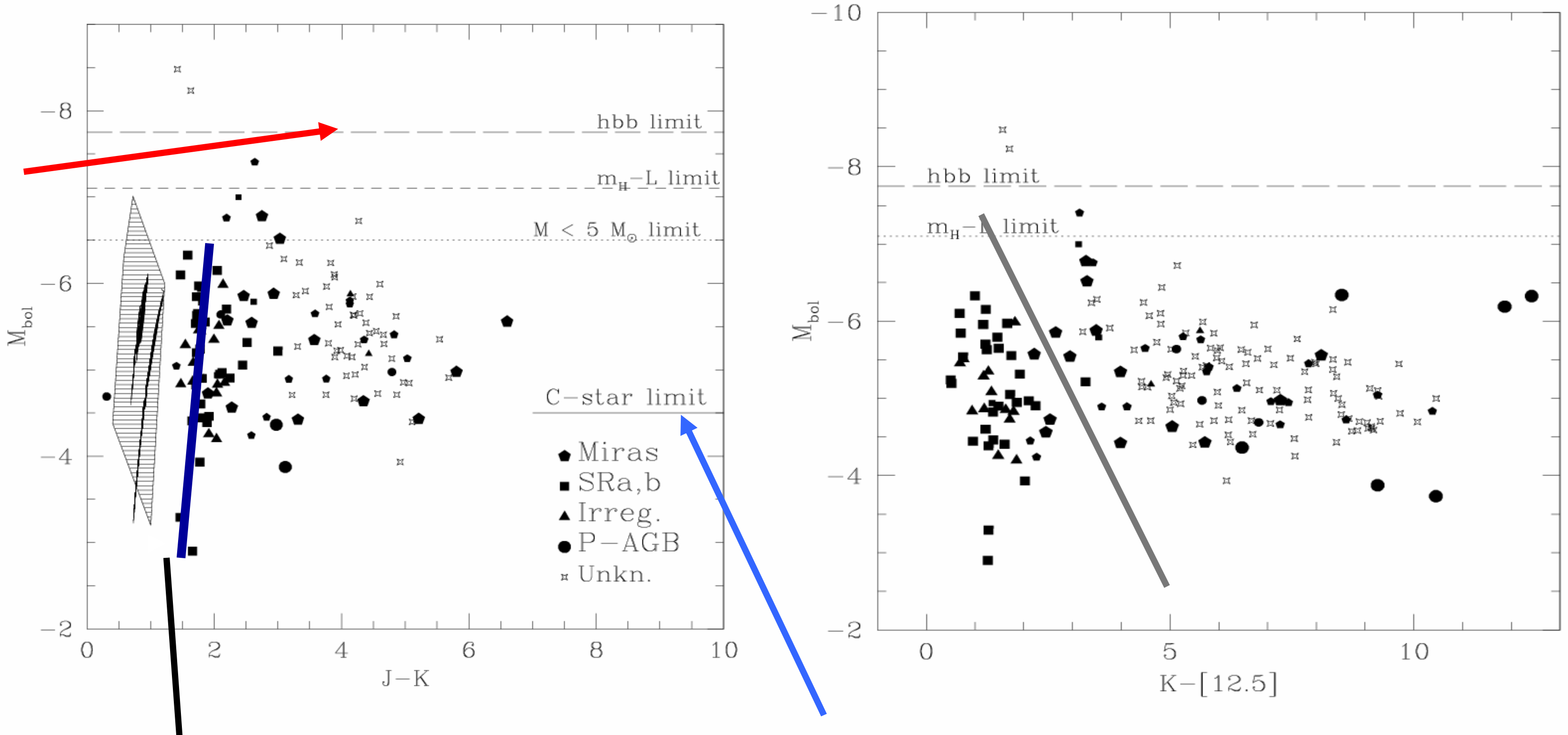
Minimum bolometric magnitude at which canonical models can explain the formation of Carbon stars is around **-4.6 / -4.8 (Cristallo et al. this meeting).**

Observations made on samples of C-stars in the Magellanic Clouds gave estimates of C star magnitude between -4 and -4.5 (Blanco et al. 1980, Costa & Frogel 1996)…

DISCREPANCY WITH MODELS!! C-STARS WITH LOWER MASSES??

