ISMServices

PADC
Paris Astronomical Data Centre

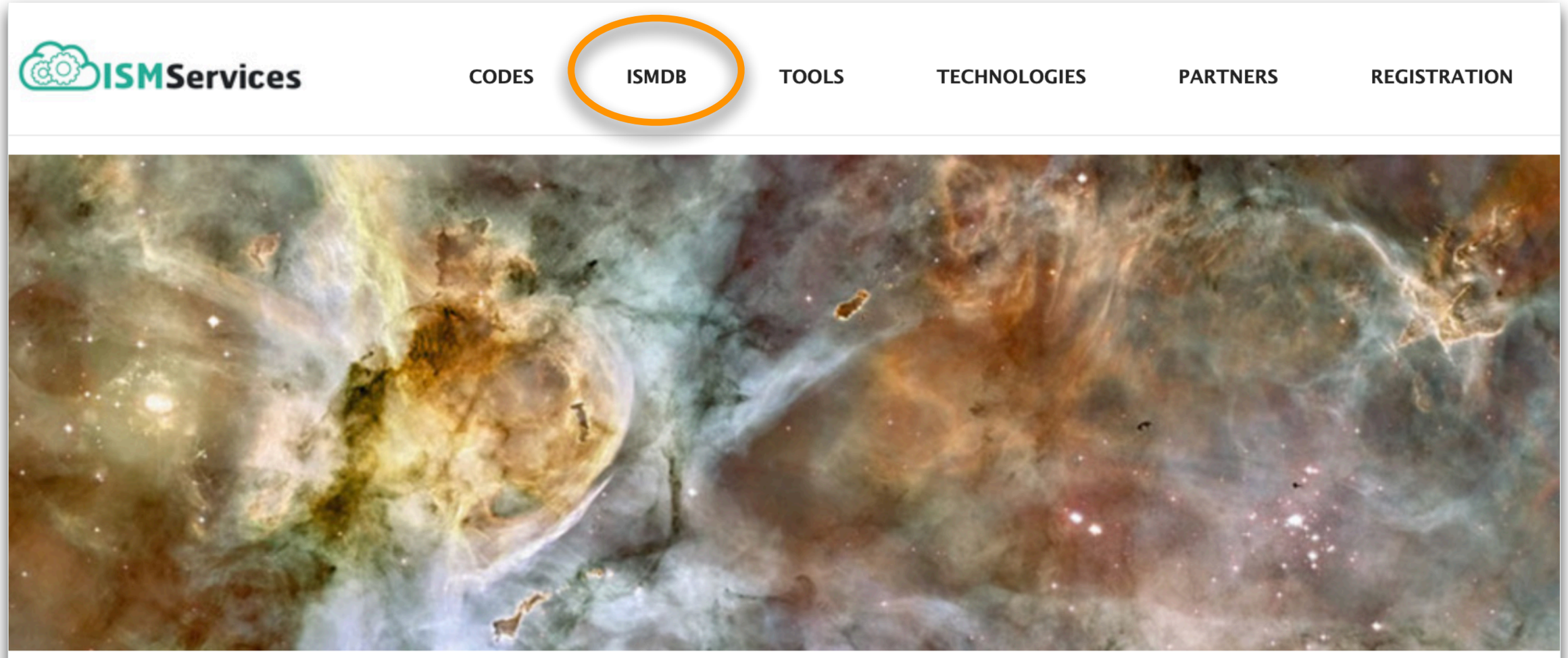
ISMDB

Interstellar Medium Database

Emeric Bron, David Languignon, Franck Le Petit, Nicolas Moreau

Interstellar medium database

SNO5 Plateforme MIS & Jets http://ism.obspm.fr



PDR Code

The Meudon PDR Code

DustEM

Dust Emission

Shock

Paris-Durham Schock model

Galactica

MHD simulations data base

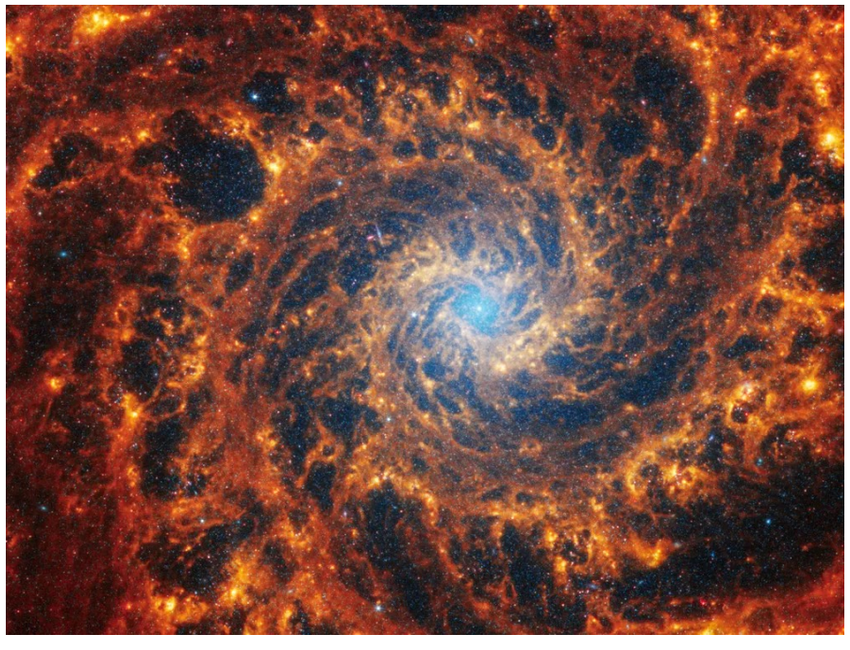
The ISM Platform gathers numerical services to prepare and interpret observations of the interstellar medium and of astrophysical jets. It provides access to several state-of-the-art numerical codes, databases of pre-computed numerical simulations and tools to analyze the results. These services are developed and maintained by scientists and software engineers of Paris Observatory / Paris Astronomical Data Center, IAS / IDOC, IRAP / GSO Data Center and at CEA. They are developed in the context of the Virtual Observatory and are part of the national “services d’observation” recognized by INSU/CNRS to support research in astrophysics.

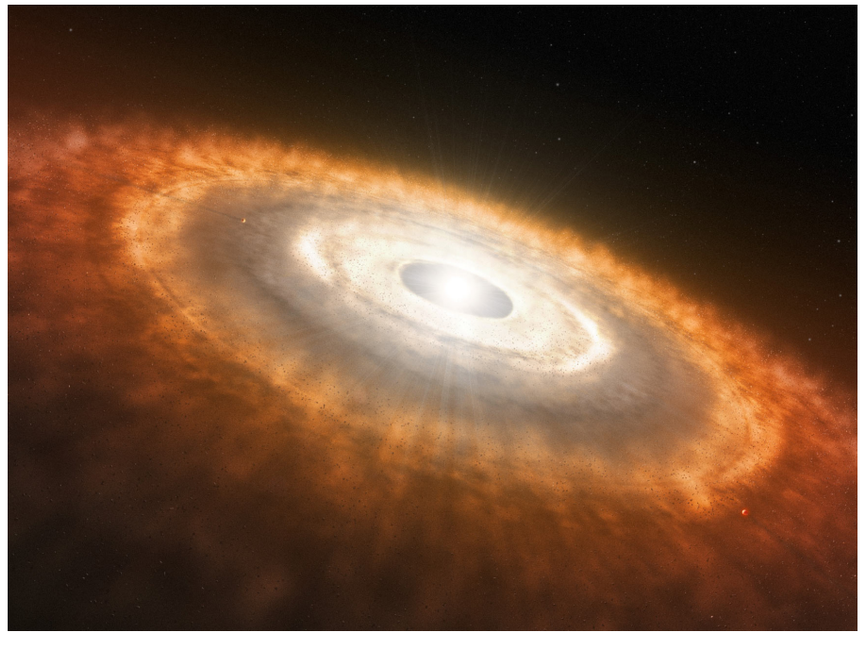
Motivations

Diffuser des **modèles numériques de référence du milieu interstellaire**

➔ **modèles calculant la structure chimique et thermiques de régions interstellaires**
Ex : modèles de régions de photo-dissociation, chocs, …

Applications larges
- Milieu interstellaire de notre Galaxie
- Gaz extragalactique
- Disques circumstellaires
- …





Services avancés permettant de répondre à des questions scientifiques
- Interprétation d'observations
- Préparation **de campagnes d'observations**

Simulations from different teams are published in ISMDB

ISMDB ISM Services

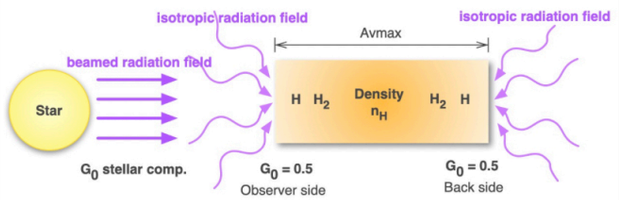
Codes Tools Technologies Partners

Published projects

Code filters :

PDR 7 | **Paris Durham Shock Code 1.1.0** | **PDR 1.5.4** | **PDR 1.5.2** | **KOSMA-tau 1.0.0**

PDR 7



Constant density PDR 7 models

[P7G1E20BG_n_240909]

September 09, 2024

Fit models to observations

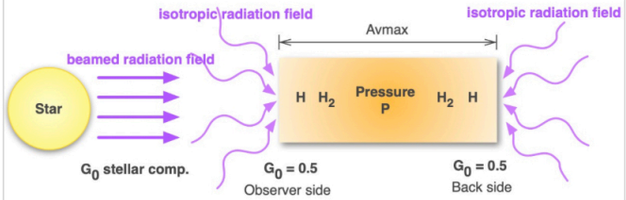
Browse models

Produced by ISM Services

	Min	Max
AVmax	1	30
nH	10	1e+10
G0 stellar component	1	1e+05

This grid of isobaric PDR 7 models (revision 2118) covers photo-dominated regions conditions. Explored parameters are the proton density, the

PDR 7



Isobaric PDR 7 models

[P7G1E20BG_P_240819]

August 19, 2024

Fit models to observations

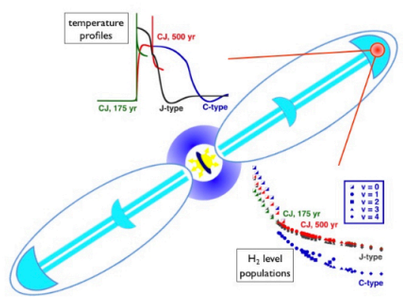
Browse models

Produced by ISM Services

	Min	Max
AVmax	1	30
Pressure	1e+03	1e+09
G0 stellar component	1	1e+05

This grid of isobaric PDR 7 models (revision 2118) covers photo-dominated regions conditions. Explored parameters are gas thermal pressure.

Paris Durham Shock Code 1.1.0



Low velocity shock models (qPAH=1e-8)

[shockgrid_110_q1m8_2022]

May 04, 2022

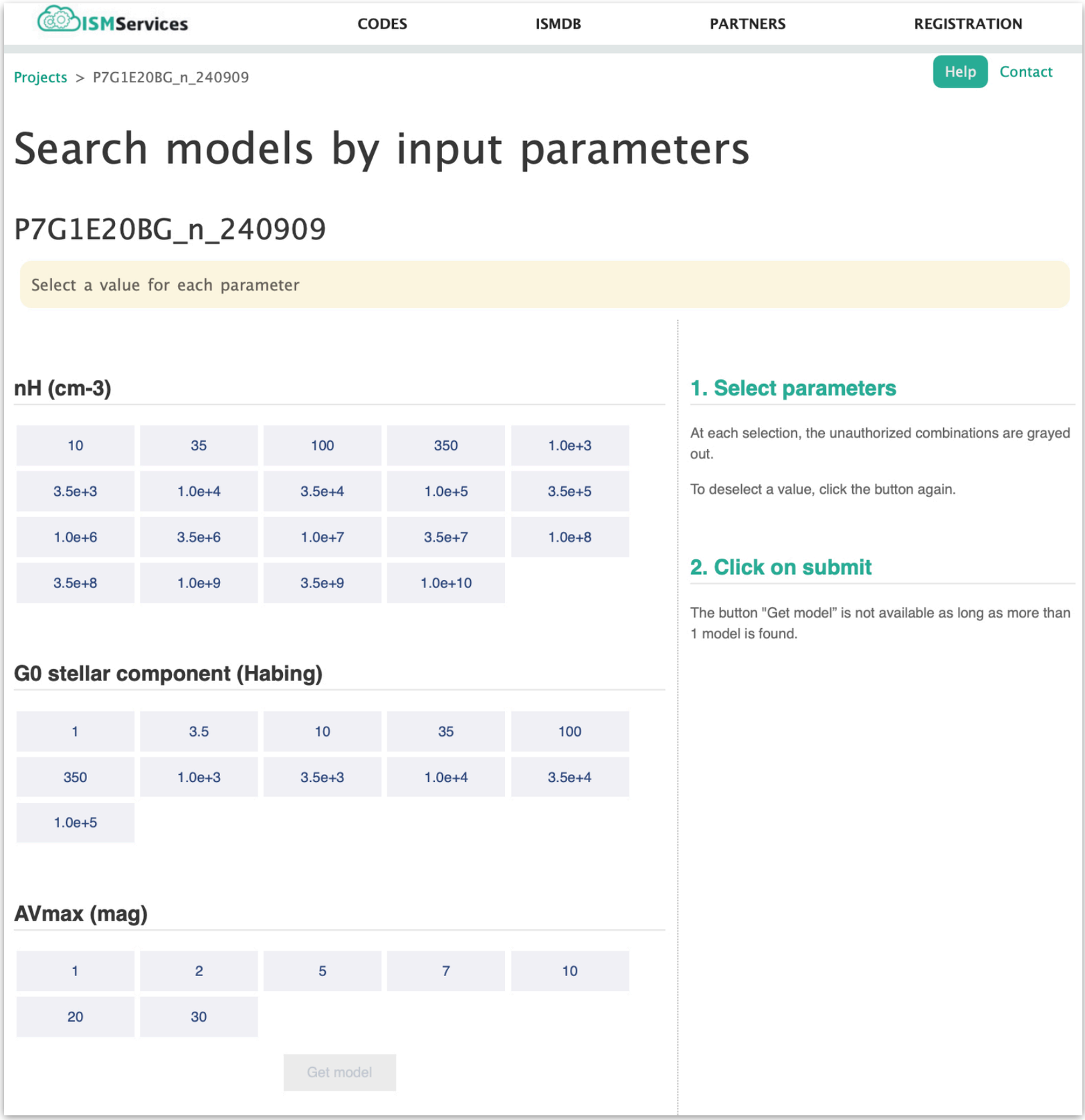
Browse models

Produced by ISMServices

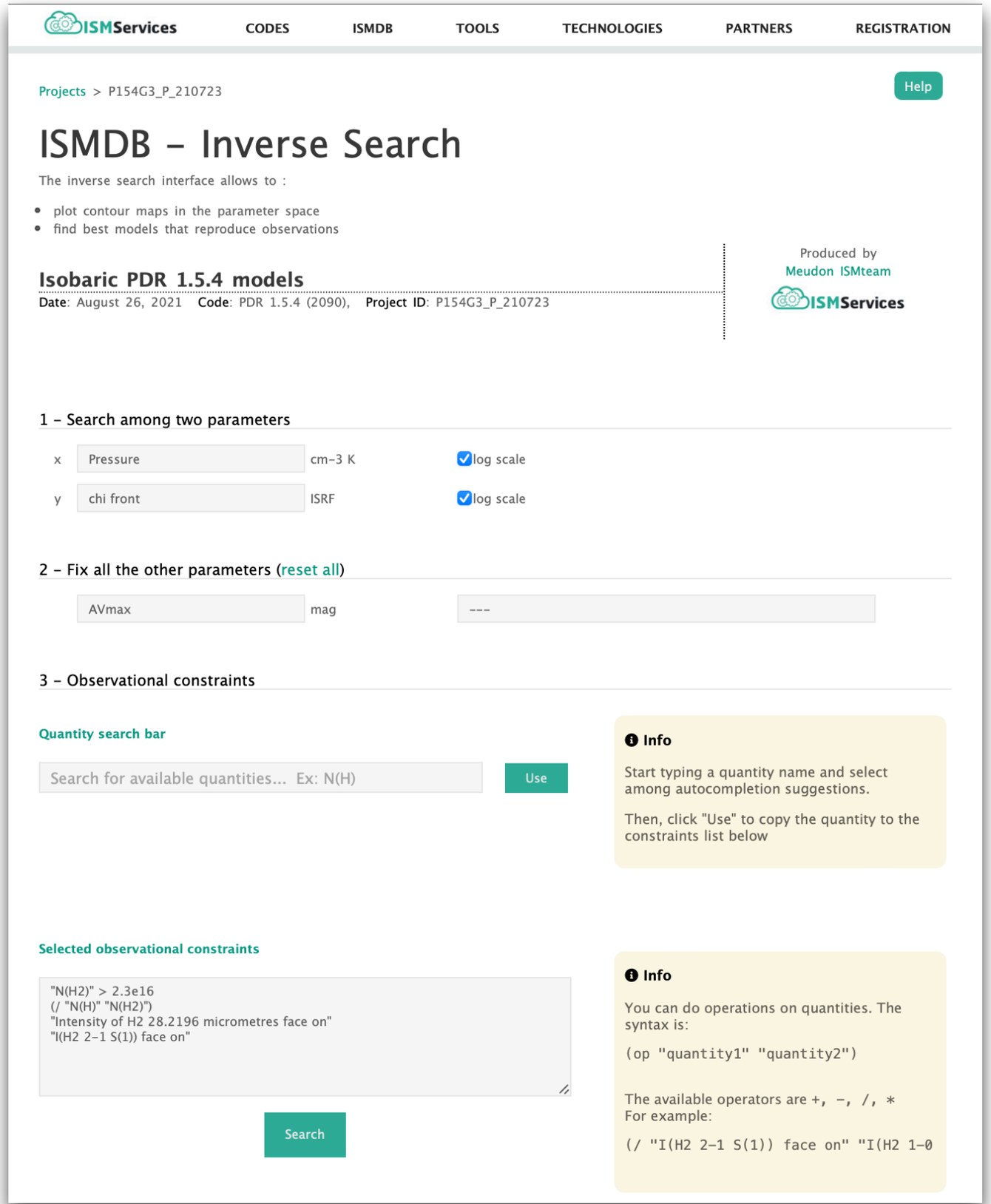
	Min	Max
beta magnetic	0.1	10
Shock speed	2	90
Initial density	1e+02	1e+08
zeta	1e-17	1e-15

