Cloudy: plasma & spectral simulations

- **Accurate simulation of physical processes at the atomic & molecular level**
  - "universal fitting formulae" to atomic processes fail when used outside realm of validity, and are not used
- **Assumptions:**
  - energy is conserved
  - (usually) atomic processes have reached steady state
- **Limits:**
  - Kinetic temperature 2.7 K < T < 10^{10} K
  - No limits to density (low density limit, LTE, STE)
  - Radiation field 10 m to 100 MeV

Simultaneous solution of

- **Ionization lightest 30 elements**
  - From ionization balance equations
- **Chemistry ~140 molecules**
  - Large network based on UMIST
- **Gas kinetic temperature**
  - Heating and cooling
- **Grain physics**
  - Charging, CX, photoejection, quantum heating, temperature & temperature fluctuations
- **The observed spectrum**
  - Radiative transport

Cloudy and its physics

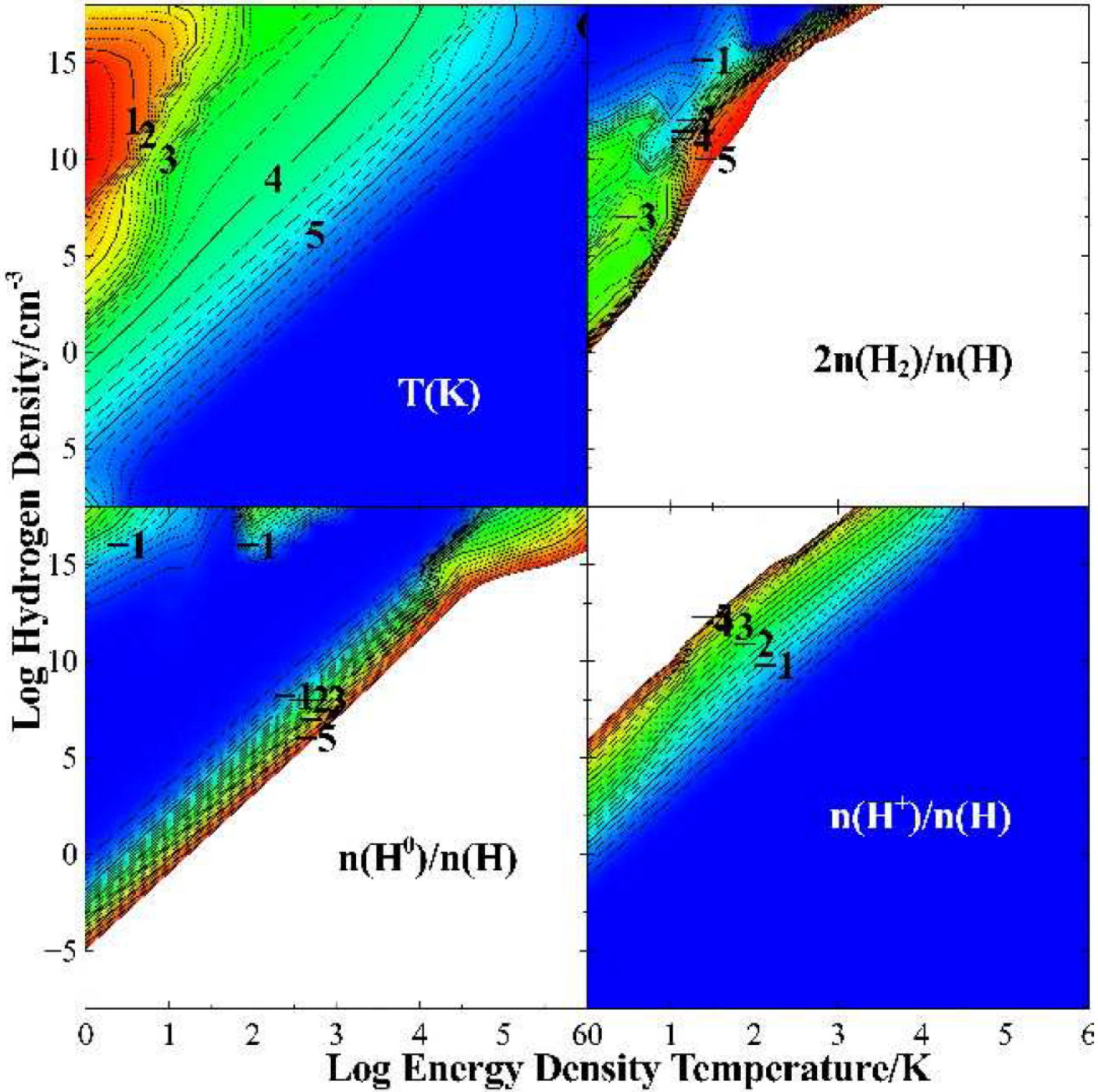
- **Osterbrock & Ferland 2006, *Astrophysics of Gaseous Nebulae and Active Galactic Nuclei*, 2nd edition (AGN3)**
- **Ferland+2013, Rev Mex 49, 137, *The 2013 Release of Cloudy***
- **Ferland 2003, ARA&A, 41, 517, *Quantitative Spectroscopy of Photoionized Clouds***