Results

Bolometric Magnitude - Colors



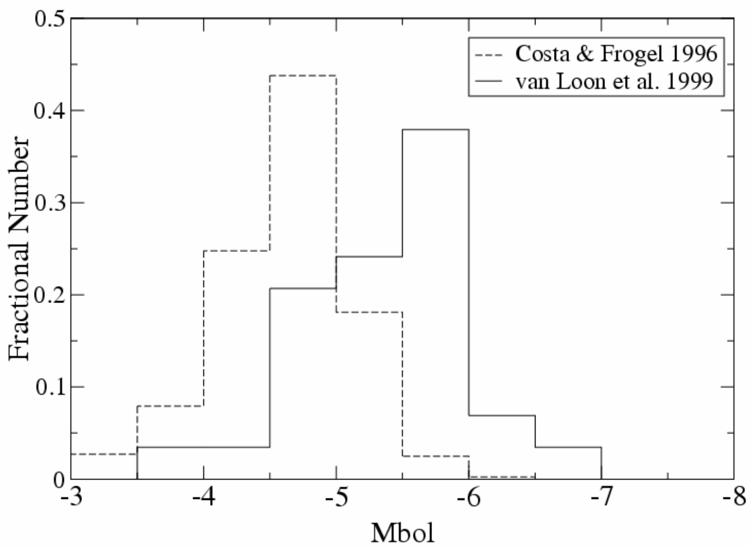
Marigo et al.
Molec. Opac. ?