This grid of shock models is run with the Paris-Durham Shock code (version 1.1.0, revision 115). It covers low velocity shocks propagating

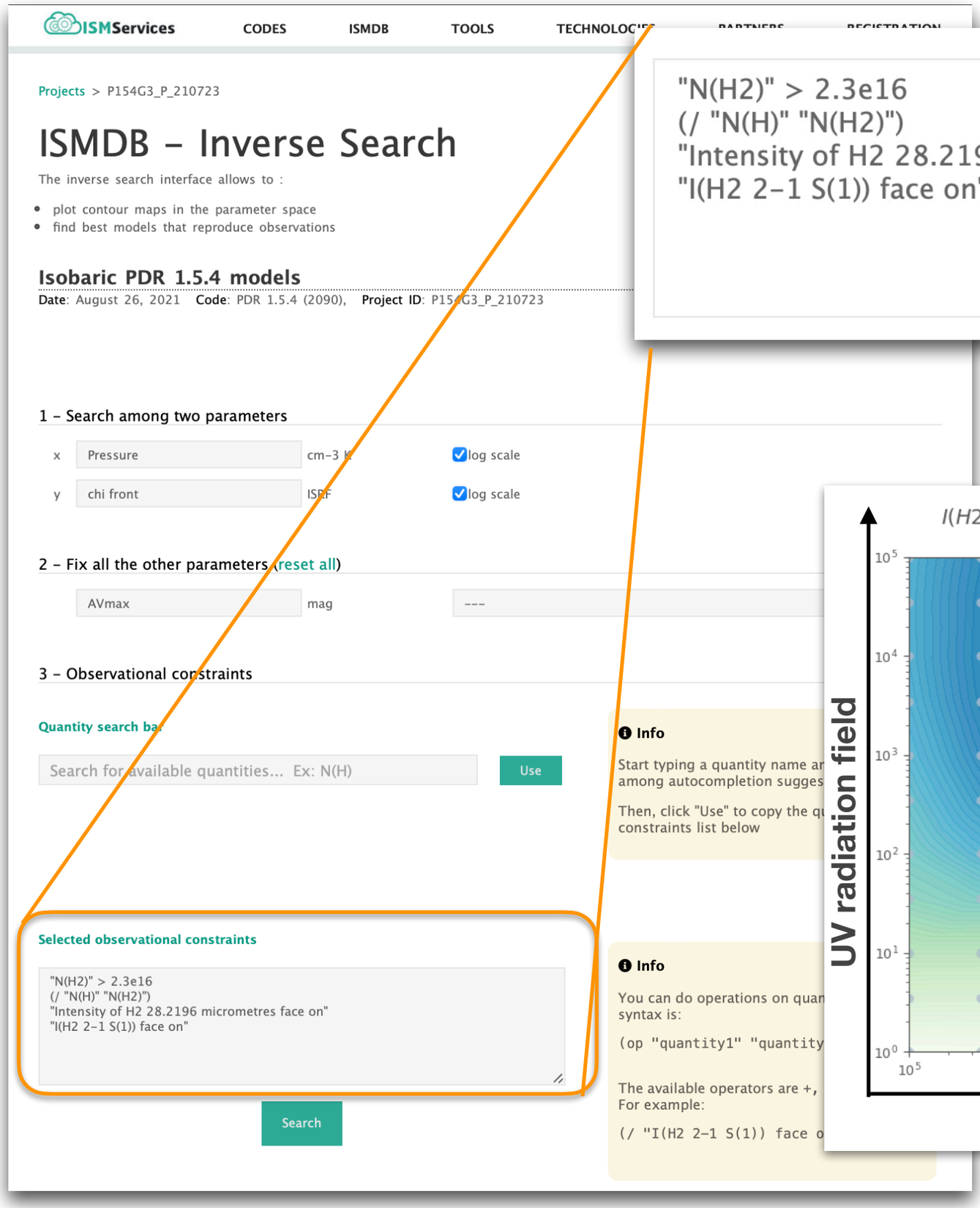
Model browser



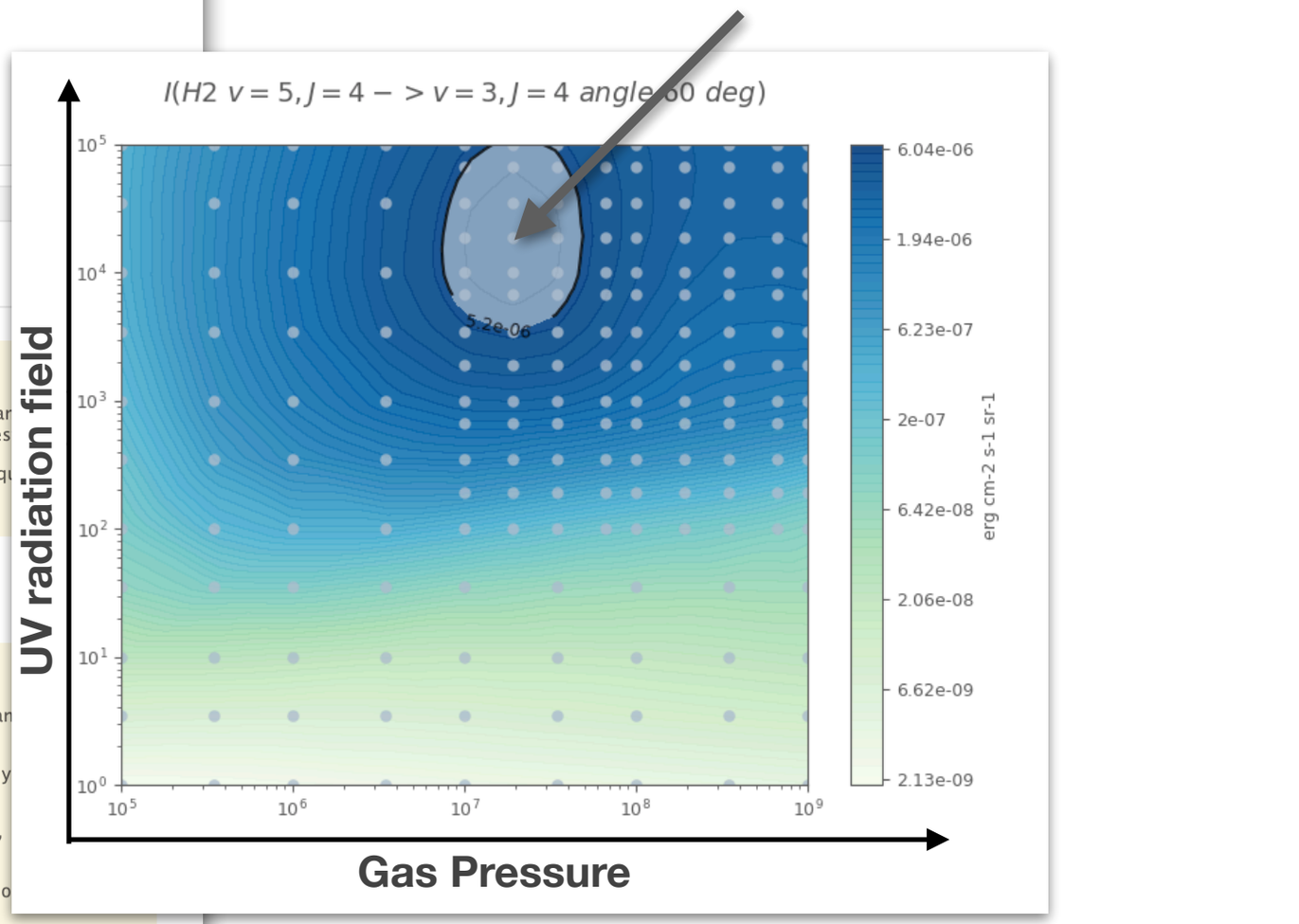
Inverse Search



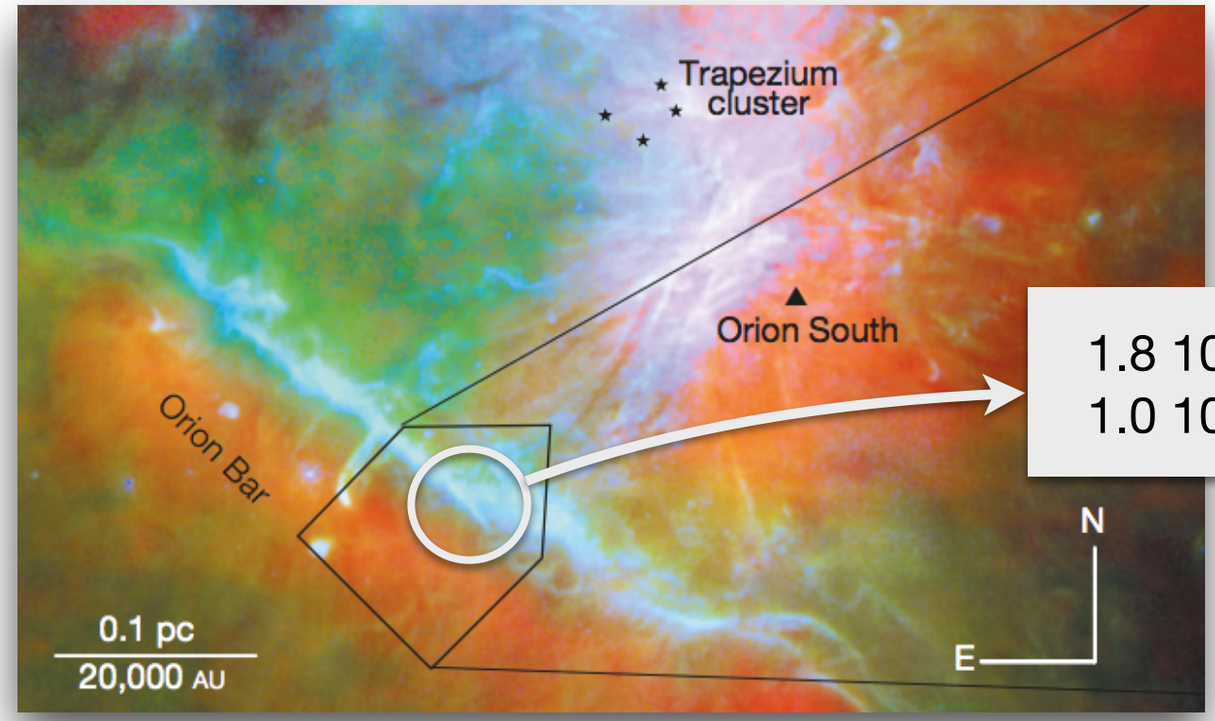
Inverse Search



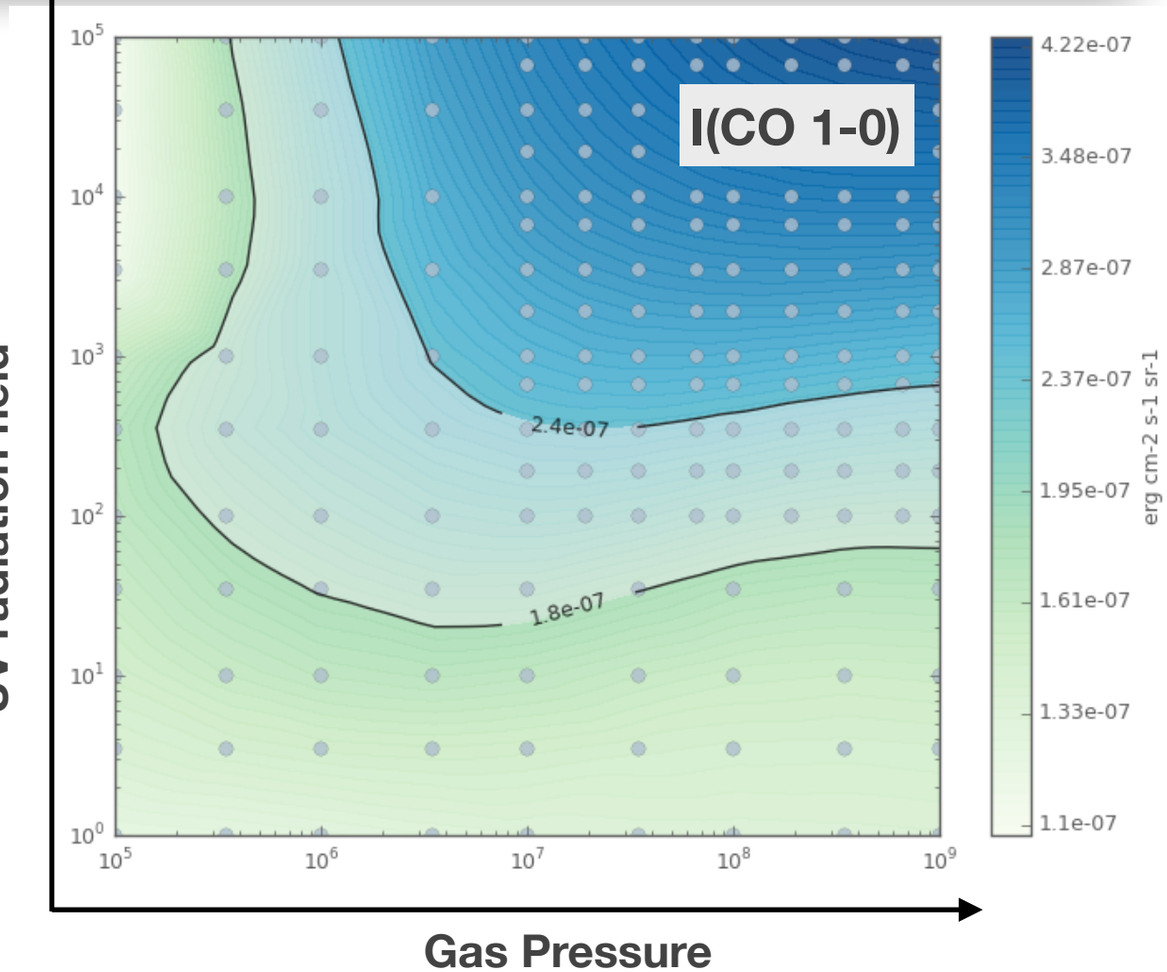
Solution to the problem

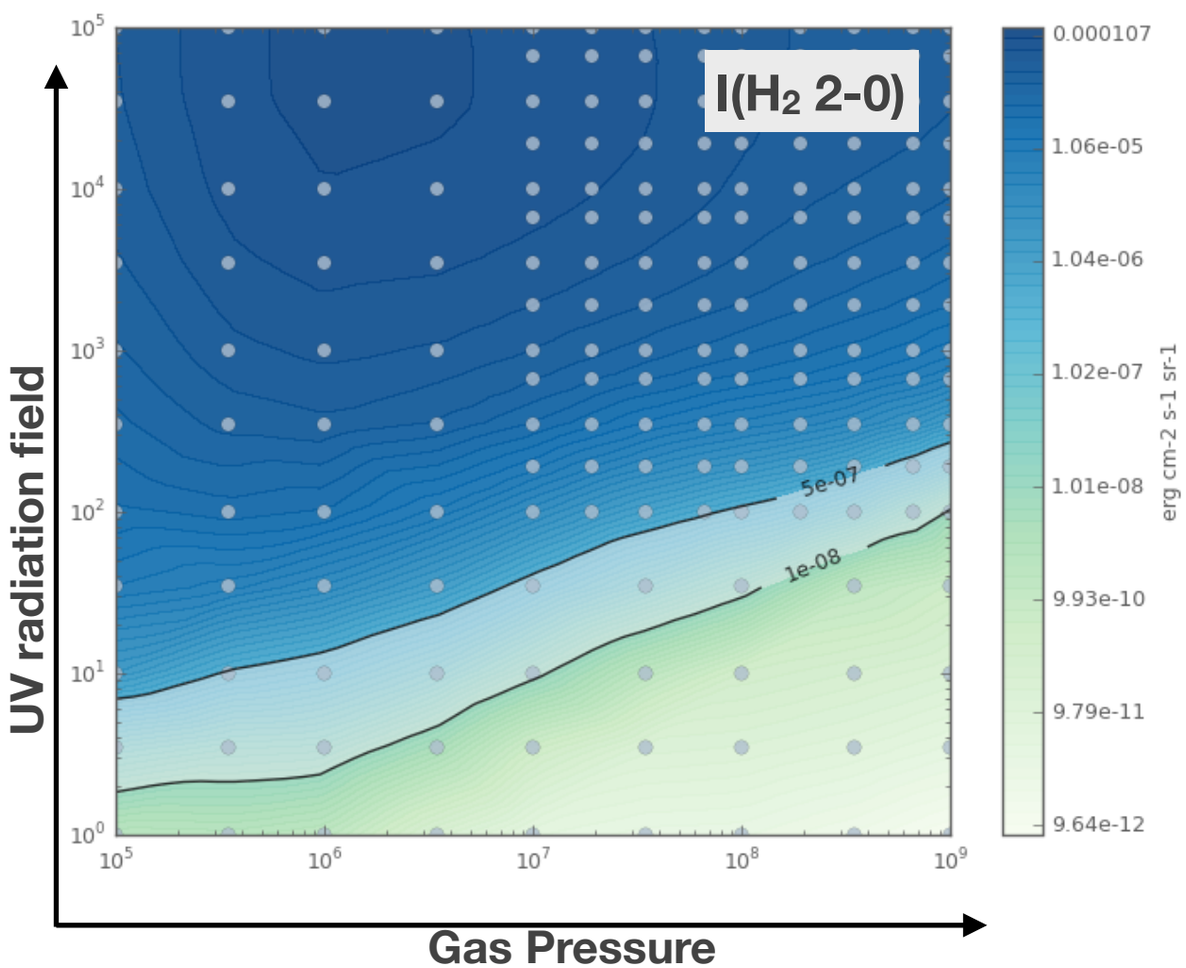


Inverse Search



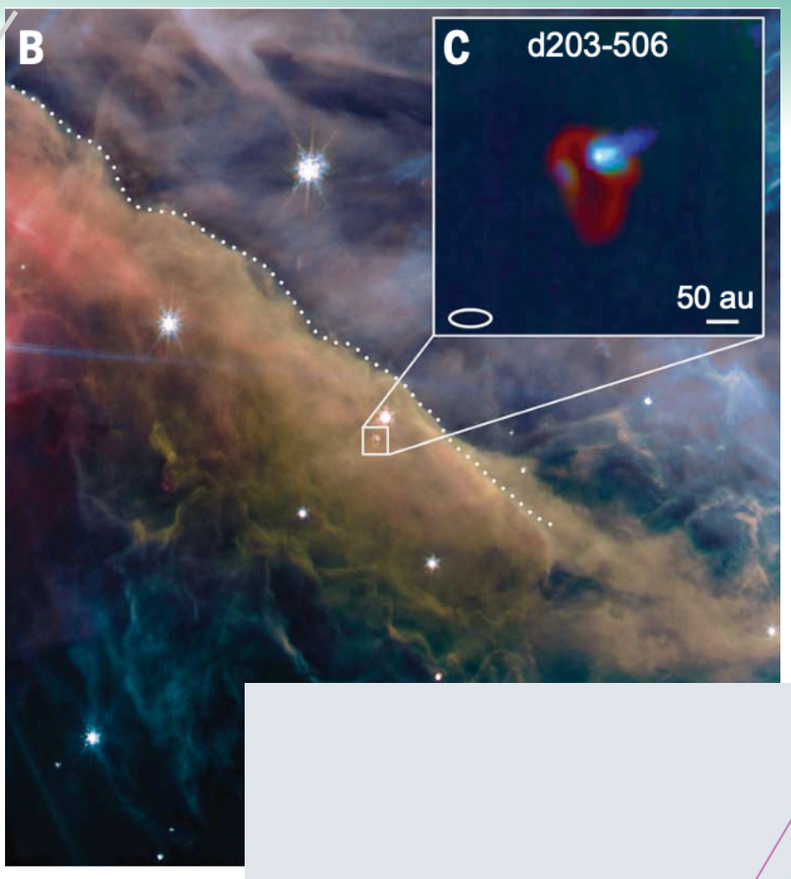
1.8 10^{-7} < **I(CO 1-0)** < 2.4 10^{-7} erg cm^{-2} s^{-1} sr^{-1}