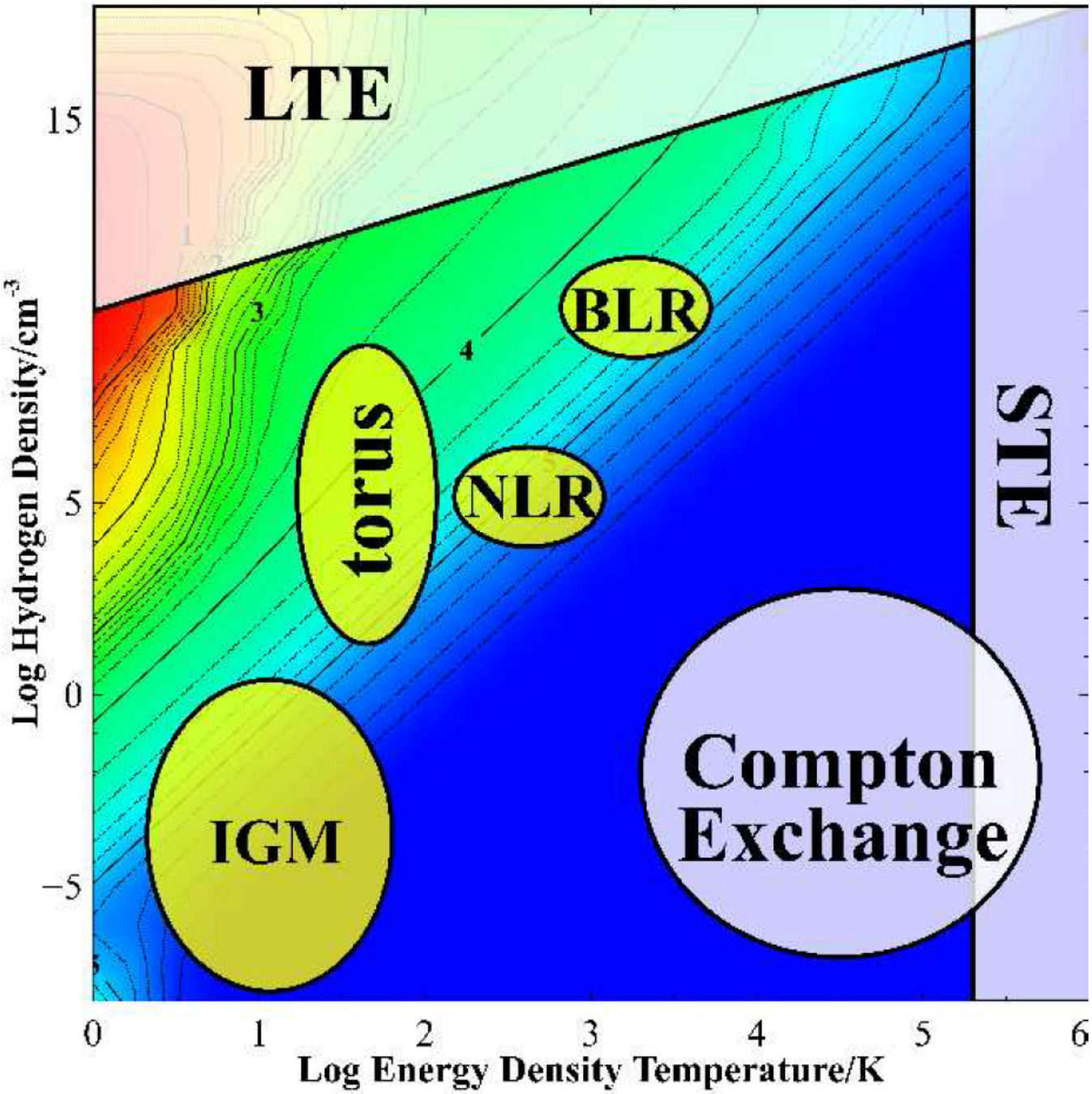
- **Links at http://cloud9.pa.uky.edu/~gary/cloudy/CloudySummerSchool/CloudyBackgroundInfo.html**

