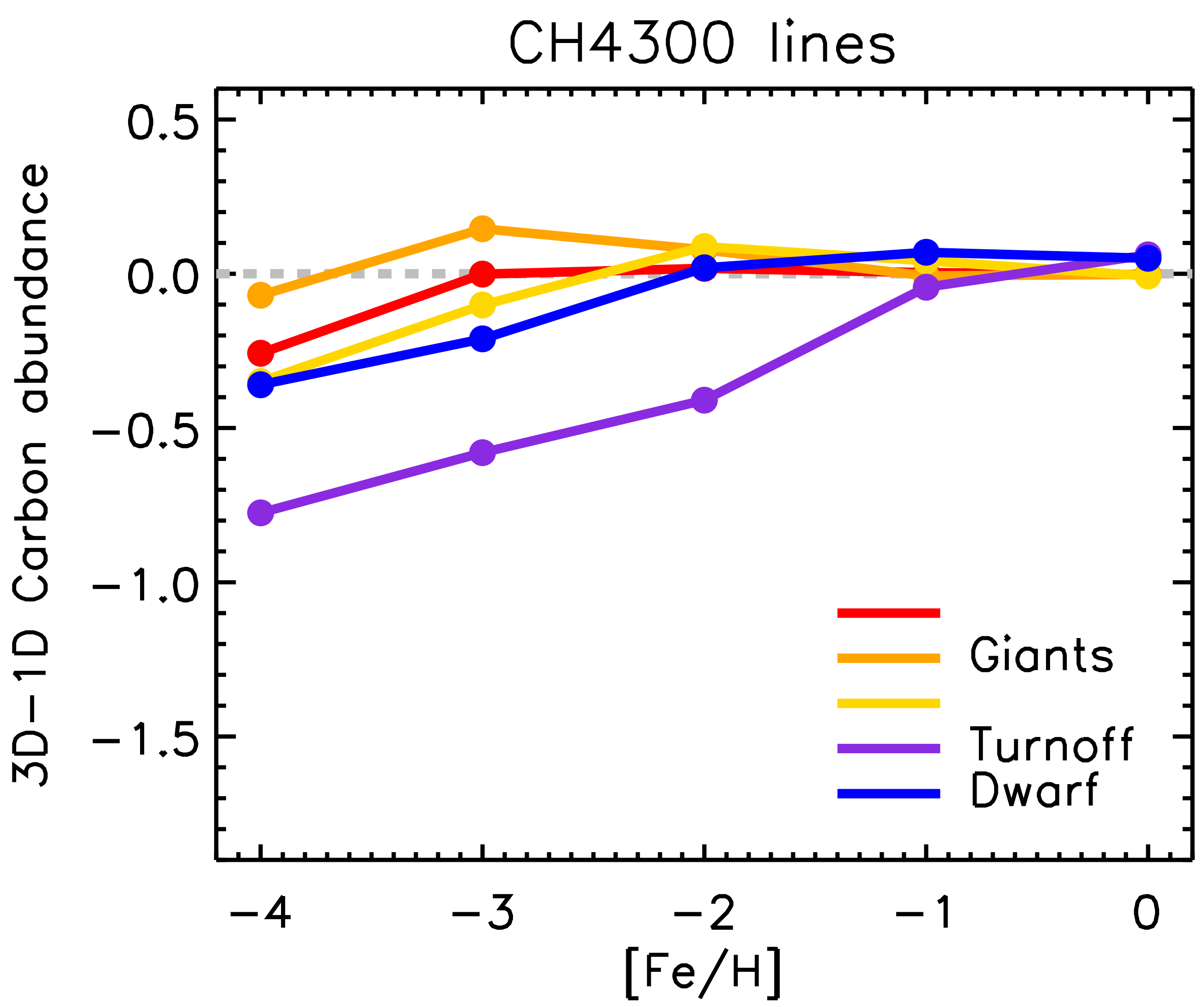
Carbon Abundances

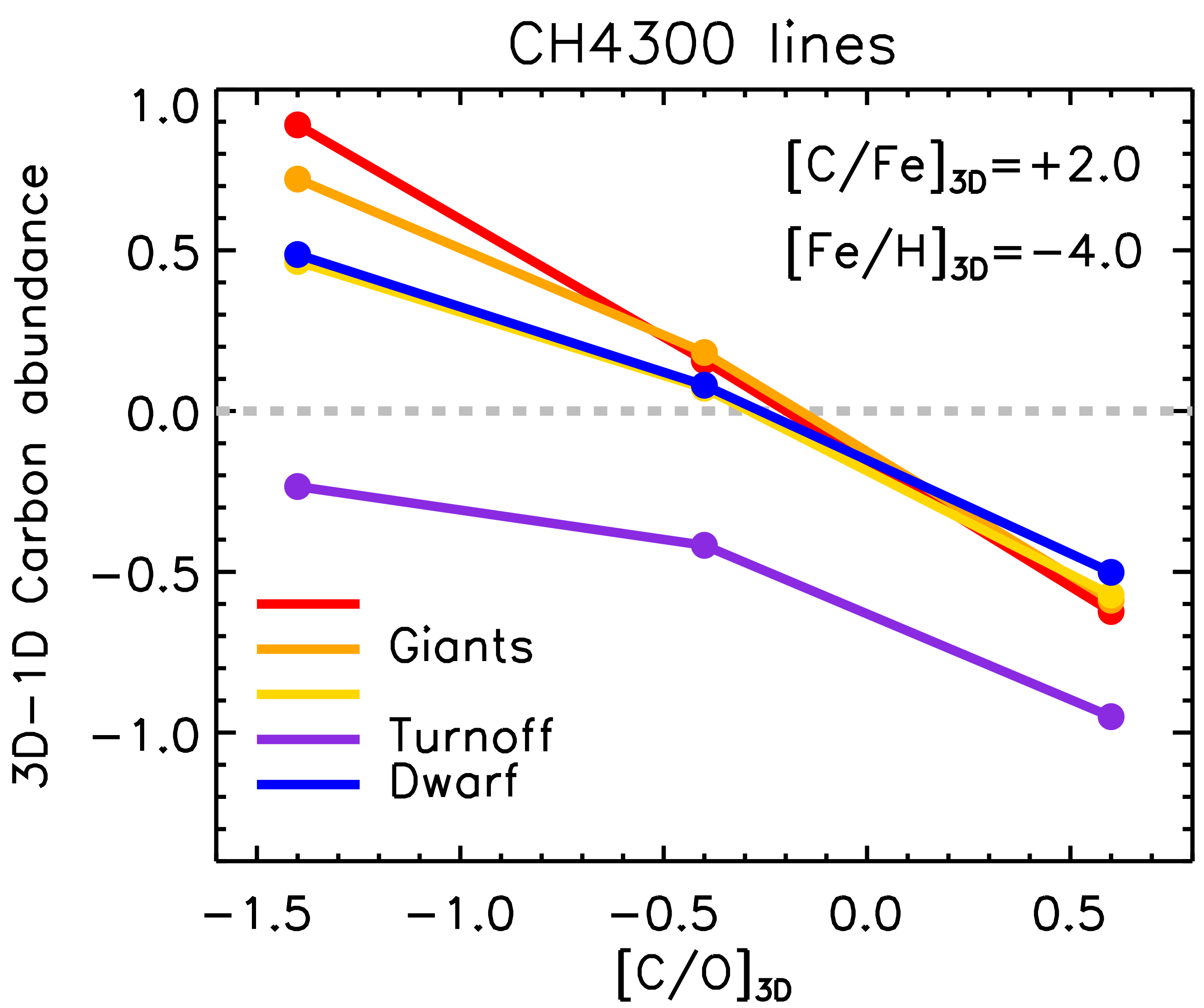
In the light of 3D model stellar atmospheres

Remo Collet
Stellar Astrophysics Centre, Aarhus University

STELLAR ASTROPHYSICS CENTRE

AARHUS UNIVERSITY





3D hydrodynamic surface convection simulations of late-type stars offer a modern and more realistic alternative to 1D hydrostatic model atmospheres: in 3D, stellar surface temperature and density inhomogeneities are modelled consistently with bulk gas flows, and convection arises naturally from the direct solution of the radiation-hydrodynamics equations. [1,2,3]

Because of the inherent differences in basic physical assumptions, 1D and 3D models predict different temperature stratifications for the atmospheres of late-type stars, particularly at low metallicities. [4]
In spectroscopic abundance analyses, 3D model atmospheres can lead to significantly different results compared with traditional 1D models. [4,5,6]

The **figure at the top** shows the differences between carbon abundances needed by spectral line syntheses with 3D [7] and 1D model atmospheres to reproduce the same line strengths for CH molecular features in the G band at around 4300 Å.