1.0 10^{-8} < **I(H_2 2-0)** < 5.0 10^{-7} erg cm^{-2} s^{-1} sr^{-1}

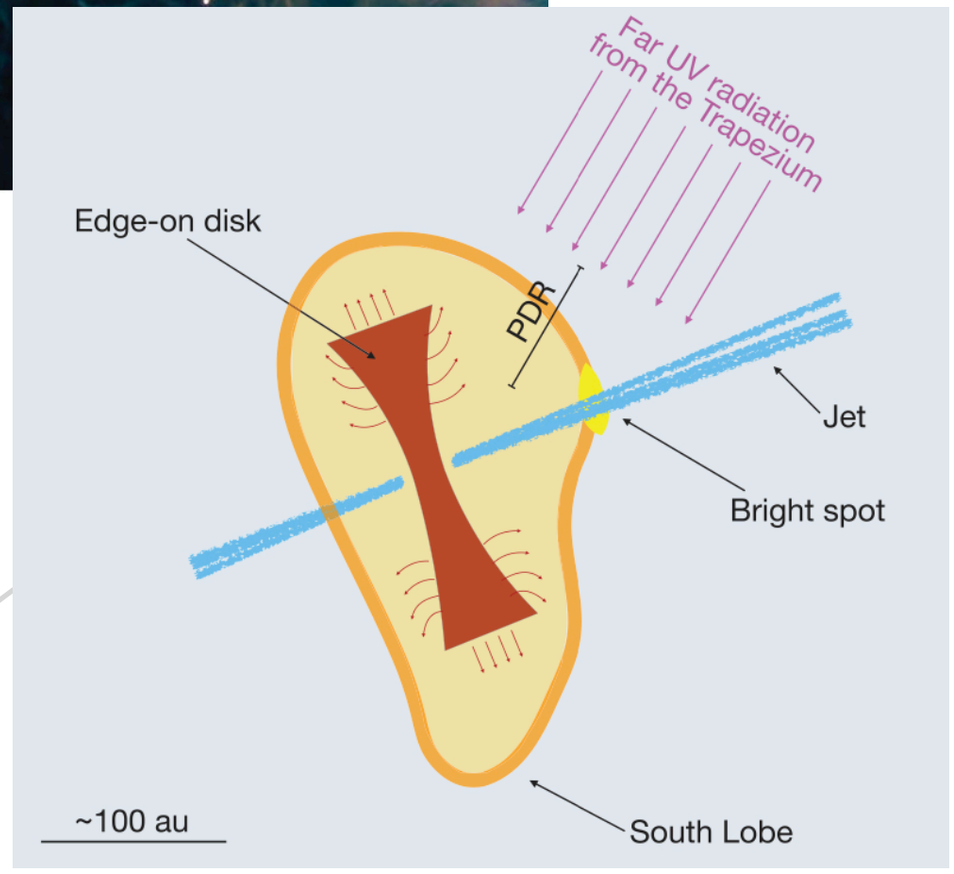




Observation interpretation

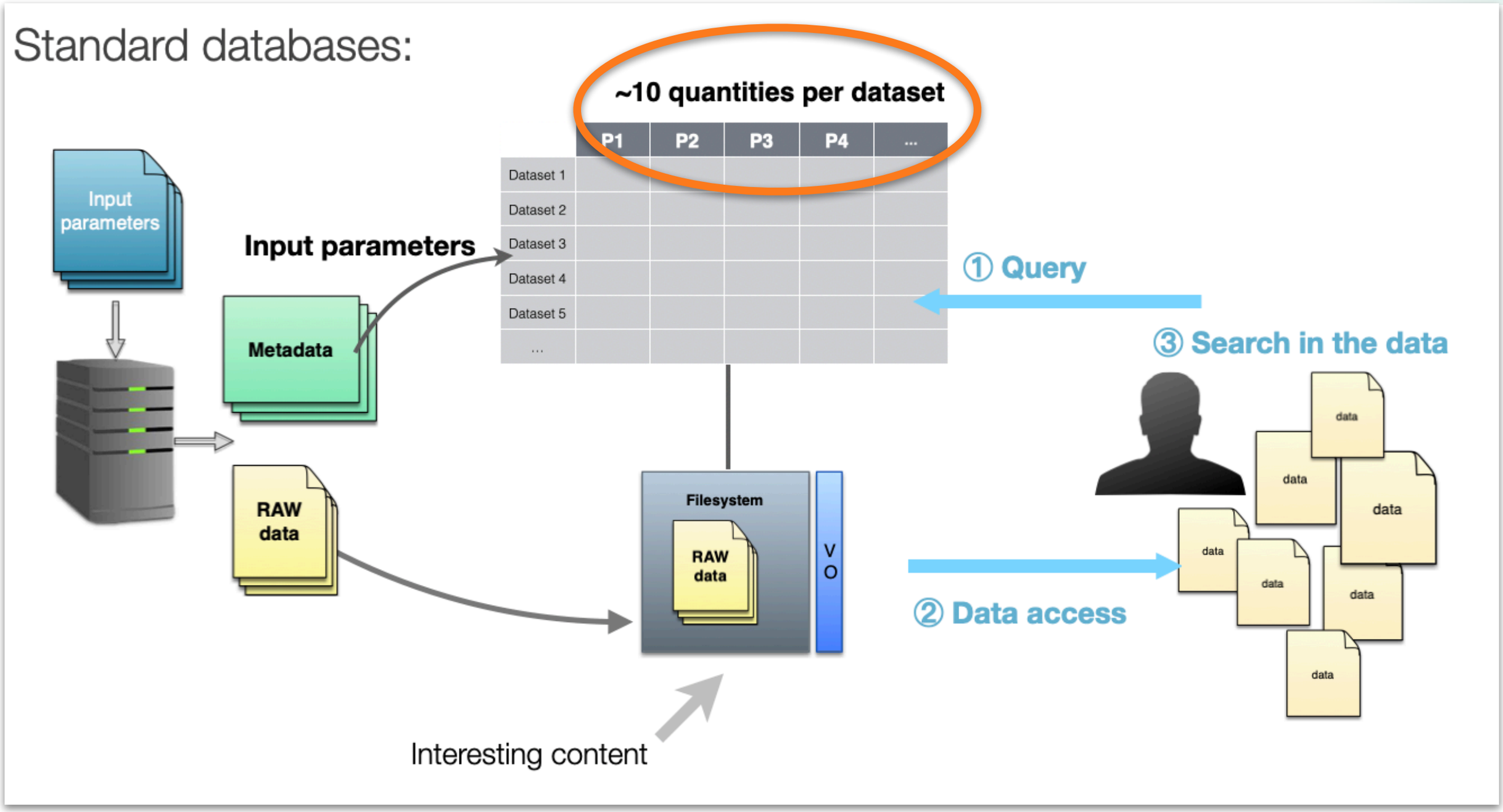
A first interpretation of data is delivered instantly, replacing weeks of manual work





Then, run the codes to refine the result

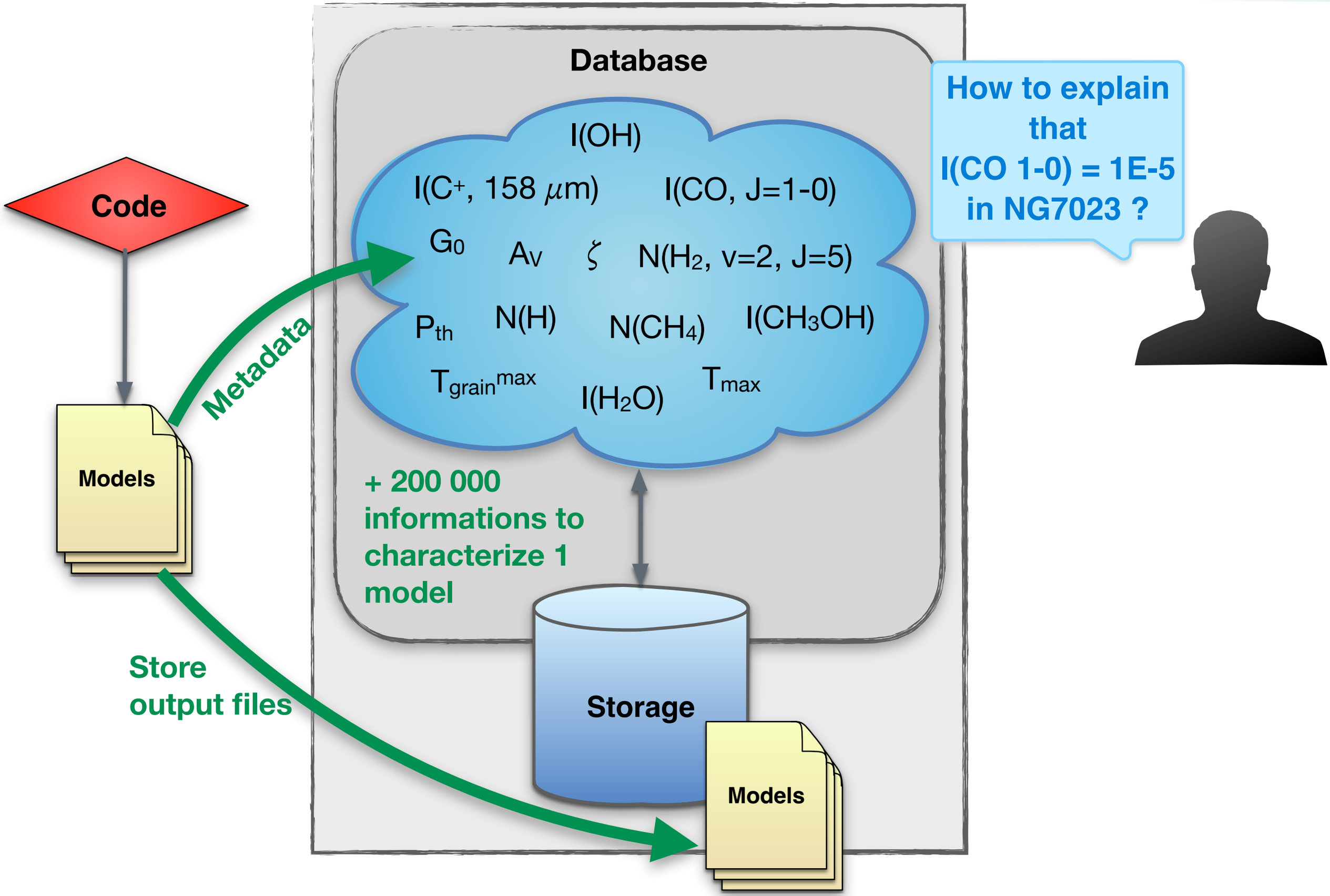
Technical challenges



Problem

we have +200 000 properties per model -> does not fit easily in traditional SGBD

ISMDB : High dimension database



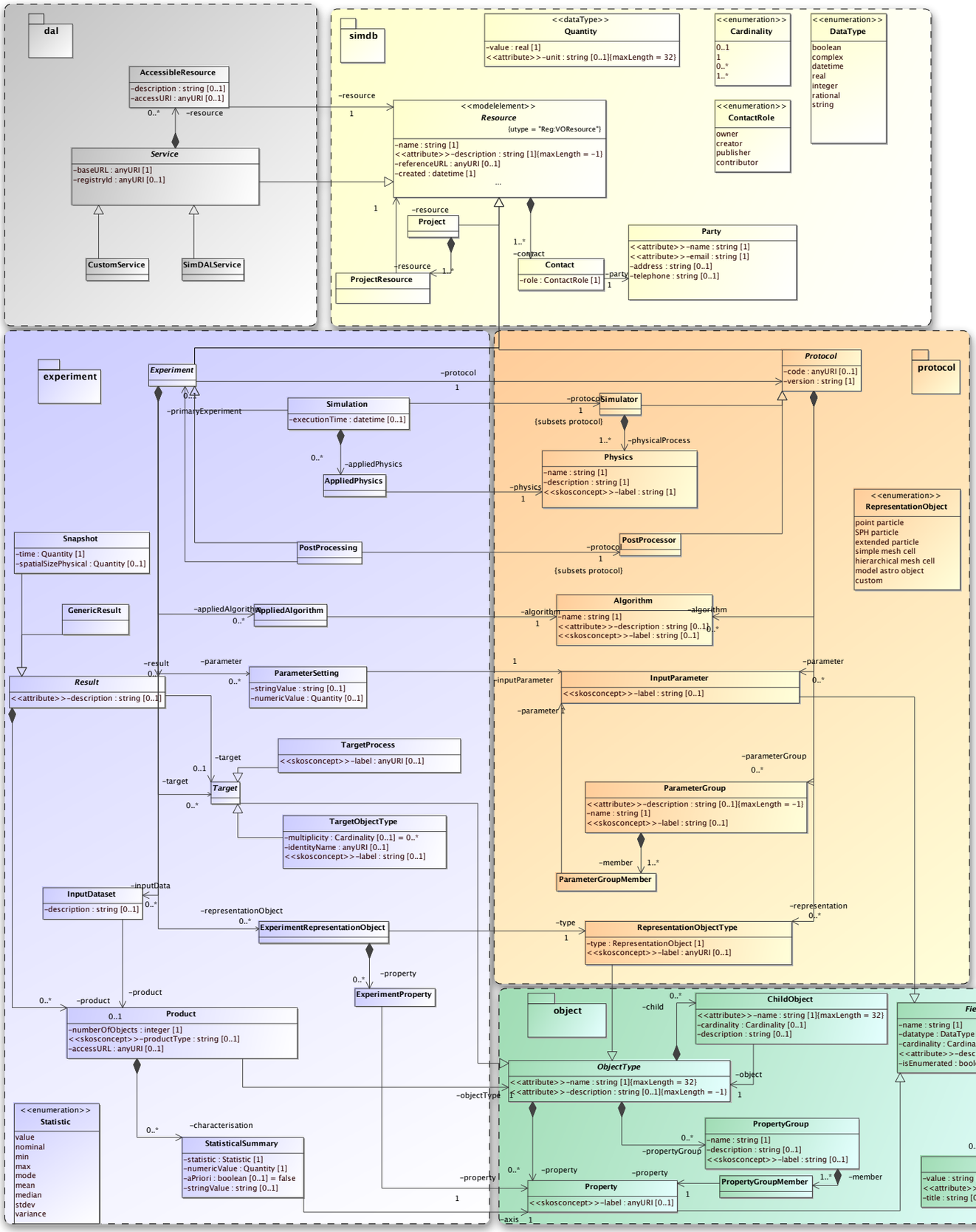
Des services avancés permis grâce à deux éléments