Guandalini et al. 2006

Results:
C-rich Stars Luminosity

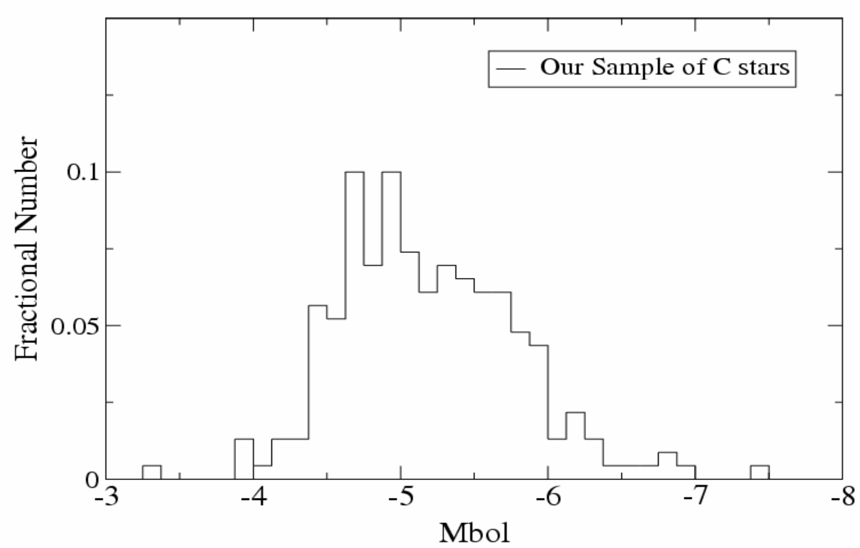
Magellanic Clouds

Costa & Frogel 1996;
Van Loon et al. 1999



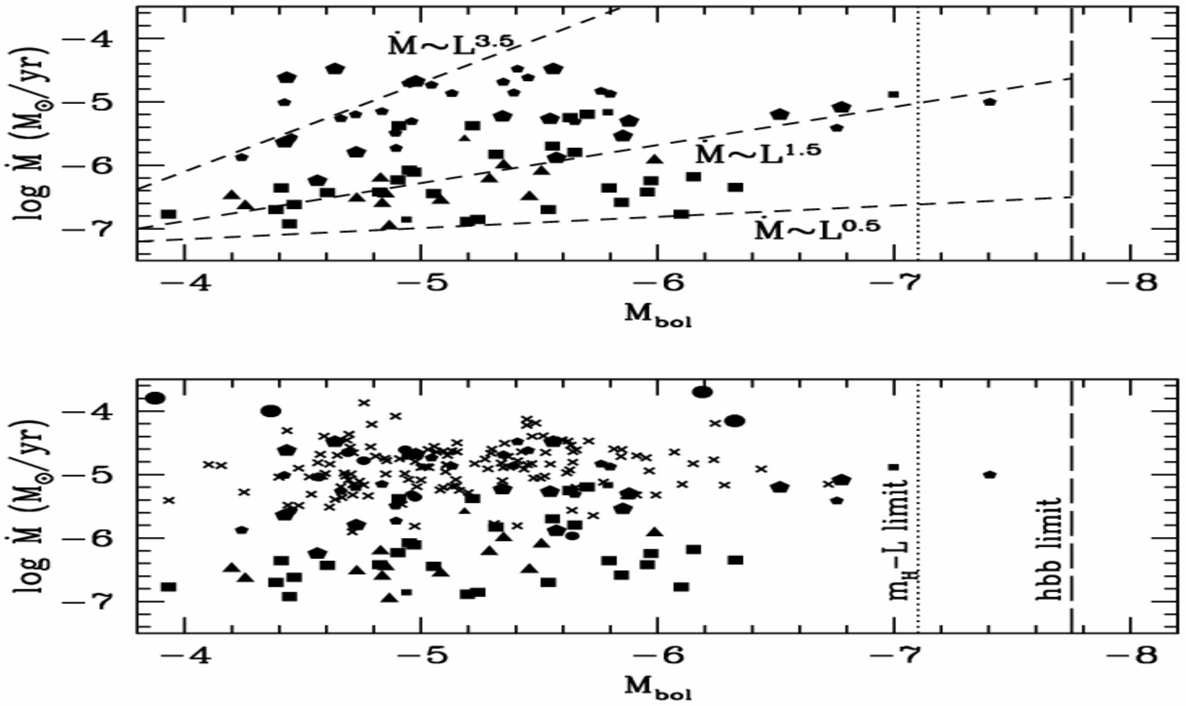
Galaxy

Guandalini et al. 2006



Results:

Mass Loss – Bolometric Magnitude

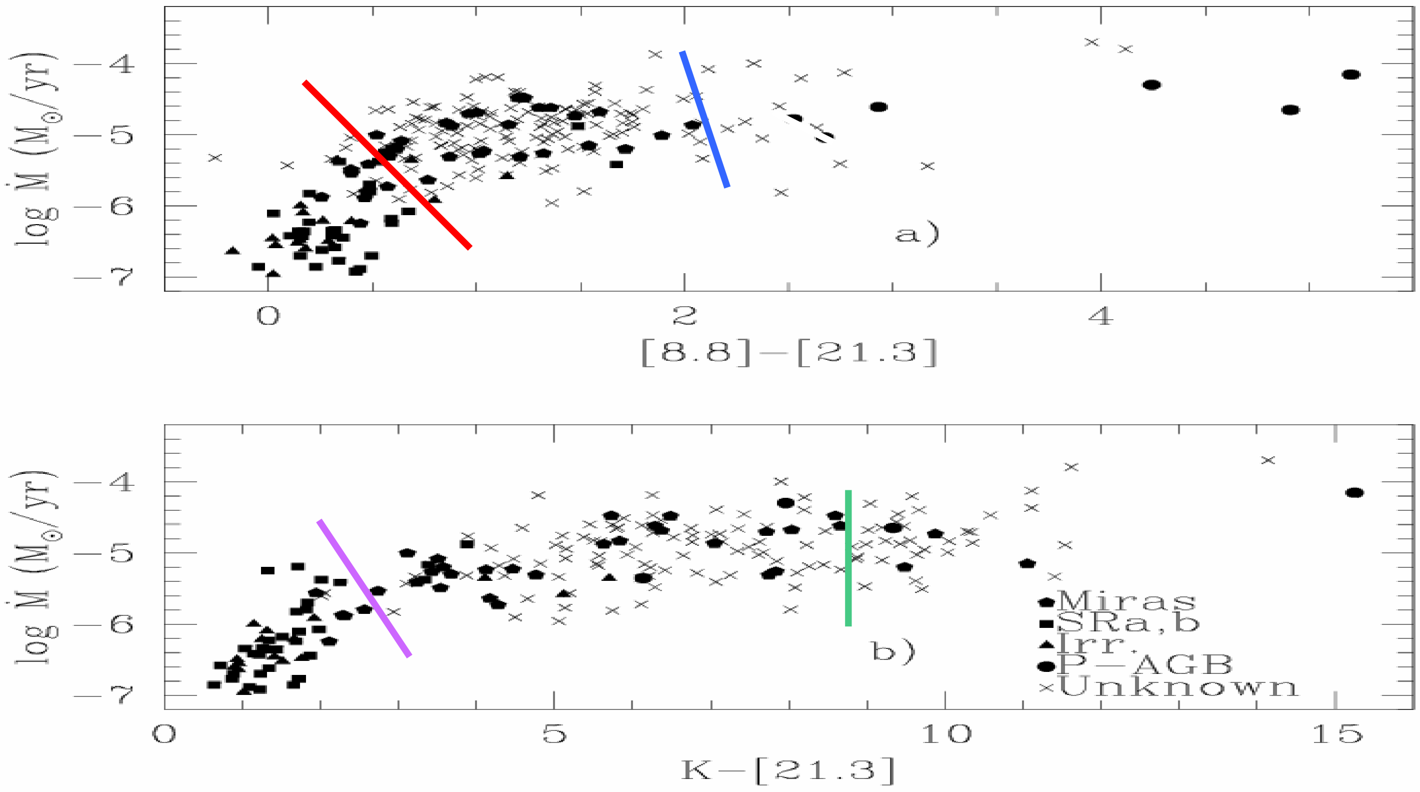


Guandalini et al. 2006

No clear correlation. There are different relations for different variability types. Various