Some applications to astronomy

- **Hamann & Ferland, ARA&A, 37, 487, *Elemental Abundances in Quasistellar Objects: Star Formation and Galactic Nuclear Evolution at High Redshifts***
- **Ferland 2001, PASP, 113, 41, *Physical Conditions in the Orion H II Region***

- **And the ~200 papers that cite its documentation each year**


T(K)
2n(H2)/n(H)
n(H0)/n(H)
n(H+)/n(H)
Log Hydrogen Density/cm-3
Log Energy Density Temperature/K


LTE
STE
BLR
torus
NLR
IGM
Compton
Exchange
3
4
5
15
0
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1
2
3
4
5
6
Log Hydrogen Density/cm^{-3}
Log Energy Density Temperature/K

Open source since 1978

- All versions, all source, all data, on svn at nublado.org
- You are most welcome to help!

Cloudy & Associates

Photoionization Simulations for the Discriminating Astrophysicist Since 1978

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Welcome to the Cloudy home page!

Cloudy is a spectral synthesis code designed to simulate conditions in interstellar matter under a broad range of conditions.

Please post question or problems on the Cloudy discussion board. Updates to Cloudy will be announced on that board.

Summer school on Cloudy, and the physics and spectroscopy of the interstellar medium Summer 2012 in Lexington. More details on the Summer School page.

Getting started with Cloudy

StepByStep instructions for downloading and installing the release version.

StellarAtmospheres in Cloudy are now very flexible. They are described on this web site rather than in Hazy.

KnownProblems are described on this page.

HotFixes are small corrections to the source that fix problems discovered after the current stable version was released.

Frequently asked questions are on the FaqPage

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The RevisionHistory pages list changes and new features in past, current and the next versions.

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https://www.nublado.org/

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Introduction to installing Cloudy

This page contains step by step instructions for installing the current stable version of Cloudy. *Hazy*, the code's documentation, the download.

Each version of the code has a set of pages giving updates. The HotFixes page lists corrections that need to be made to the do source. These are bug fixes that were not included in the version of the code available for download and used to generate the the test suite. So the hot fixes should be applied after the test suite has been run and your system validated. A KnownProblem known problems with that version of the code. The RevisionHistory page lists improvements.

Cite the code by giving the version number and a reference to the last major review of Cloudy, Ferland et al. (1998; PASP, 11(available here). An example would be "We used version 05.07b of Cloudy, last described by Ferland et al. (1998)". Then, ye when someone wants to know how an answer was obtained, the version used to obtain it can be retrieved from the old version web site. The **print citation** command will print the correct citation for the version you are using.

Setting up this version

1. DownLoad the code, data, and documentation. This creates several directories, Each contains a readme.htm file describing t that directory.

2. EditPath - instructions for how to specify where the data files are located. **Important!** The code will not run if it cannot find

3. CompileCode - how to compile the code using a variety of compilers.

4. RunCode - This explains how to execute the code and run a smoke test.

5. MpiParallel describes how to use the optimize and grid commands on a parallel cluster, using either MPI or a makefile.