① **Simulation Data Model** (SimDM) :

permet d'associer des métadonnées riches aux simulations diffusées

② **Technologies pour manipuler des métadonnées de grande dimensions**

(solutions classique de type BDD relationnelle ne fonctionnent pas)



Inverse Search

ISMServices CODES ISMDB TOOLS TECHNOLOGIES PARTNERS REGISTRATION

Projects > P154G3_P_210723

Help

ISMDB – Inverse Search

The inverse search interface allows to :

- plot contour maps in the parameter space
- find best models that reproduce observations

Isobaric PDR 1.5.4 models

Date: August 26, 2021 **Code**: PDR 1.5.4 (2090), **Project ID**: P154G3_P_210723

Produced by
Meudon ISMteam
ISMServices

1 – Search among two parameters

x	Pressure	cm-3 K	log scale
y	chi front	ISRF	log scale

2 – Fix all the other parameters (reset all)

AVmax	mag	---

3 – Observational constraints

Quantity search bar

Search for available quantities... Ex: N(H) Use

Info

Start typing a quantity name ar
among autocompletion sugges

Then, click "Use" to copy the qu
constraints list below

Selected observational constraints

```
"N(H2)" > 2.3e16
(/ "N(H)" "N(H2)")
"Intensity of H2 28.2196 micrometres face on"
"I(H2 2-1 S(1)) face on"
```

Search

Info

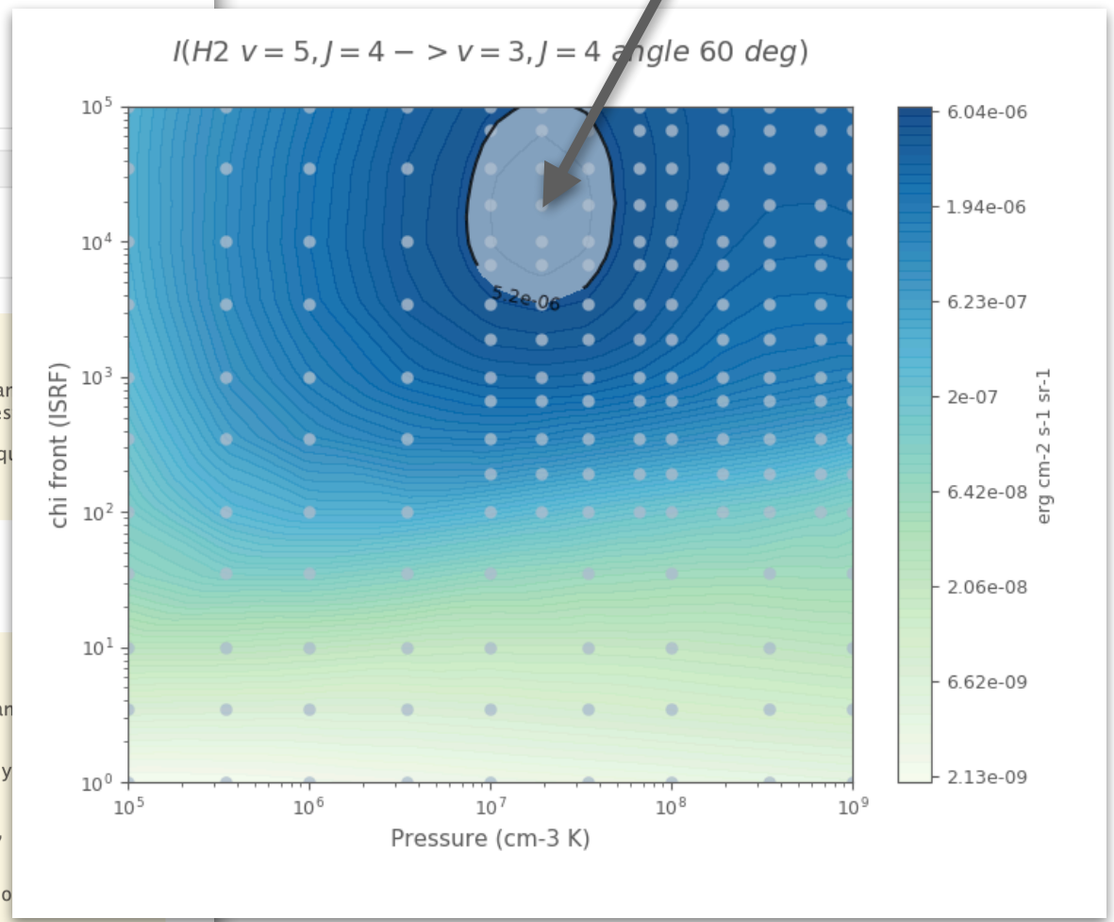
You can do operations on quan
syntax is:

```
(op "quantity1" "quantity
```

The available operators are +,
For example:

```
(/ "I(H2 2-1 S(1)) face o
```

Model we want to explore



Model viewer

ISMServices CODES ISMDB PARTNERS REGISTRATION

Projects > PDRG1NoPAH_P_200618 > PDRG1NoPAH_P1p9e8r1p9e4A3e1

ISMDB – Model viewer

Model PDRG1NoPAH_P1p9e8r1p9e4A3e1 June 18, 2020
Code: PDR 1.5.4 (2065), **Project id**: PDRG1NoPAH_P_200618

Produced by Meudon ISM team
ISMServices

Parameters (toggle all parameters)

Main parameters

chi front	1.9e+04	ISRF
AVmax	30	mag
Pressure	1.9e+08	cm-3 K

Other

zeta	1e-16	s-1 per H2
Z	1	

Algorithms

Rad. transfer algo.	0	

Grain properties

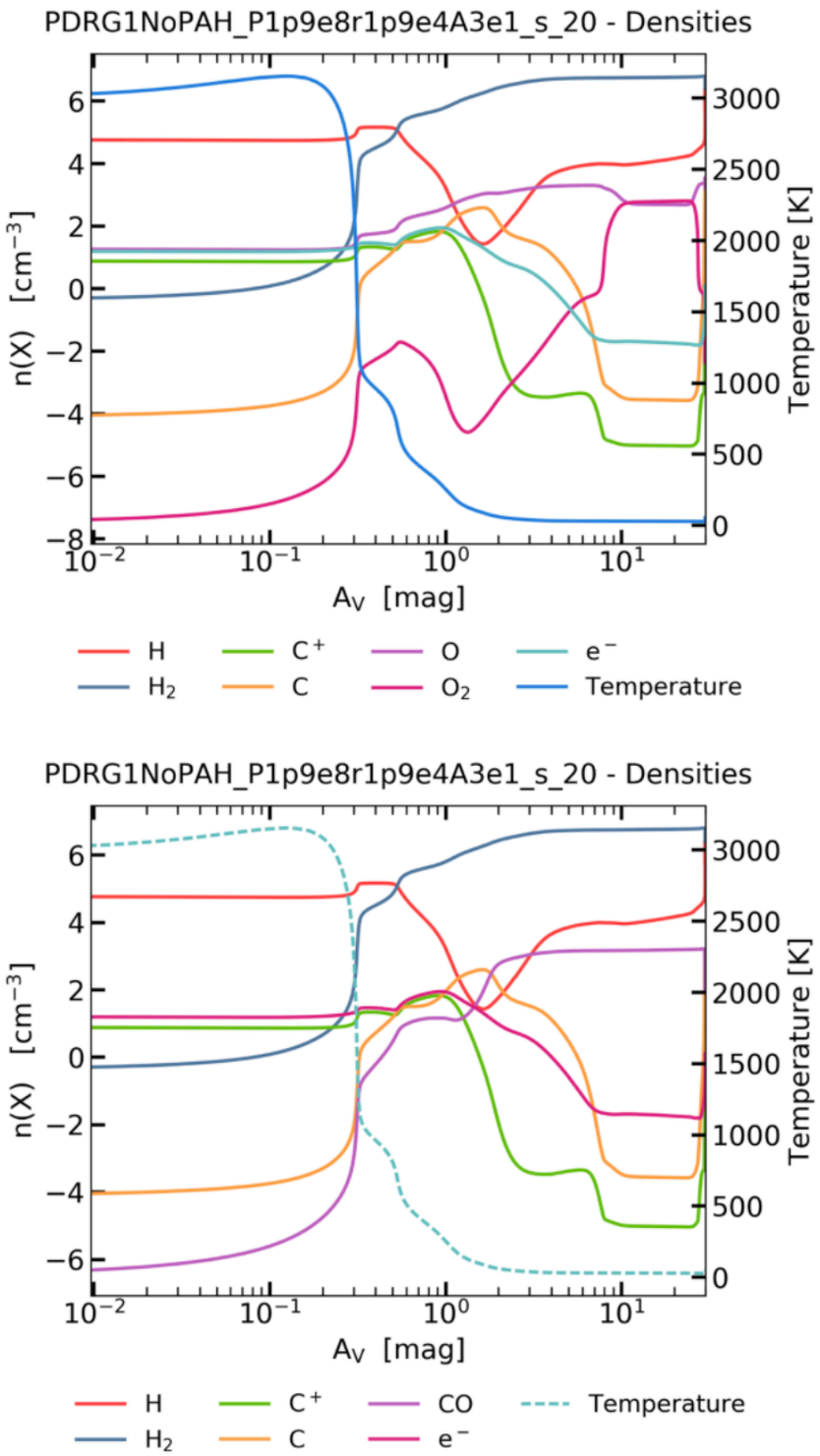
Extinction curve	Galaxy	
RV	3.1	
NH/E(B-V)	5.8e+21	cm-2 mag-1
m(dust)/m(gas)	0.01	
m(PAH)/m(dust)	0	
Grains distrib. slope	3.5	
Grains min radius	1e-07	cm
Grains max radius	3e-05	cm

Online analysis

online analysis with IDAT

Download

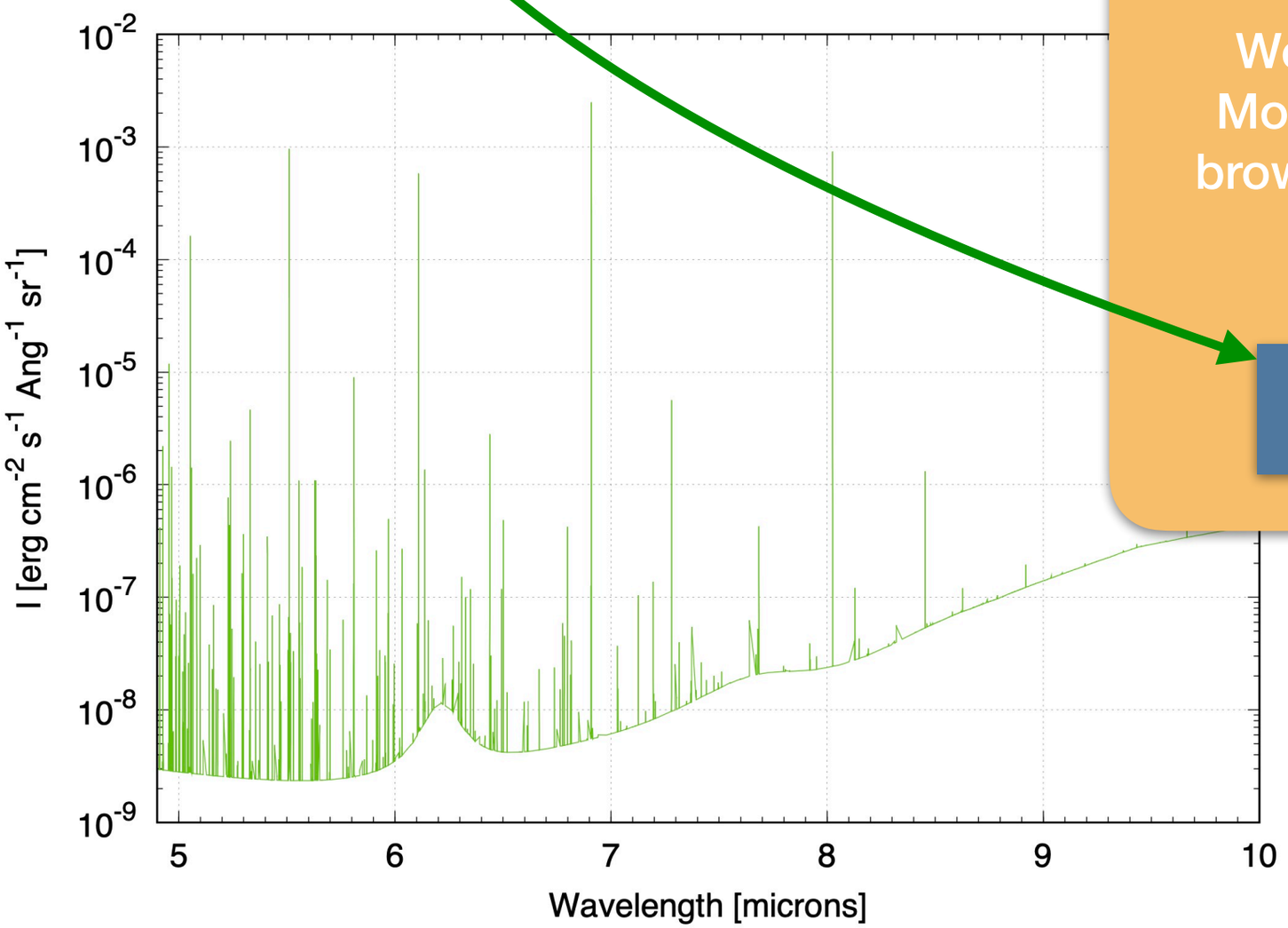
- Source code
- Chemistry file
- Main output
- Chemistry analysis output
- Emissivity output



IDAT : Browse the content of a model

Models compute thousand heterogeneous quantities
➔ neet dedicated tools to explore the content of models and extract interesting quantities

Retrieve the full
content of the models



Web
Model
browser

IDAT

ISMDB

I(OH)
I(C+, 158 μm)
I(CO, J=1-0)
G0
AV
ζ
N(H2, v=2, J=5)
Pth
N(H)
N(CH4)
I(CH3OH)
Tgrainmax
I(H2O)
Tmax

Storage

Models

IDAT : explore the content of models

IDAT: Data analysis

Local version

Opened model: OrBarJ18_BestMod_s_20.hdf5

This tool allows to **extract data** produced by the ISM platform codes (as text files) and to **plot the results**.

- Search among the computed quantities with the search bar or in the data tree listing all availa quantities.
- The quantities you select will appear in the boxes of section 2.
- If you already know the quantity names, you can also directly type or paste them into the boxes.
- Export as text files or plot the data with our interactive plot tool using the corresponding buttons.