parameters modify the order of magnitude of mass loss rates during AGB evolution. One reason could be different scattering mechanisms.

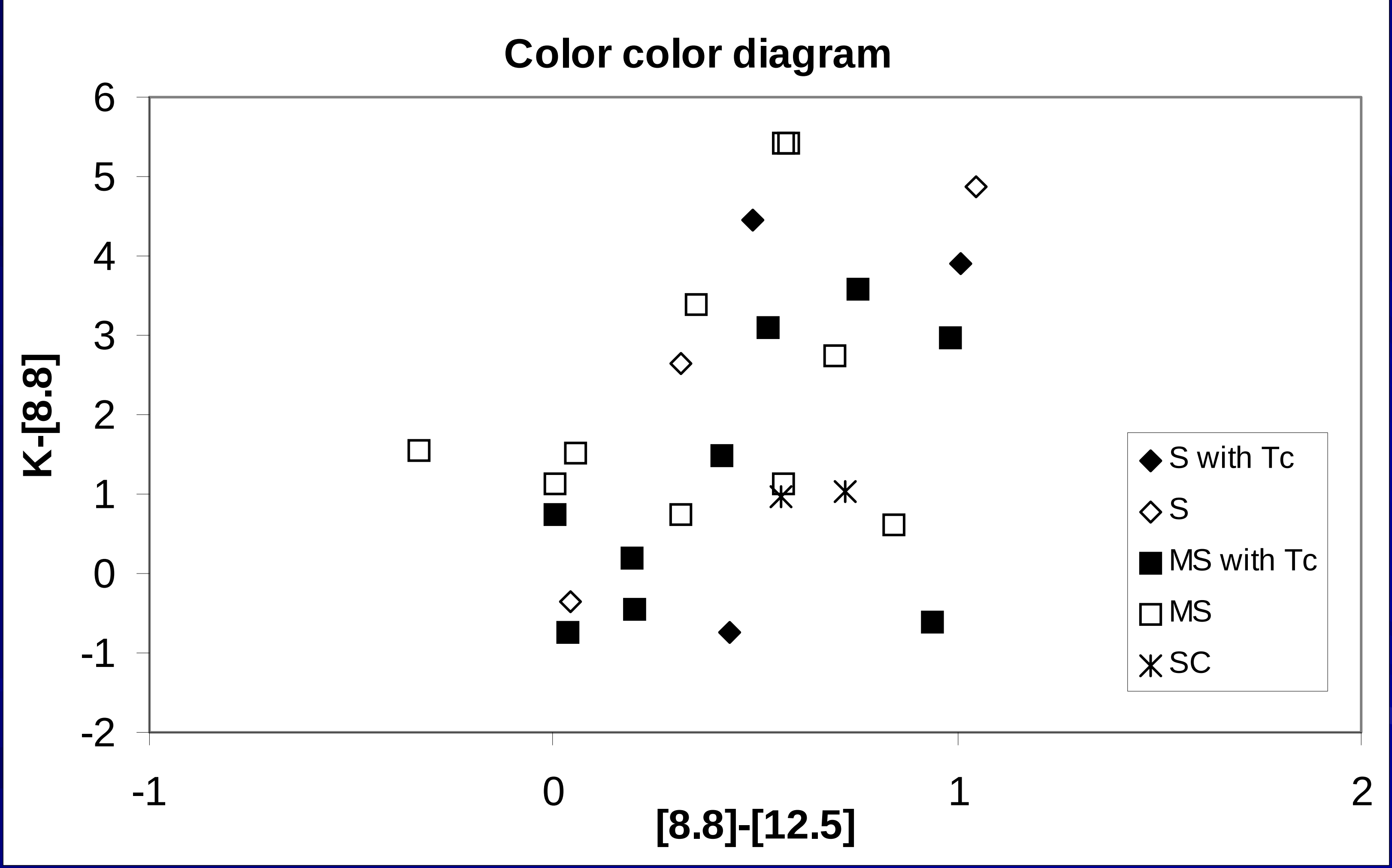
Results:

Mass Loss – IR Colors



Guandalini et al. 2006

S Stars: preliminary results



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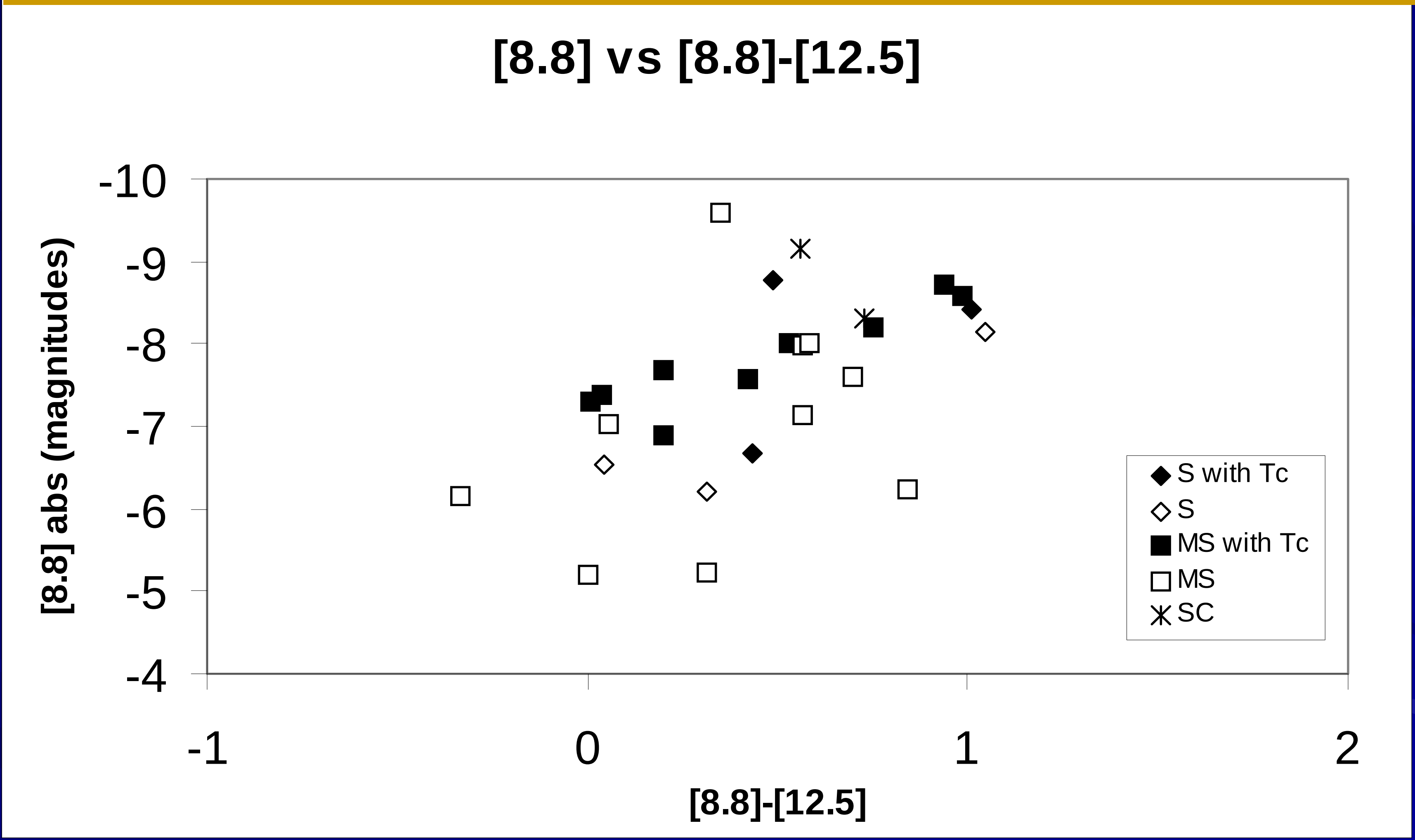
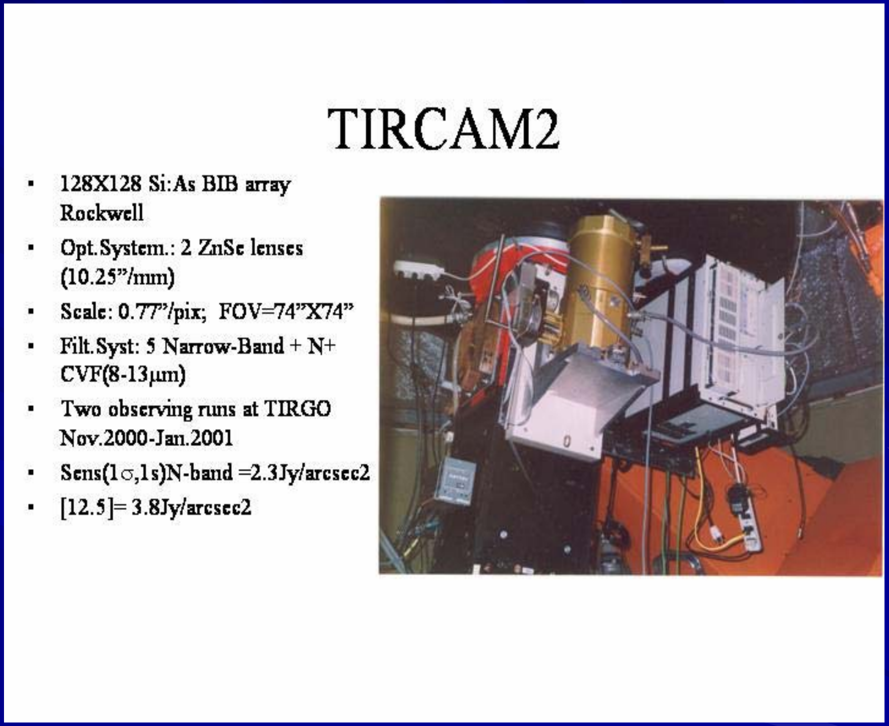