6. CompileStars - You must compile some stellar data files if you want to use the some of the table star command to include re continua.

7. TestSuite is a large number of test cases that you should run to confirm that all is well. This is a critical step since it will che your compiler. That directory also contains a group of programs that show how to call the code as a subroutine.

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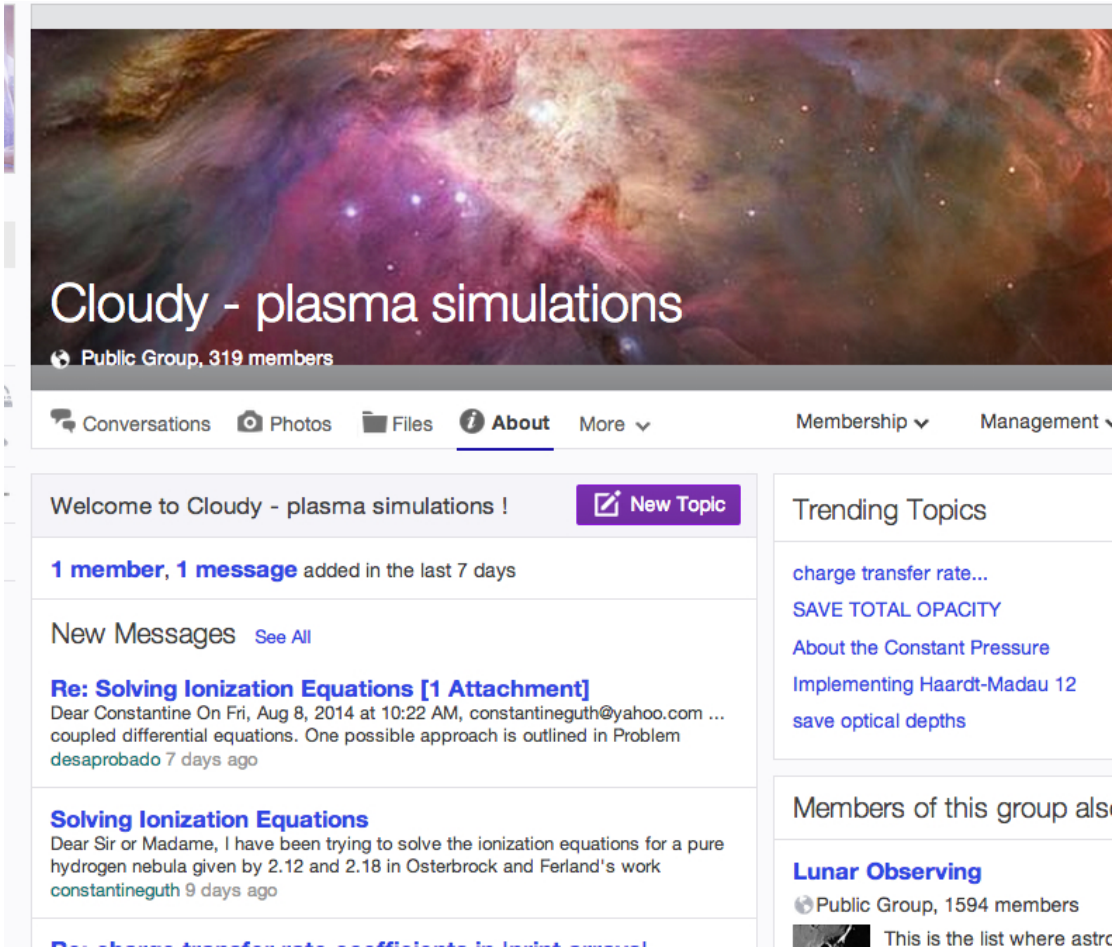
Where to go for help