1. Select quantities to extract or plot

Find quantities computed by the code with the search bar

Find quantities in the data tree

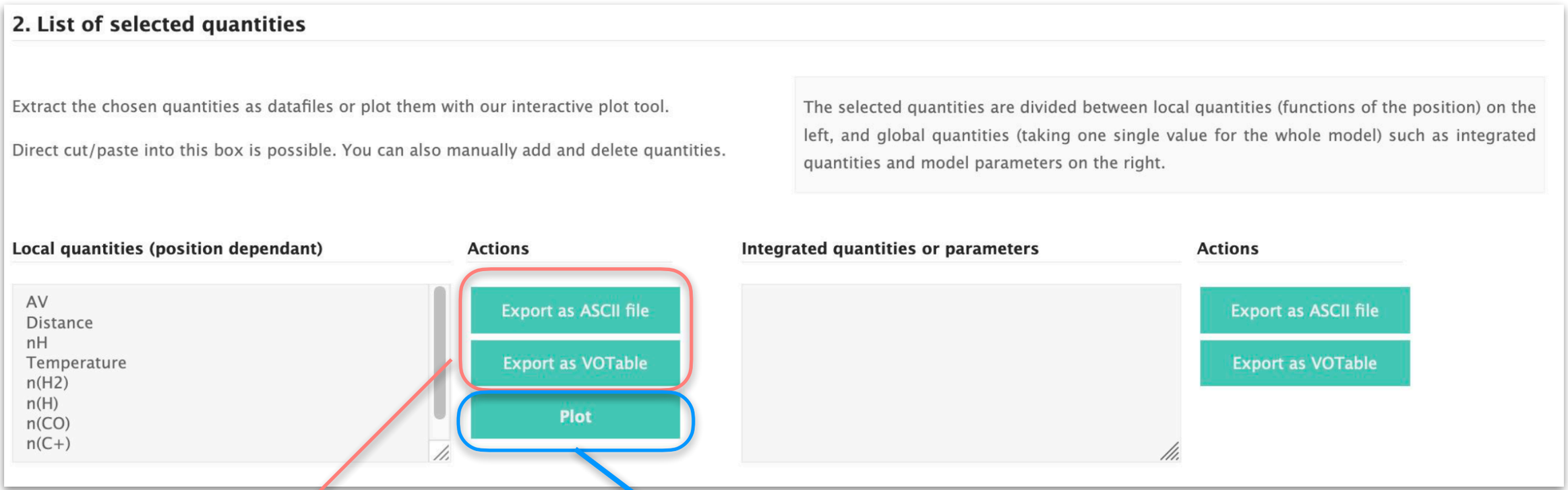
- Integrated quantities
- Local quantities
  - Auxiliary
  - Densities
    - Column densities
    - Densities
  - Dust
  - Gas state
  - Positions
- Parameters

n(a-C3H4) n(a-C3H4+) n(Ar) n(Ar+) n(ArH+) n(C) n(C+) n(C++) n(c-C3H) n(c-C3H2)
n(c-C3H2+) n(c-C3H3+) n(C2) n(C2+) n(C2H) n(C2H+) n(C2H2) n(C2H2+) n(C2H3) n(C2H3+)
n(C2H3O+) n(C2H4) n(C2H4+) n(C2H5+) n(C2HO+) n(C2N+) n(C2S) n(C2S+) n(C3) n(C3+)
n(C3H) n(C3H+) n(C3H2+) n(C3H3) n(C3H3+) n(C3H5+) n(C4) n(C4+) n(C4H) n(C4H+)
n(C4H2) n(C4H2+) n(C4H3+) n(CH) n(CH+) n(CH2) n(CH2+) n(CH3) n(CH3+) n(CH3OH)
n(CH3OH+) n(CH4) n(CH4+) n(CH5+) n(CH5O+) n(CN) n(CN+) n(CNC+) n(CO) n(CO+) n(CO2)
n(CO2+) n(CS) n(CS+) n(e-) n(Fe) n(Fe+) n(Fe++) n(H) n(H+) n(H2) n(H2+) n(H2:)
n(H2C3) n(H2CO) n(H2CO+) n(H2CS) n(H2CS+) n(H2NC+) n(H2O) n(H2O+) n(H2O2) n(H2S)
n(H2S+) n(H3+) n(H3CO) n(H3CO+) n(H3CS+) n(H3O+) n(H3S+) n(H:) n(H::) n(HCN) n(HCN+)

Next step >>

Clear all selection

IDAT : explore the content of models



Download data

Visualize data

IDAT : explore the content of models

3. Plot selected quantities

graph

Title: Chemical abundance profile in the Orion Bar PDR

x axis

Quantity: AV | Label: A_V | log: ☐

Min: | Max:

Min auto: ☑

y1 axis

Label: \mathrm{cm}^{-3}]$ | log: ☑ | Min: | Max:

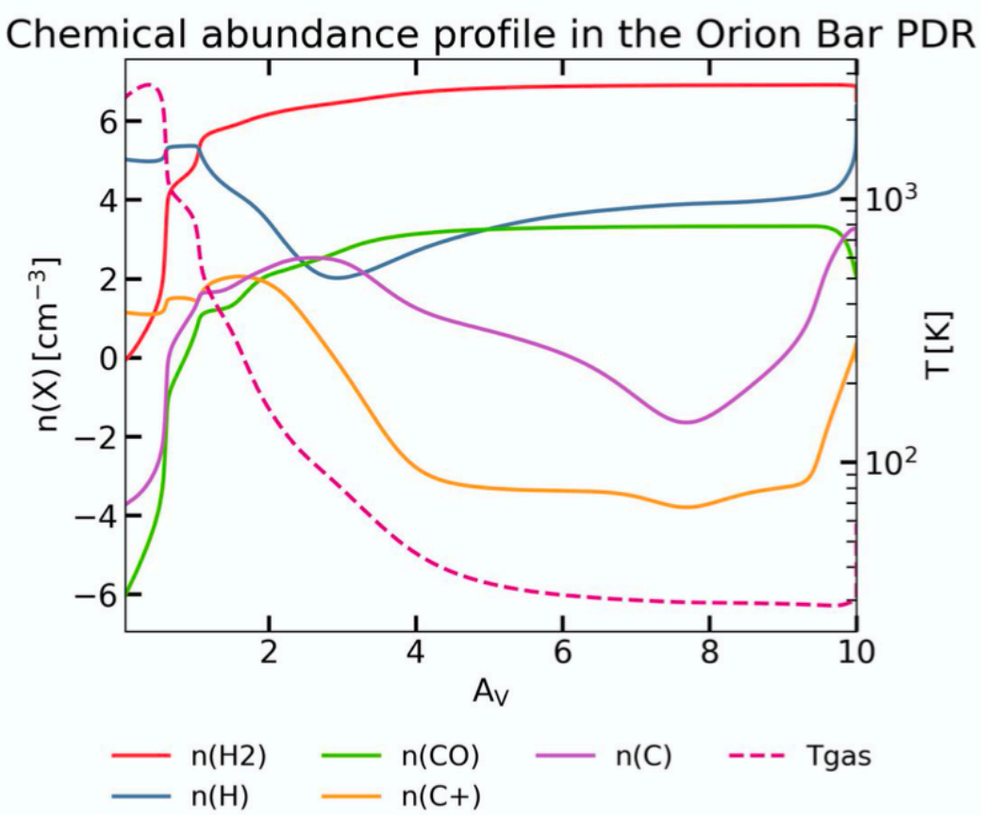
☑	n(H2)	cm-3	n(H2)
☑	n(H)		n(H)
☑	n(CO)	cm-3	n(CO)
☑	n(C+)	cm-3	n(C+)
☑	n(C)	cm-3	n(C)

y2 axis

Label: $T\,[\mathrm{K}]$ | log: ☑ | Min: | Max:

☐	AV	mag	AV
☐	Distance	cm	Distance
☐	nH		nH
☑	Tgas	K	Temperature
☐	n(H2)	cm-3	n(H2)

Plot

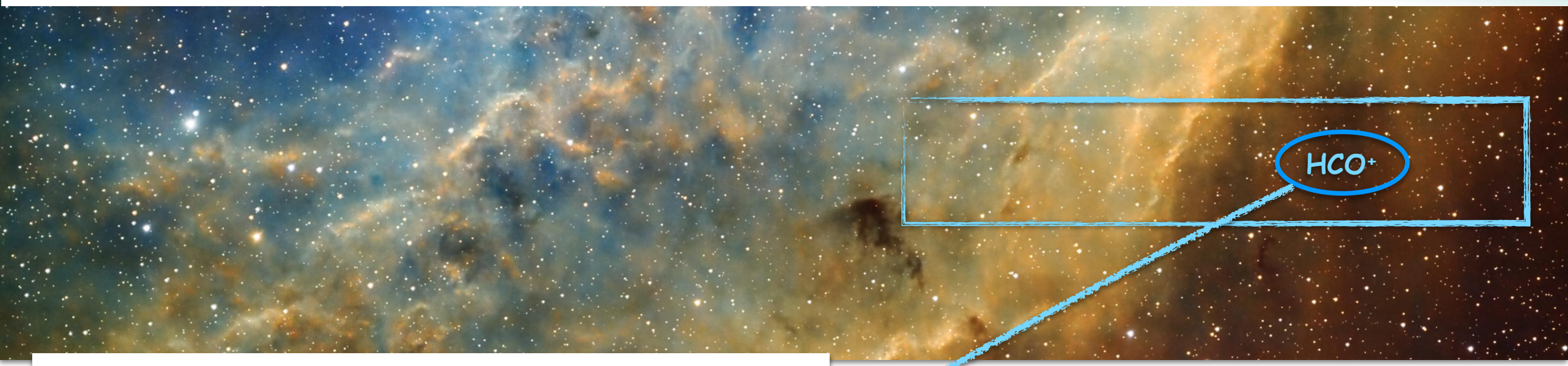


To save the figure: right click and select Save

Download figure

Save plot configuration file

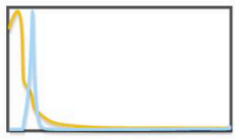
Chemistry analyser : Analyse the reactions



Profile

OrBarJ18_BestMod_c_20.hdf5

Log x ☐ Log y ☐



Temperature n(HCO+)

AV (mag)

1.0970813

Species

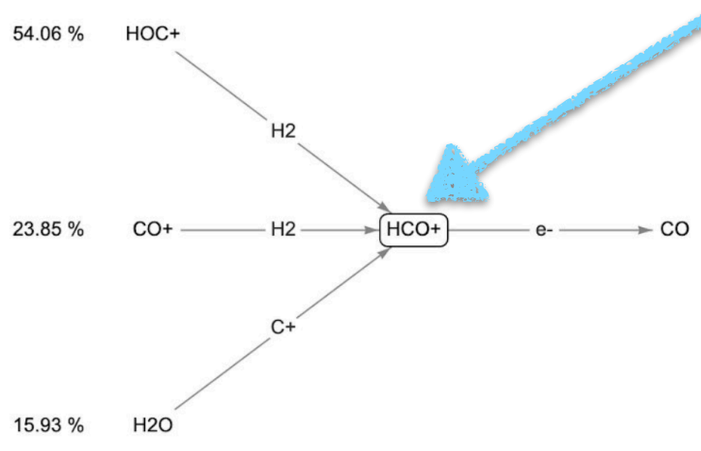
n(HCO+) 3.62e-2 cm-3

HCO+

back

Quantities

Gas ☑ Grains ☐



Gas conditions

ng(e-)	6.05e+1	cm-3
nd(e-)	-1.62e-3	cm-3
nH	7.65e+5	cm-3
Tg	5.39e+2	K
UV	2.09e+11	cm-2 s-1
zeta	5.00e-17	s-1 / H2

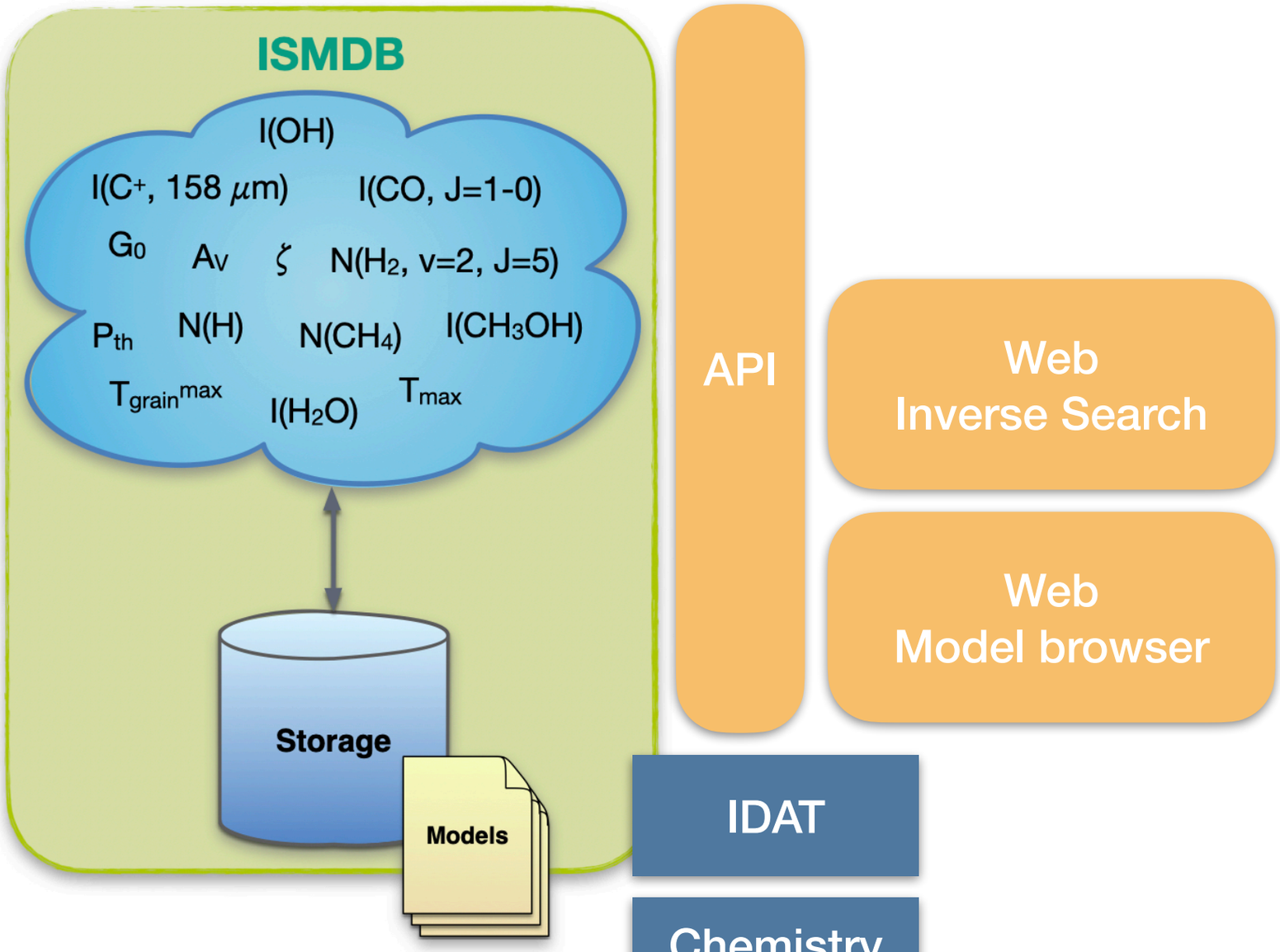
Formation of HCO+ — Total formation rate 3.86e-7 cm-3 s-1

A + B → C + D	n(A) (cm-3)	n(B) (cm-3)	k	rate (cm-3 s-1)	proportion
$H_2 + HOC^+ \rightarrow H_2 + HCO^+$	3.22e+5	1.71e-3	3.80e-10	2.09e-7	54.06 %
$H_2 + CO^+ \rightarrow H + HCO^+$	3.22e+5	3.81e-4	7.49e-10	9.20e-8	23.85 %
$H_2O + C^+ \rightarrow H + HCO^+$	2.61e+0	4.51e+1	5.22e-10	6.14e-8	15.93 %

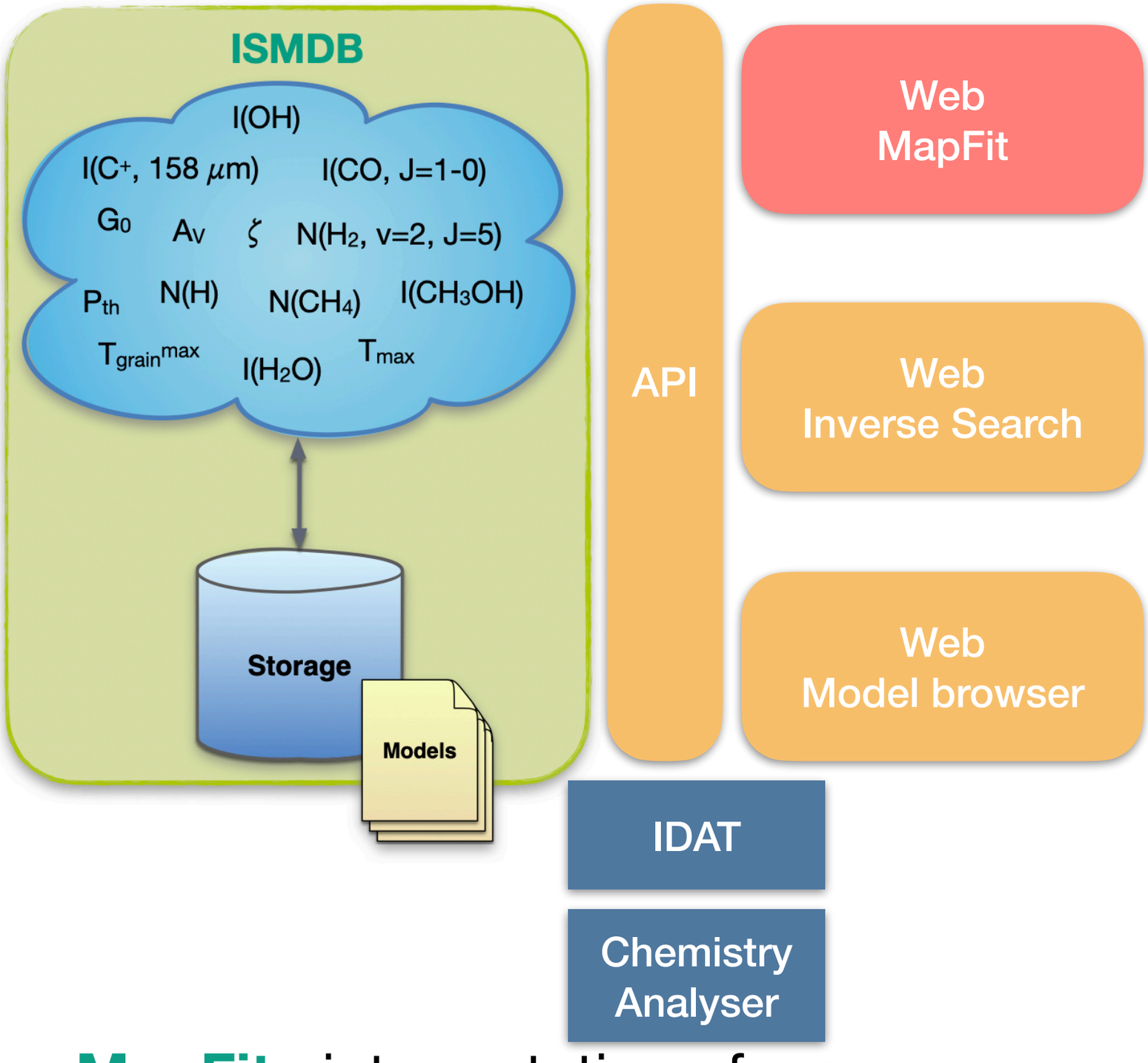
Destruction of HCO+ — Total destruction rate 3.86e-7 cm-3 s-1