Mid-IR Observations from the Ground: TIRCAM2



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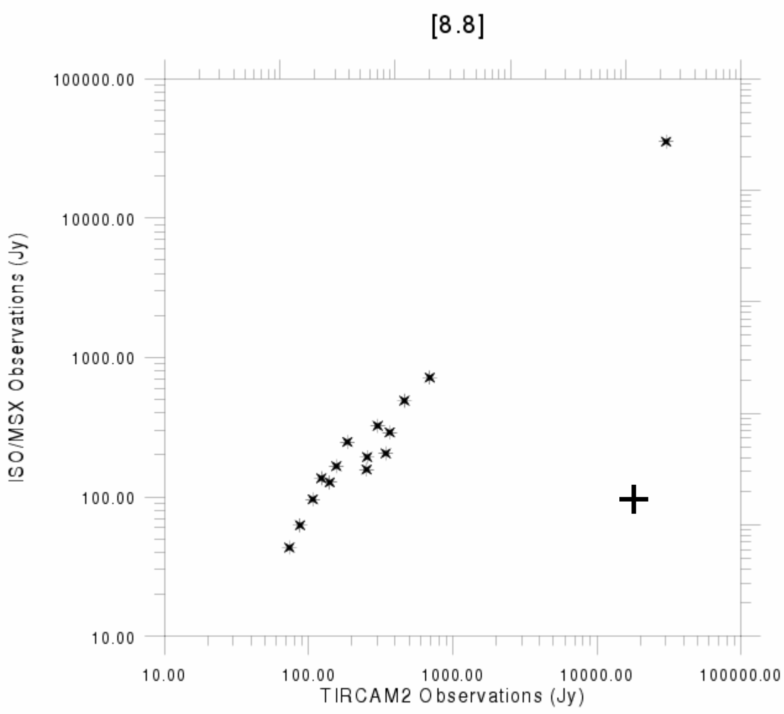
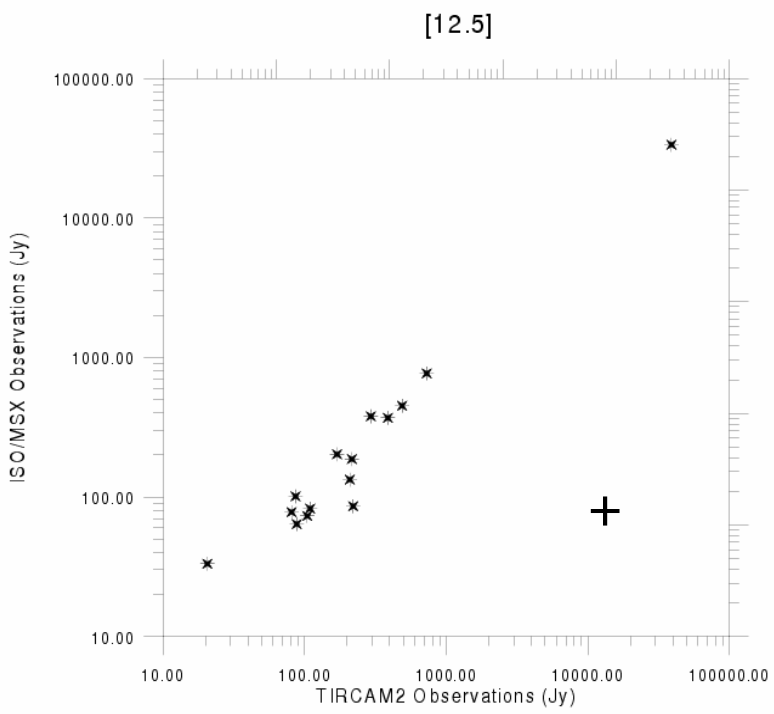
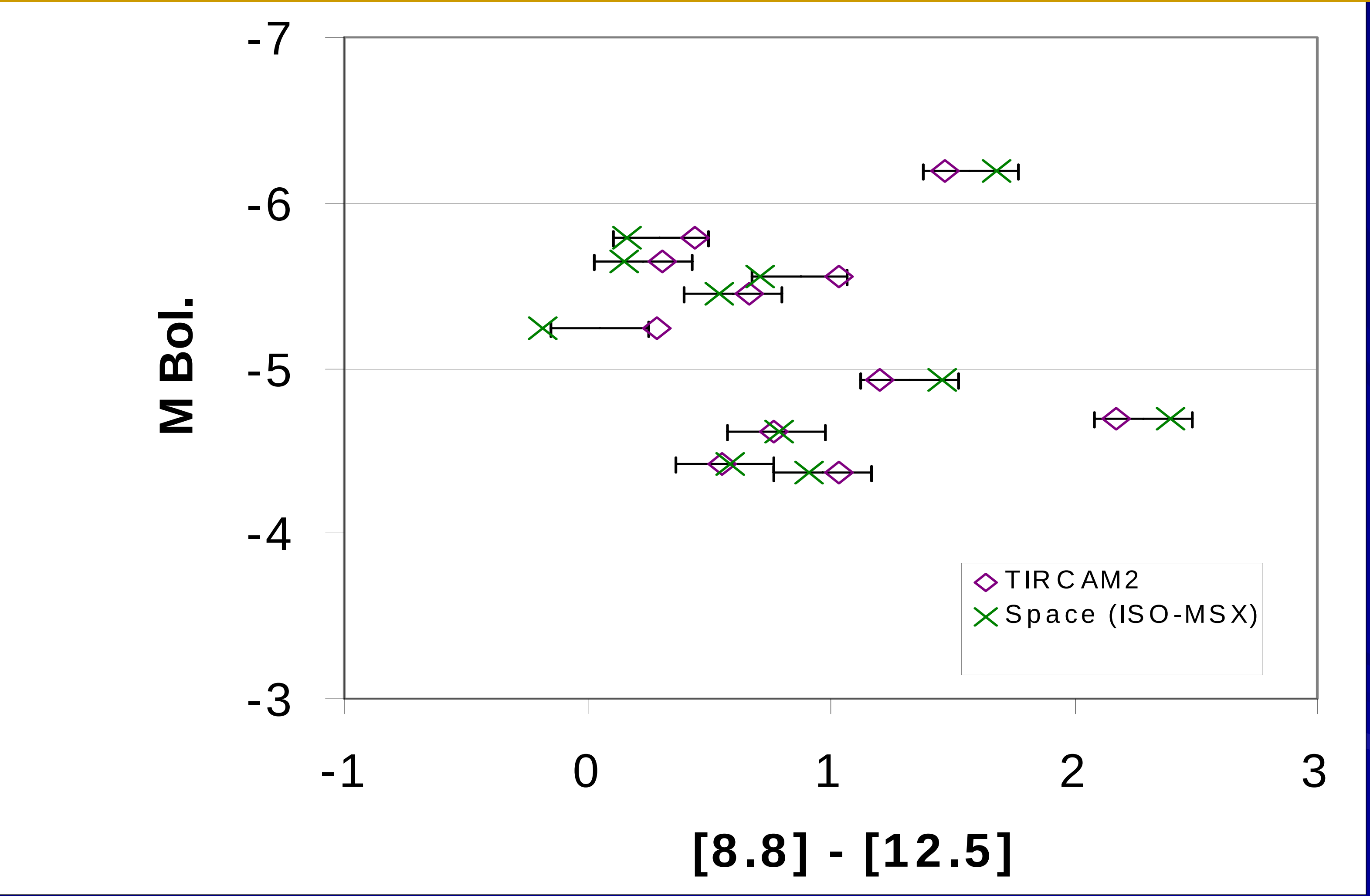