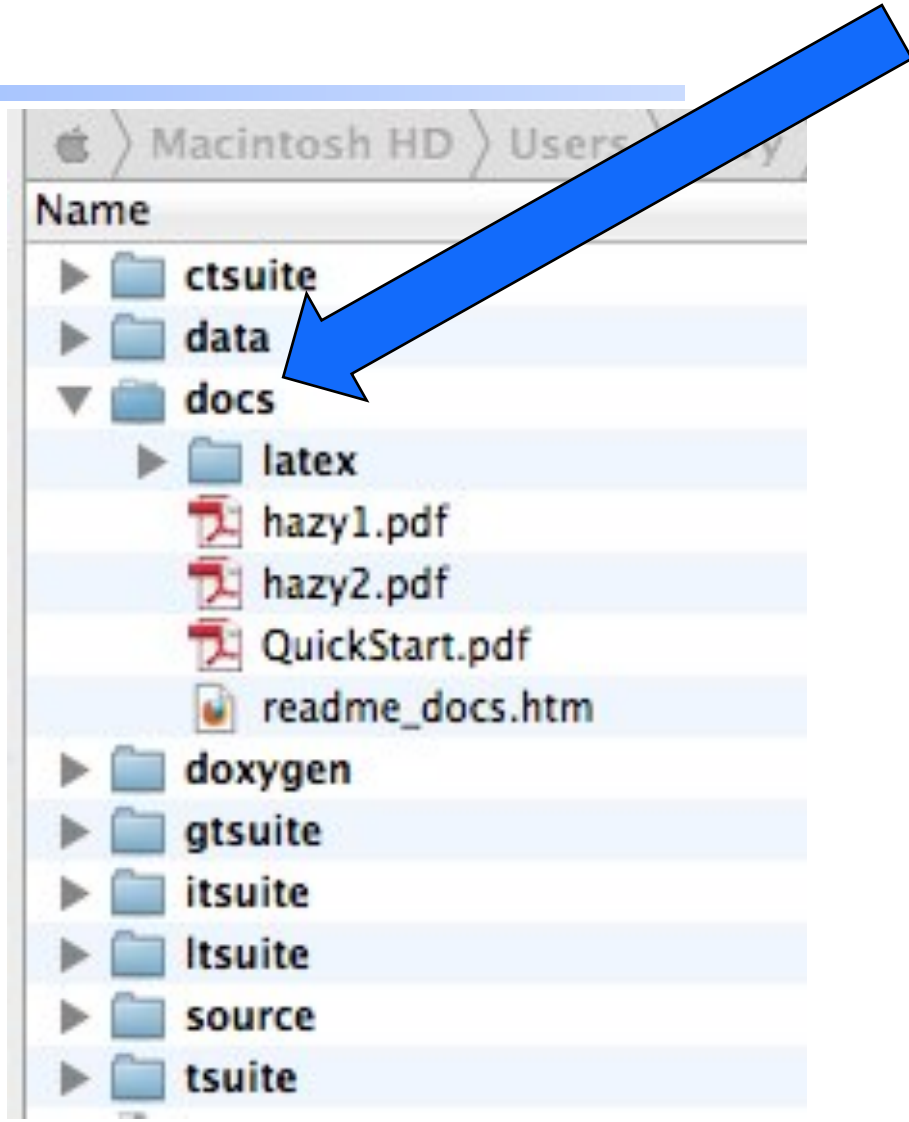
- **https://groups.yahoo.com/neo/groups/cloudy_simulations/info**



Topics (List as Individual Messages)	Messages	Latest Post
C10.00 Segmentation Fault with GCC 4.6.2 Hello, After upgrading to Fedora16 and the new GCC 4.6.2 C10.00 compiles with no complaints, but segfaults on every model including the smoke test. I have been...	7	Jun 1, 2012 2:02 pm Peter van Hoof peter_van_hoof
compile grain failed. I was trying to compile a new grain with optical constant data, but the extrapolation failed with a message 'something went wrong' in the .out file. What I...	1	May 30, 2012 12:28 pm af1815
Molecular Hydrogen Reaction Rates Hello, I have been using Cloudy to look at the molecular hydrogen fraction of the ISM at various densities, temperatures etc., however I have run into some...	3	May 30, 2012 11:00 am Gary J. Ferland gary_ferland
PROBLEM DISASTER PROBLEM DISASTER This is in the middle of some experiments, but since the log file has the request to report the problem -- the input file and the log file are here: ...	1	May 19, 2012 12:59 pm notkochanek
Understanding Compton effects Hi, I'm currently working to extend the capabilities of Knox Long's Python radiative transfer code into the X-ray regime. As part of this I'm putting Compton...	3	May 9, 2012 2:47 pm Nicholas Higginbottom nick_soton
Re: beginner	1	May 8, 2012