A + B → C + D	n(A) (cm-3)	n(B) (cm-3)	k	rate (cm-3 s-1)	proportion
$HCO^+ + e^- \rightarrow H + CO$	3.62e-2	6.05e+1	1.64e-7	3.59e-7	93.03 %

New functionalities in 2025



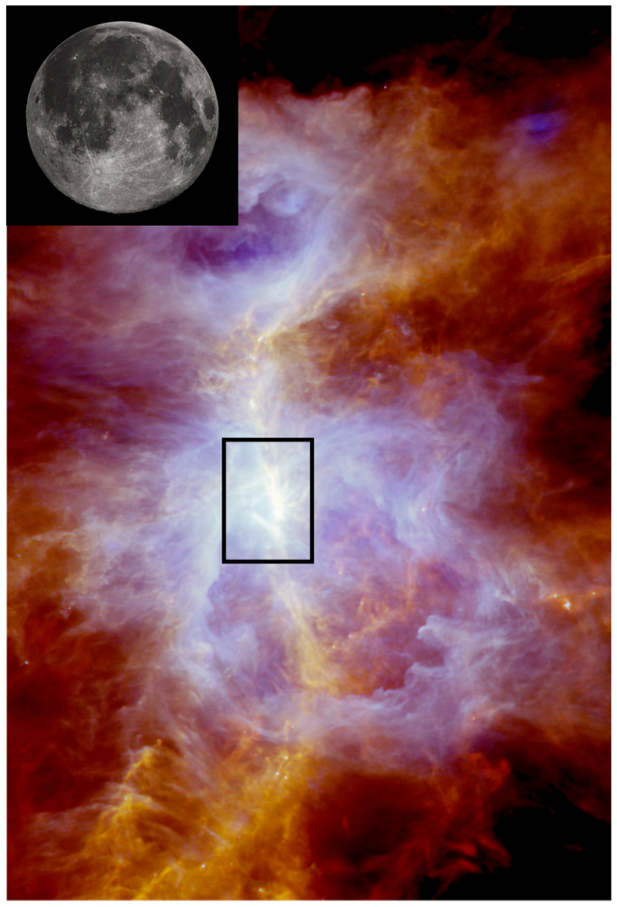
New functionalities in 2025

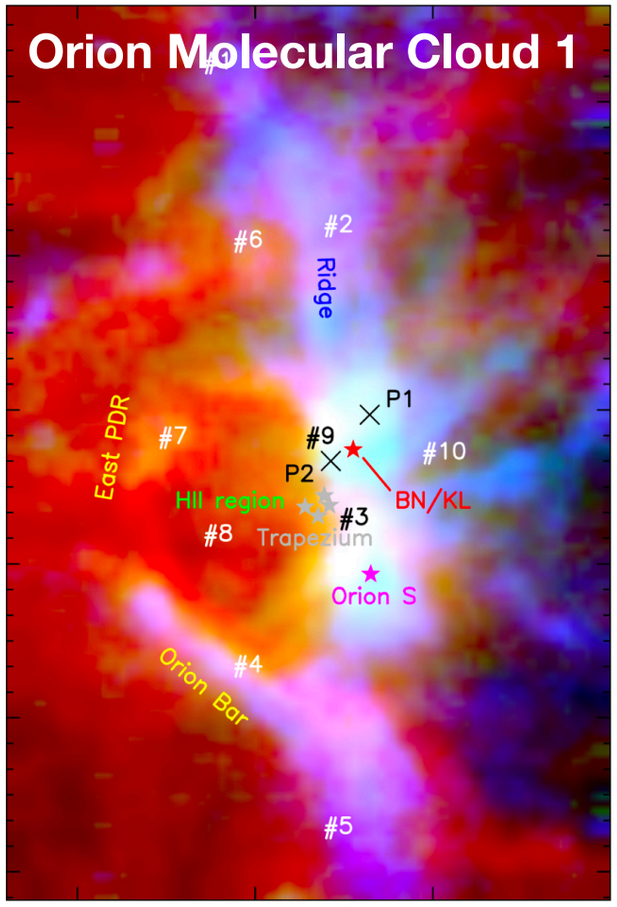


- **MapFit** : interpretation of maps
- Access to ISMDB via **python notebooks** (or clients)

MapFit

New tool for **inverse problems on hyperspectral maps**
(IRAM, JWST, MUSE, …)

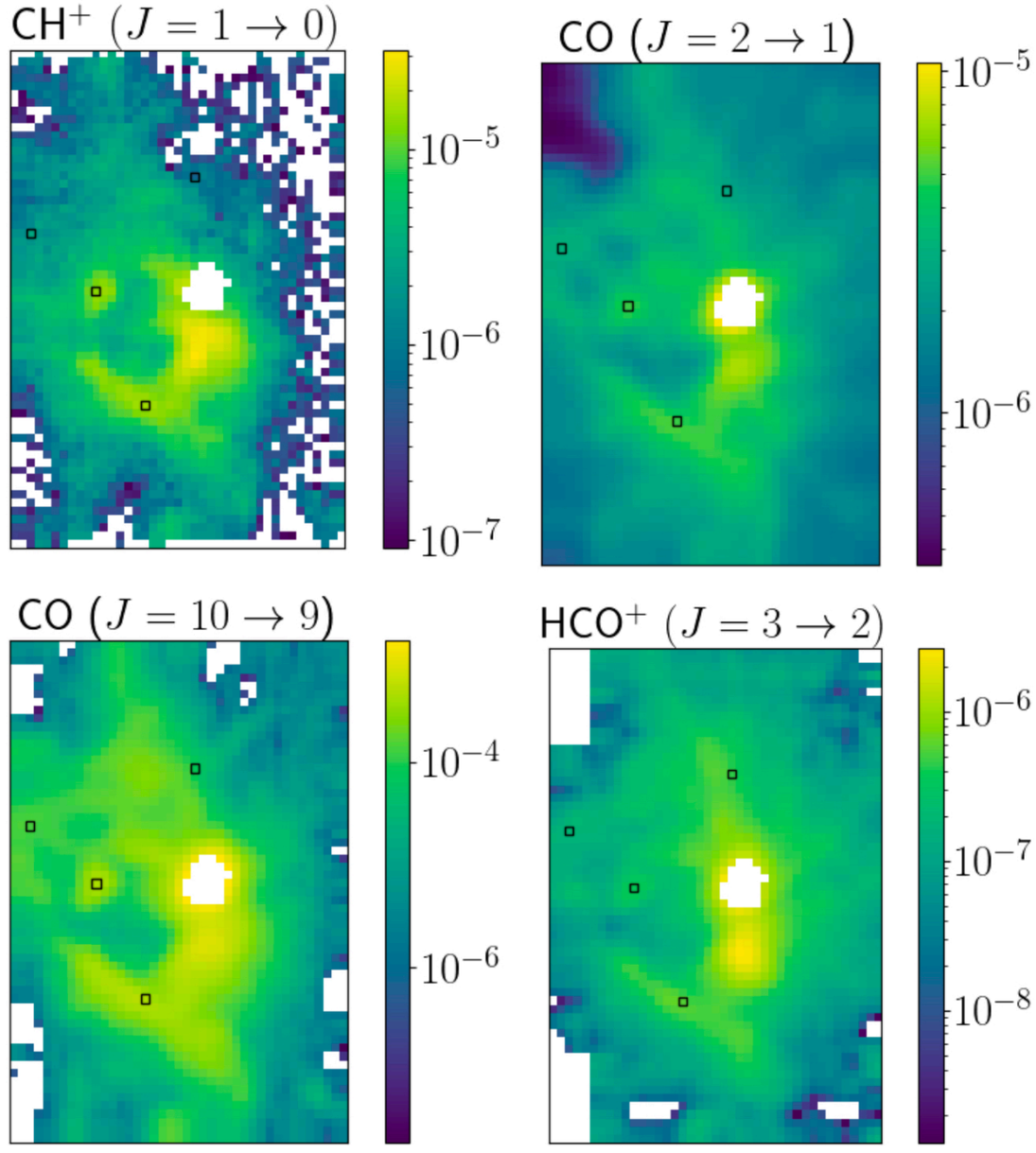




① **Provide the line observation maps** to ISMDB

② ISMDB returns the **maps of the physical parameters** that explain the observations

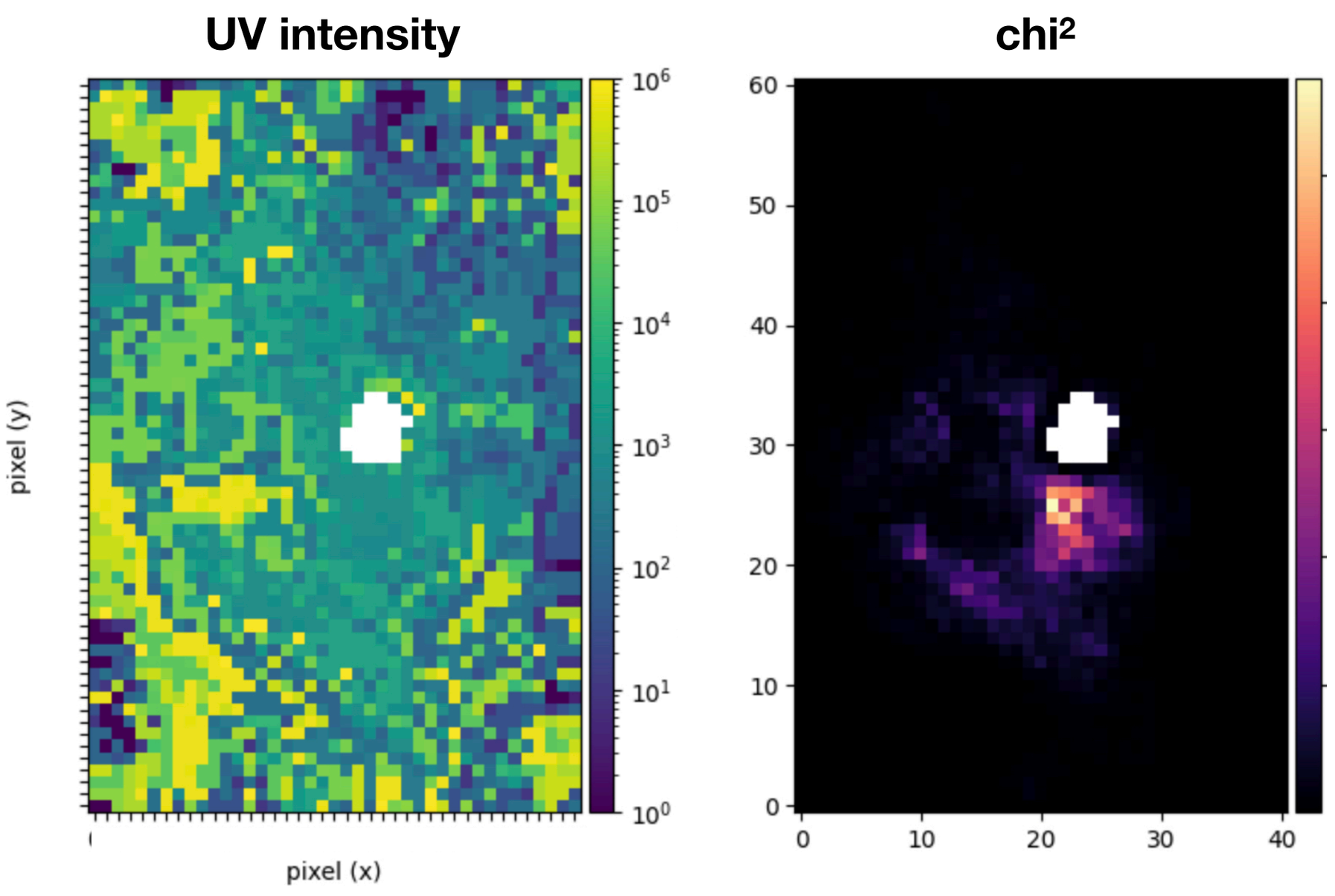
Observed lines



User Map Fit *[proj_20250333518b5414]*

ismdb grid	P7G1E20BG_P_240819
map size	41x61
fit status	finished

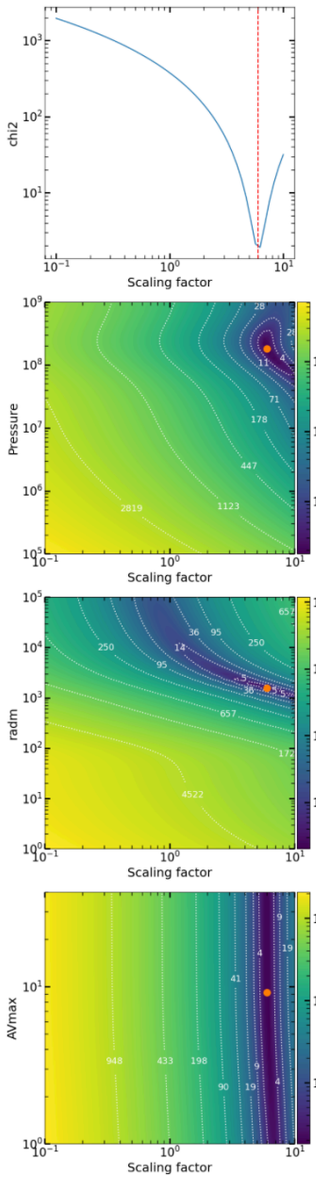
G0 stellar component



User Map Fit *[proj_20250333518b5414]*

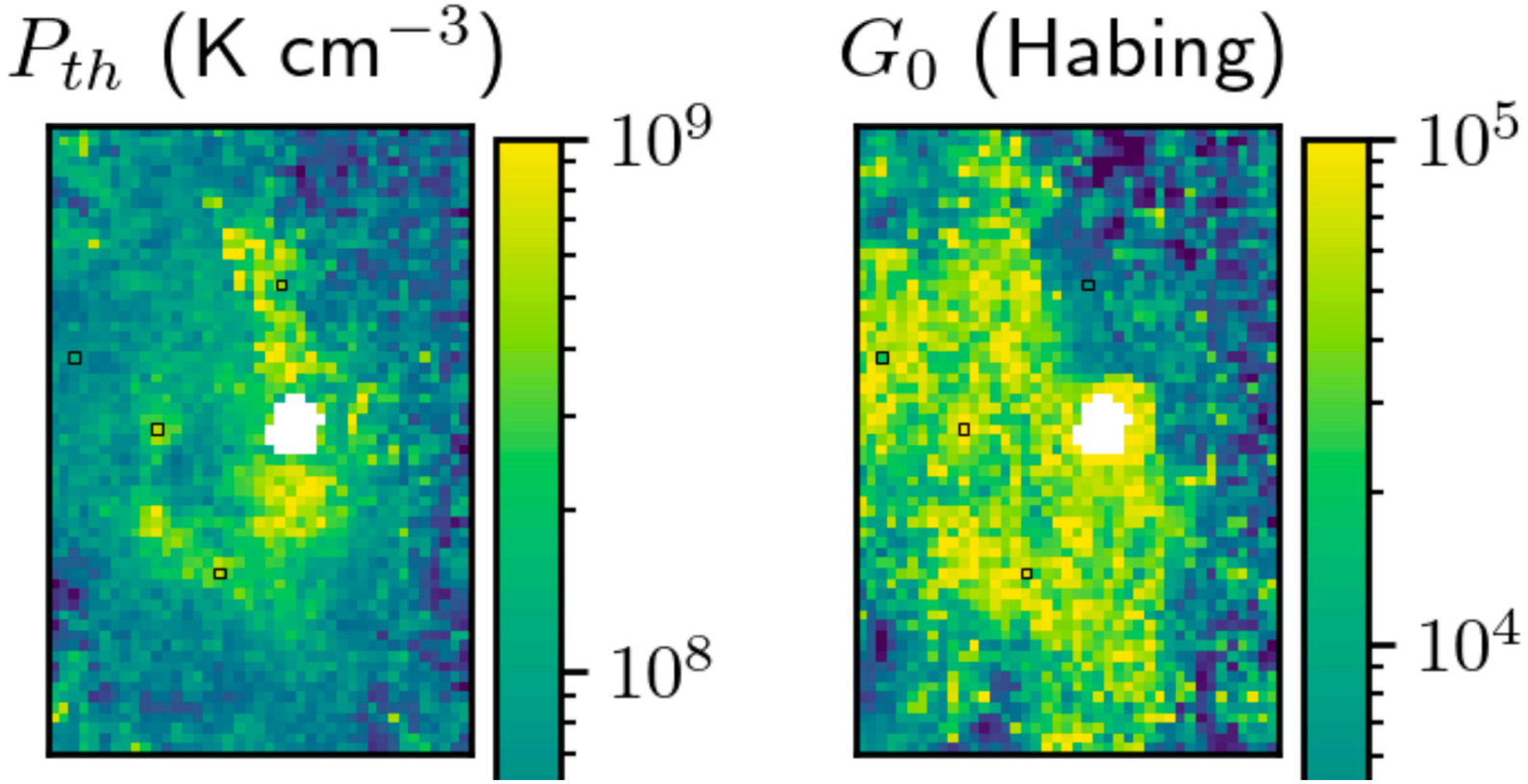
ismdb grid	P7G1E20BG_P_240819
map size	41x61
fit status	**finished**