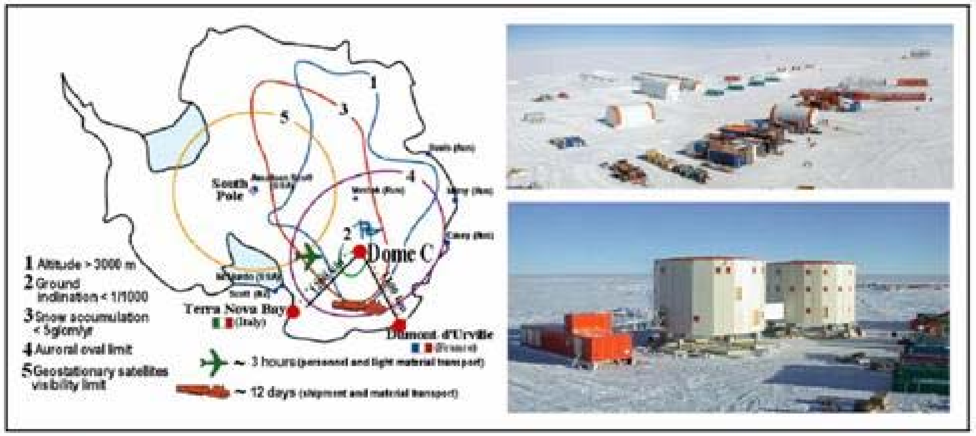


Mid-IR Observations from the Ground:
TIRCAM2



Mid-IR Observations from the Ground: IRAIT

Dome C



Quantity	Value		Quantity	Value
Temperature	−50°C mean −80°C min		snowfall duration	35 day/year eq. to 10 water mm/year
Wind	2.5 m/s mean, 16 m/s max		altitude	3280 m above s.l.
Absol. humidity	2 g/m^3			

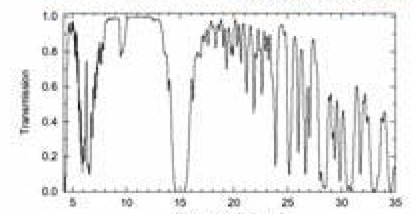
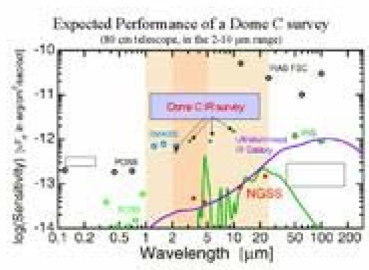


Fig. 1. Assumed atmospheric transmission at Dome C, derived from the considerations of Chamberlain et al. (2000).



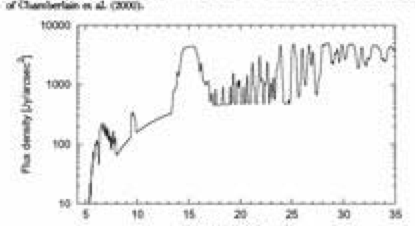


Fig. 2. Assumed background emission flux, obtained considering the telescope emissivity and the contribution of the thermal emission from the lower atmosphere, with T=230°K.

(Straniero this meeting).

Conclusions

Main Results

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