3D-1D carbon abundance corrections vary considerably depending on stellar parameters and tend to be largest at low metallicities and for turn-off stars.

Molecular equilibrium is sensitive to the detailed stellar chemical composition.
In particular, the number densities of carbon- and oxygen-based molecules are strongly controlled by the stellar carbon-to-oxygen C/O ratio via CO molecule formation.
The **figure at the bottom** shows that in carbon-enriched metal-poor (CEMP) stars **3D-1D carbon abundance differences vary dramatically as a function of the C/O ratio.**
When evaluating 3D-1D carbon abundance corrections for such objects it is therefore paramount to simultaneously and consistently determine both the carbon and the oxygen abundance in order to avoid large systematic errors. [8,9]

[1] Nordlund et al. 2009, Liv. Rev. Sol. Phys., 6, 2
[2] Freytag et al. 2012, JCP, 231, 919
[3] Vögler 2004, A&A, 421, 755
[4] Asplund et al. 1999, A&A, 346, L17
[5] Collet et al. 2007, A&A, 469, 687
[6] Dobrovolskas et al. 2010, NITC, 288
[7] Magic et al. 2013, A&A, 557, A26
[8] Collet 2015, IAU GA, Meeting #29, id.2256428
[9] Gallagher et al. 2016, A&A, in press