G0 stellar component



Inversion bayesienne - régularisation spatiale

Inversion classique



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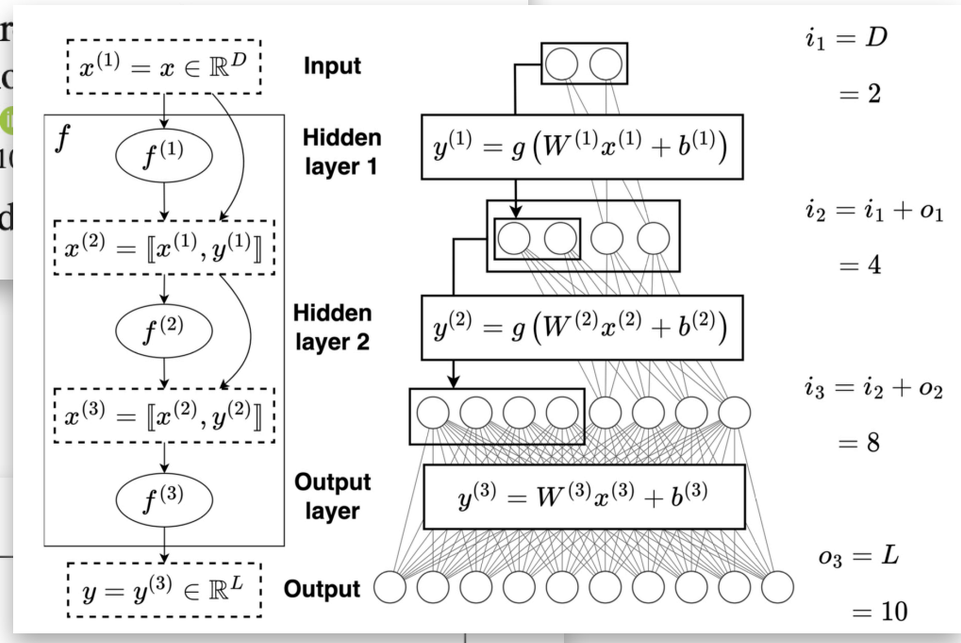
https://doi.org/10.1051/0004-6361/202347074

Astronomy & Astrophysics

Neural network-based emulation of interstellar medium models

Pierre Palud[1,3,⋆], Lucas Einig[2,4,⋆], Franck Le Petit[1], Émeric Bron[1], Pierr
Jocelyn Chanussot[4], Jérôme Pety[2,5], Pierre-Antoine Thouvenin[3], David Languignc
Miriam G. Santa-Maria[6], Jan H. Orkisz[2], Léontine E. Ségal[2,7], Antoine Zakardjian[8]
Maryvonne Gerin[5], Javier R. Goicoechea[6], Pierre Gratier[9], Viviana V. Guzman[1
François Levrier[11], Harvey S. Liszt[12], Jacques Le Bourlot[1], Antoine Roueff[7], and



Astronomy & Astrophysics manuscript no. main
January 6, 2025

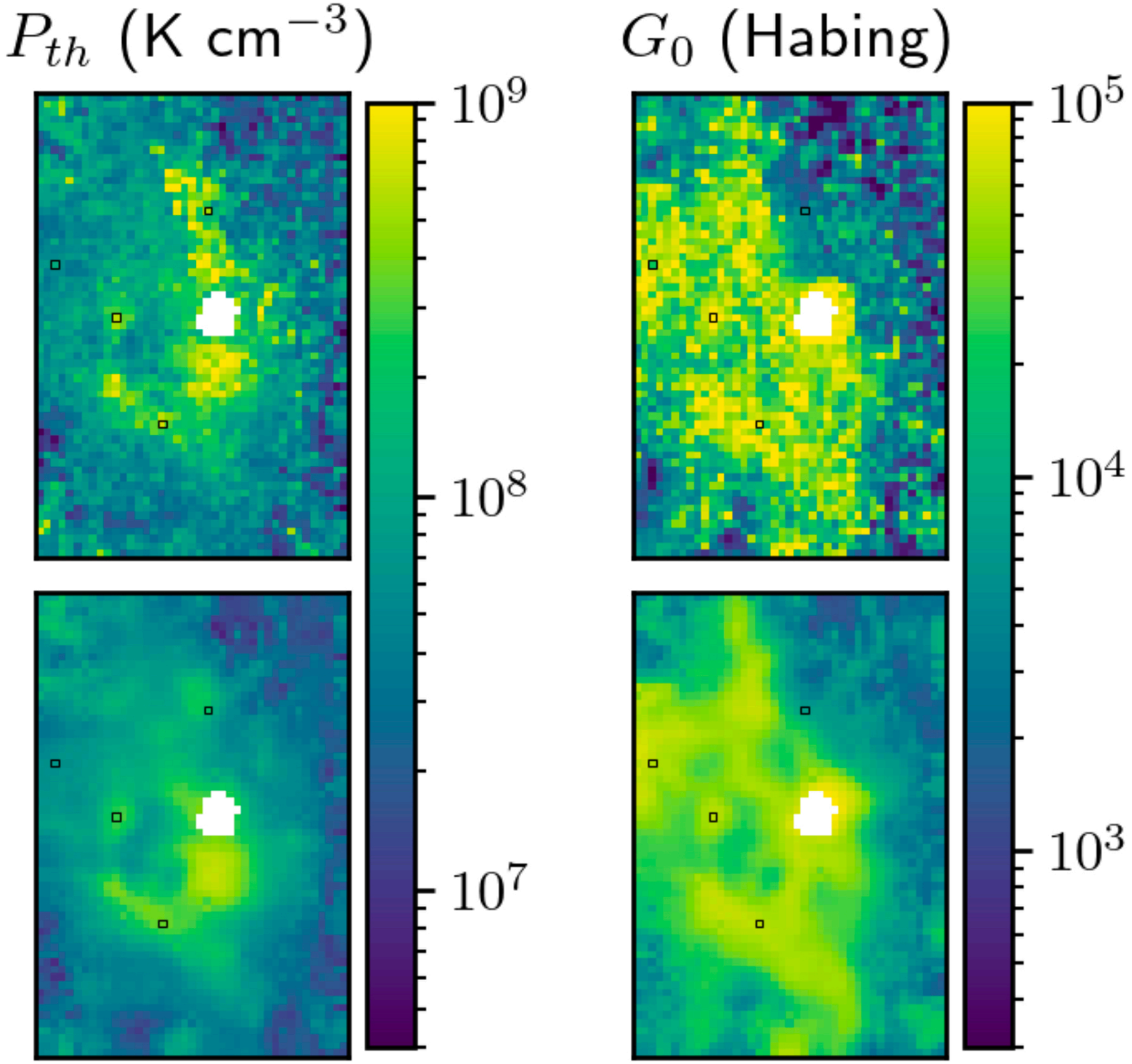
BEETROOTS: Bayesian inference of interstellar medium physical parameter maps with a spatial regularization

Pierre Palud[2,4,5], Emeric Bron[2], Pierre Chainais[4], Franck Le Petit[2], Pierre-Antoine Thouvenin[4], Miriam G. Santa-Maria[10,11], Javier R. Goicoechea[10], David Languignon[2], Maryvonne Gerin[7], Jérôme Pety[1,7], Ivana Bešlić[7], Simon Coudé[8,9], Lucas Einig[1,3], Helena Mazurek[7], Jan H. Orkisz[1], Léontine Ségal[1,6], Antoine Zakardjian[12], Sébastien Bardeau[1], Karine Demyk[12], Victor de Souza Magalhães[13], Pierre Gratier[14], Viviana V. Guzmán[15], Annie Hughes[12], François Levrier[16], Jacques Le Bourlot[2], Dariusz C. Lis[17], Harvey S. Liszt[13], Nicolas Peretto[18], Antoine Roueff[6], Evelyne Roueff[7], and Albrecht Sievers[1]

Inversion bayesienne - régularisation spatiale

Inversion classique

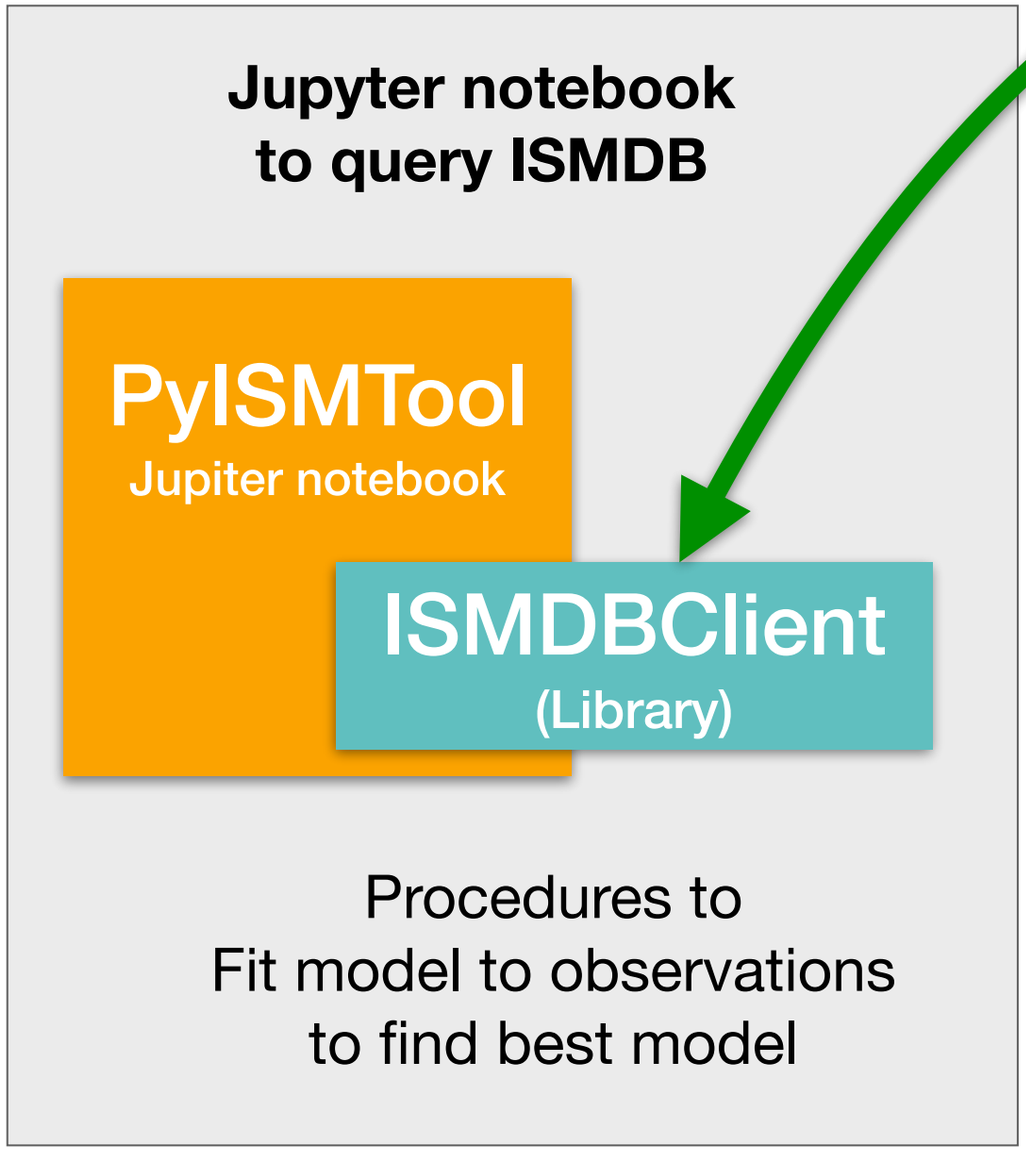
Nouvelle méthode bayesienne (NNBMA + Beetroots)

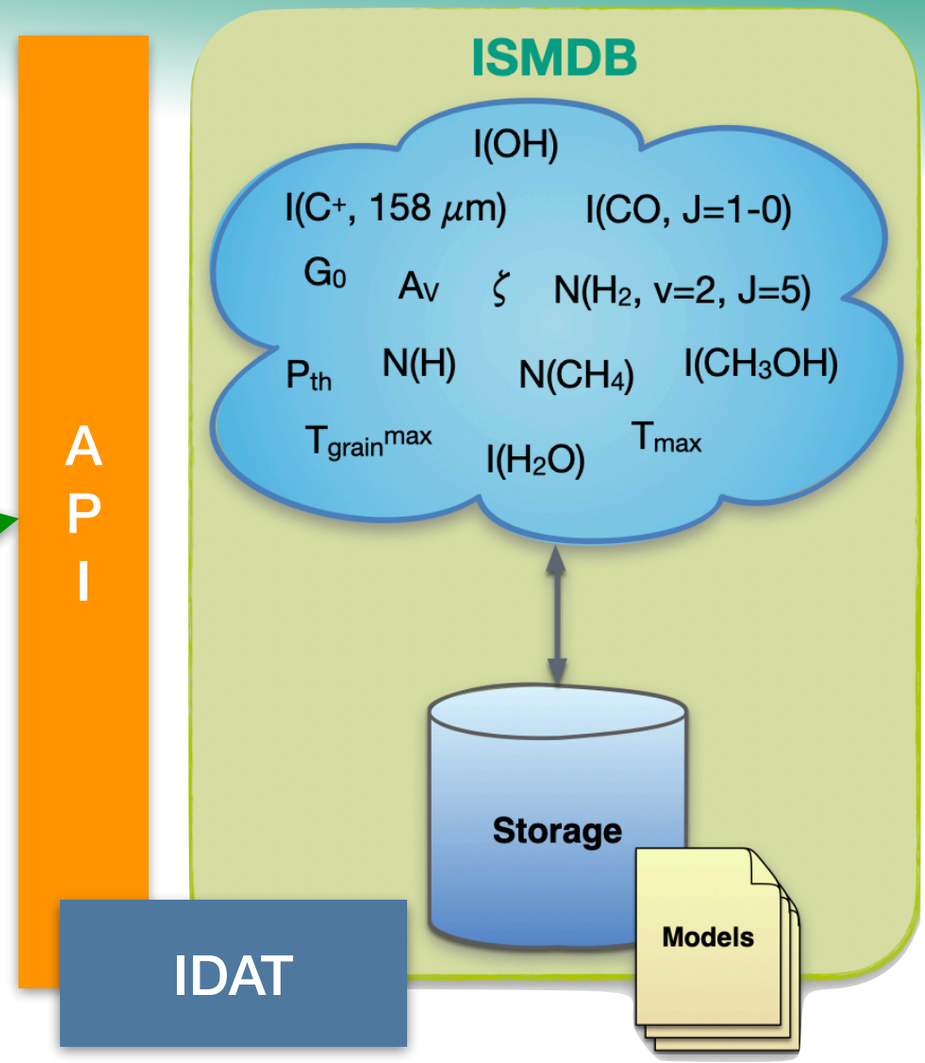


pyISMtools

Up to now : web applications

Advanced users want more flexibility
➔ **python notebooks to interact with ISMDB**





[7]:
```
# Reading a model grid from ISMDB (this might take a few tens of seconds)
grid_ID = "P7G1E20BG_P_240819"

observable_list = ["I(H2 v=1,J=2->v=0,J=0 angle 00 deg)",
                   "I(H2 v=1,J=3->v=0,J=1 angle 00 deg)",
                   "I(H2 v=1,J=4->v=0,J=2 angle 00 deg)",
                   "I(H2 v=1,J=5->v=0,J=3 angle 00 deg)",
                   "I(H2 v=1,J=6->v=0,J=4 angle 00 deg)",
                   "I(H2 v=1,J=7->v=0,J=5 angle 00 deg)",
                   "I(H2 v=1,J=8->v=0,J=6 angle 00 deg)",
                   "I(H2 v=1,J=9->v=0,J=7 angle 00 deg)"
                  ]

my_grid = ism.ismdb_api.get_grid(grid_ID,observable_list)
print(my_grid)
```

```
>> Subpart 1/2 extracted.
>> Subpart 2/2 extracted.
-------------------------------------------------------
Model grid
Grid ID : P7G1E20BG_P_240819     code version : Unknown code version
Number of models : 3054   number of parameters : 3      number of observables : 8

Parameters :
name                            min_value  max_value nb_values
Pressure                        1.00E+03    1.00E+11 25
G0 stellar component            1.00E+00    1.00E+06 21
AVmax                           1.00E+00    4.00E+01 8

Observables :
name                            min_value  max_value
I(H2 v=1,J=2->v=0,J=0 angle 00 deg)   9.02E-14   3.58E-03
I(H2 v=1,J=3->v=0,J=1 angle 00 deg)   9.64E-13   1.63E-02
I(H2 v=1,J=4->v=0,J=2 angle 00 deg)   3.74E-13   5.95E-03
I(H2 v=1,J=5->v=0,J=3 angle 00 deg)   1.79E-12   1.60E-02
I(H2 v=1,J=6->v=0,J=4 angle 00 deg)   5.85E-13   4.21E-03
I(H2 v=1,J=7->v=0,J=5 angle 00 deg)   2.02E-12   8.73E-03
I(H2 v=1,J=8->v=0,J=6 angle 00 deg)   2.83E-13   1.79E-03
I(H2 v=1,J=9->v=0,J=7 angle 00 deg)   7.19E-13   2.92E-03

Additional infos :

No infos.
-------------------------------------------------------
No trained approximator yet for this grid.
```