Documentation

- Quick start guide
- Hazy 1, all commands
- Hazy 2, description of output, comparison with observations
- Hazy 3, not compiled, badly out of date, some physics is described there



Quick Start Guide to CLOUDY *C13.1*

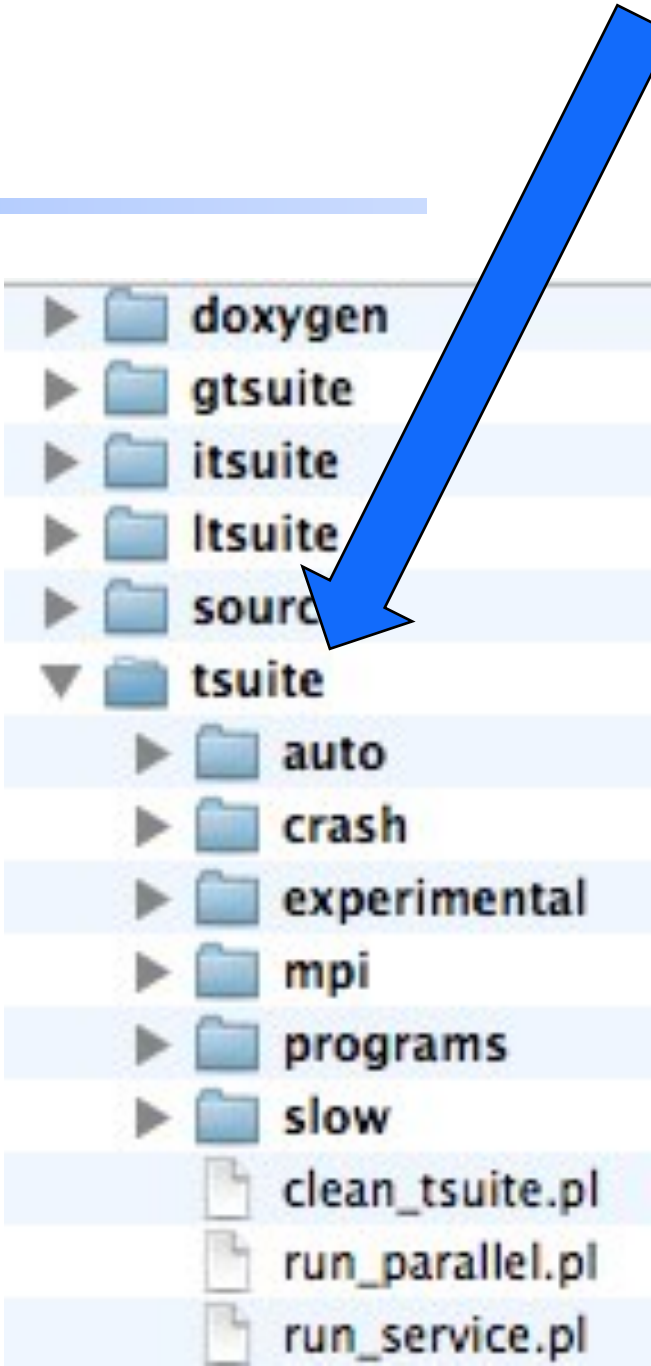
Cloudy & Associates

www.nublado.org

June 4, 2013

The test suite

- **Fully tests the code after any changes**
  - "Monitors" allow automatic comparison of current with previous results
- **Provides examples of how to use Cloudy**
  - But may include extraneous commands for testing
- **Useful examples of how to set up a simulation**



Running cloudy

- **“run” file contains**
  path-to-cloudy.exe -r $

- **If file “model.in” contains input, then**
- **run model &**
- **Produces output “model.out”**

- **Smoke test – create test.in containing the word “test”**