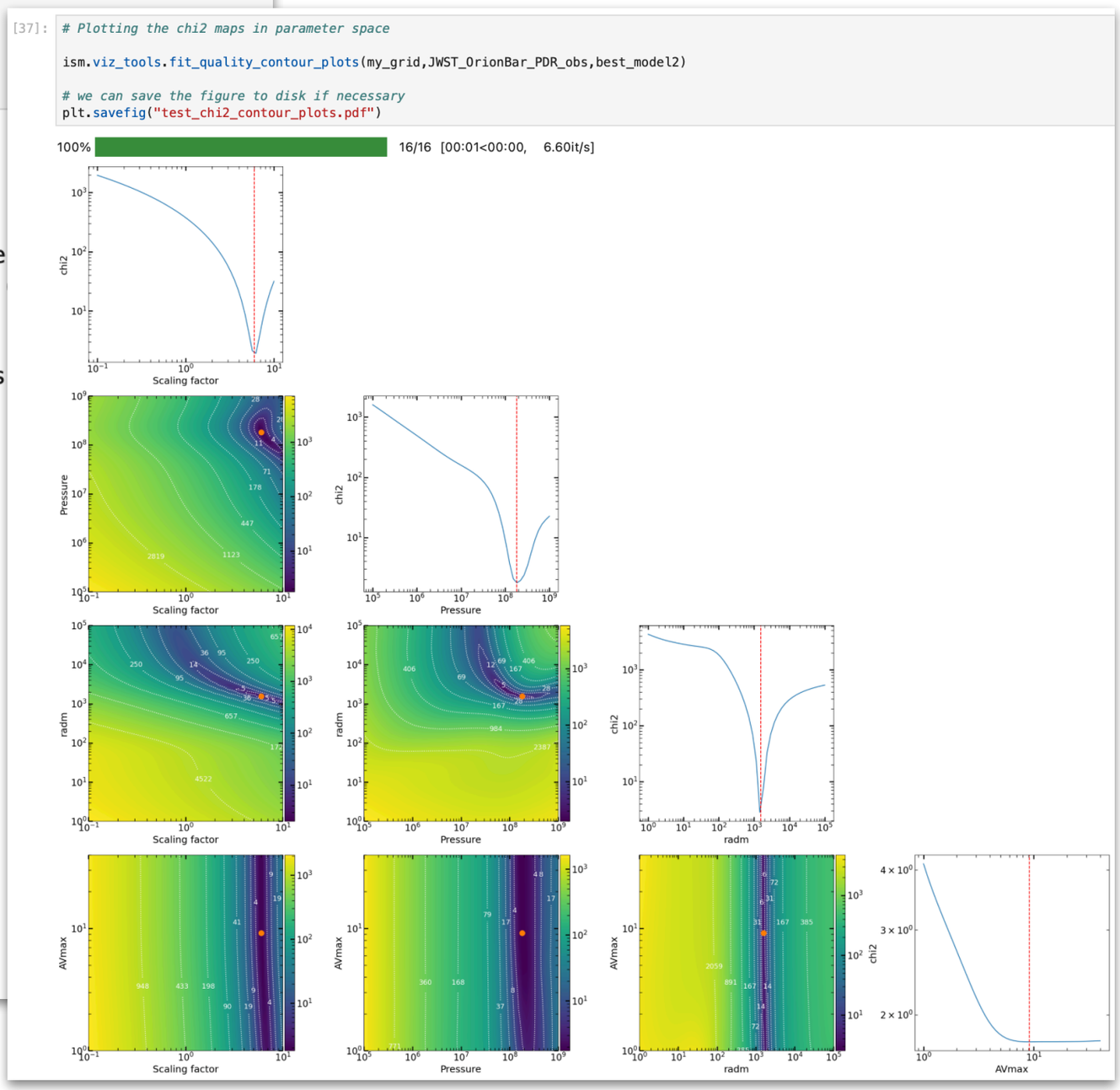
Example :
Get some H_2 line intensities in all models of a grid

[7]:
```python
# Reading a model grid from ISMDB (this might take a few tens of seconds)
grid_ID = "P7G1E20BG_P_240819"

observable_list = ["I(H2 v=1,J=2->v=0,J=0 angle 00 deg)",
                   "I(H2 v=1,J=3->v=0,J=1 angle 00 deg)",
                   "I(H2 v=1,J=4->v=0,J=2 angle 00 deg)",
                   "I(H2 v=1,J=5->v=0,J=3 angle 00 deg)",
                   "I(H2 v=1,J=6->v=0,J=4 angle 00 deg)",
                   "I(H2 v=1,J=7->v=0,J=5 angle 00 deg)",
                   "I(H2 v=1,J=8->v=0,J=6 angle 00 deg)",
                   "I(H2 v=1,J=9->v=0,J=7 angle 00 deg)"
                  ]

my_grid = ism.ismdb_api.get_grid(grid_ID,observable_list)
print(my_grid)
```

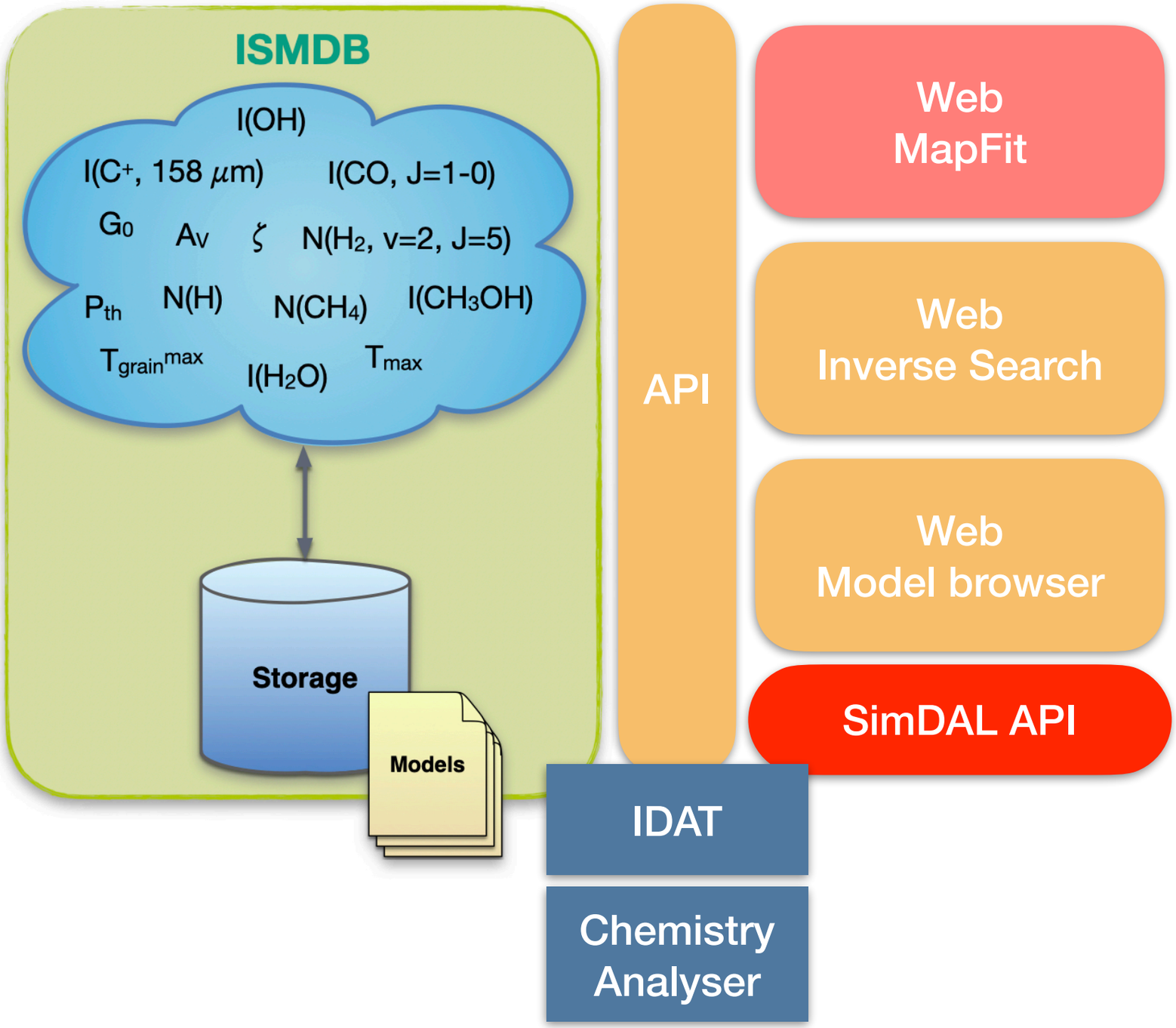
```
>> Subpart 1/2 extracted.
>> Subpart 2/2 extracted.
------------------------------------------------------------
Model grid
Grid ID : P7G1E20BG_P_240819     code version : Unknown code ve
Number of models : 3054   number of parameters : 3      number

Parameters :
name                              min_value  max_value nb_values
Pressure                          1.00E+03    1.00E+11 25
G0 stellar component              1.00E+00    1.00E+06 21
AVmax                             1.00E+00    4.00E+01 8

Observables :
name                              min_value  max_value
I(H2 v=1,J=2->v=0,J=0 angle 00 deg)   9.02E-14   3.58E-03
I(H2 v=1,J=3->v=0,J=1 angle 00 deg)   9.64E-13   1.63E-02
I(H2 v=1,J=4->v=0,J=2 angle 00 deg)   3.74E-13   5.95E-03
I(H2 v=1,J=5->v=0,J=3 angle 00 deg)   1.79E-12   1.60E-02
I(H2 v=1,J=6->v=0,J=4 angle 00 deg)   5.85E-13   4.21E-03
I(H2 v=1,J=7->v=0,J=5 angle 00 deg)   2.02E-12   8.73E-03
I(H2 v=1,J=8->v=0,J=6 angle 00 deg)   2.83E-13   1.79E-03
I(H2 v=1,J=9->v=0,J=7 angle 00 deg)   7.19E-13   2.92E-03

Additional infos :

No infos.
------------------------------------------------------------
No trained approximator yet for this grid.
```

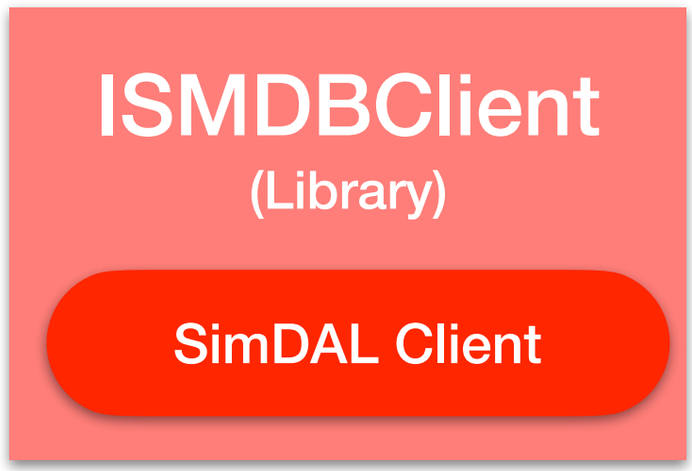
[37]:
```python
# Plotting the chi2 maps in parameter space

ism.viz_tools.fit_quality_contour_plots(my_grid,JWST_OrionBar_PDR_obs,best_model2)

# we can save the figure to disk if necessary
plt.savefig("test_chi2_contour_plots.pdf")
```

```
100%|██████████| 16/16 [00:01<00:00,  6.60it/s]
```

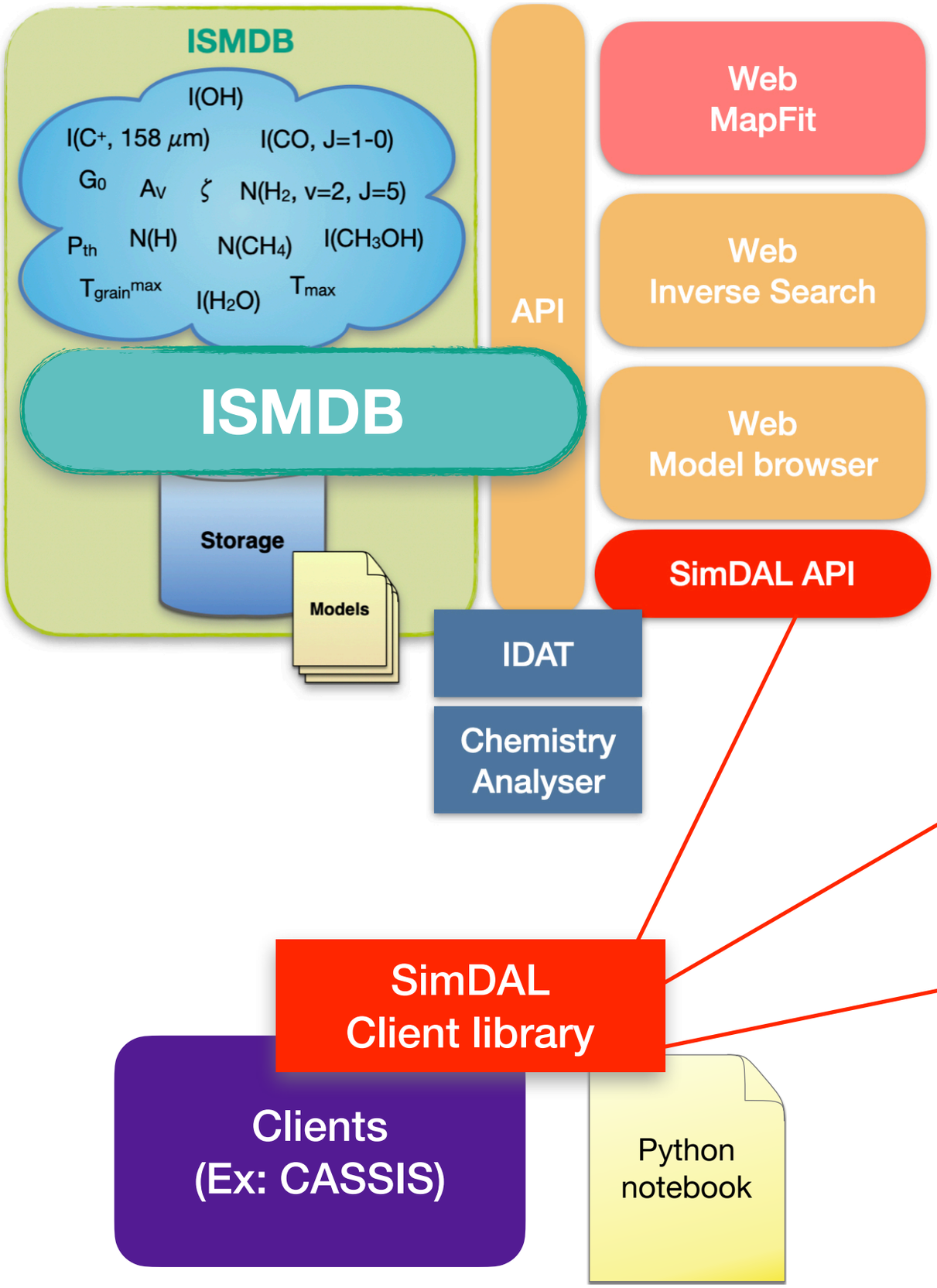


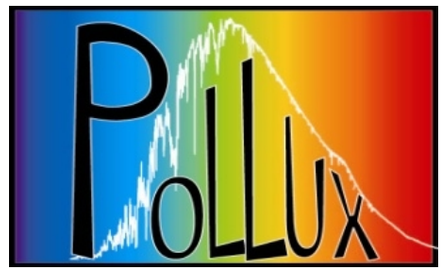
Where we go


ISMDB
I(OH)
I(C+, 158 μm)
I(CO, J=1-0)
G0
AV
ζ
N(H2, v=2, J=5)
Pth
N(H)
N(CH4)
I(CH3OH)
Tgrainmax
I(H2O)
Tmax
Storage
Models
API
Web
MapFit
Web
Inverse Search
Web
Model browser
SimDAL API
IDAT
Chemistry
Analyser


ISMDBClient
(Library)
SimDAL Client

Towards a common interface to access all theoretical databases





POLLUX

SimDAL API

GALACTICA

SimDAL API

SimDAL
Client library

Clients
(Ex: CASSIS)

Python
notebook