International Forum on Recent Developments of CCS Implementation

Leading the way to a low-carbon future

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Confirmed Speakers

The organising committee are delighted to announce the following keynote speakers:

Dr. Vassilios Kougionas - DG Research & Innovation, European Commission - "Future EC Funding Strategy and Opportunities in CCS"

Mr. John Gale- General Manager, IEA Greenhouse Gas R&D Programme - "A Global Overview of CCS Implementation"

Dr. Paul Fennel - Reader in Clean Energy, Imperial College London - "Comparative Costings for 1st, 2nd and 3rd Generation CCS technologies"

Mr. Russell Cooper - Technical Services Manager, National Grid, UK - "The White Rose CCS Project"

Call for Abstracts

Abstracts called for the following sessions:

- Whole-systems CCS
- BECCS and Carbon Neutral Technologies
- CCS for CO_2-intensive Industries
- Demonstration Projects
- CO_2 Capture
- CO_2 Storage
- CO_2 Transport
- Materials for CCS
- Governance of Development and Deployment of CCS

26th —27th MARCH 2015

VENUE

Athens Ledra Hotel, 115 Syngrou Avenue, Athens, Greece

REGISTRATION DEADLINE

Early bird registration (only € 440 including accommodation) is available until the

31st January 2015.

CALL FOR ABSTRACTS

We invite you to submit an abstract for either oral or poster presentation .

Deadline for submissions is the

15th December 2015.

Co-organised by

CO_2QUEST

IoLiCAP

ECR funding is available from

UKCCS RESEARCH CENTRE

To register http://goo.gl/xkMVcq

contact Abigail Ward—a.ward@leeds.ac.uk

or visit www.co2quest.eu

www.co2quest.eu

School of Chemical and Process Engineering
FACULTY OF ENGINEERING
UNIVERSITY OF LEEDS

Numerical modelling of trans-triple point temperature near-field sonic dispersion of CO_2 from high pressure dense phase pipelines

Dr Chris Wareing

UKCCSRC Equation of State Workshop,
11th November 2014, York

C J Wareing, R M Woolley, M Fairweather, S Falle
University of Leeds, Leeds, LS2 9JT, United Kingdom

COOLTRANS: The Don Valley CCS Project is co-financed by the European Union's European Energy Programme for Recovery
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Overview

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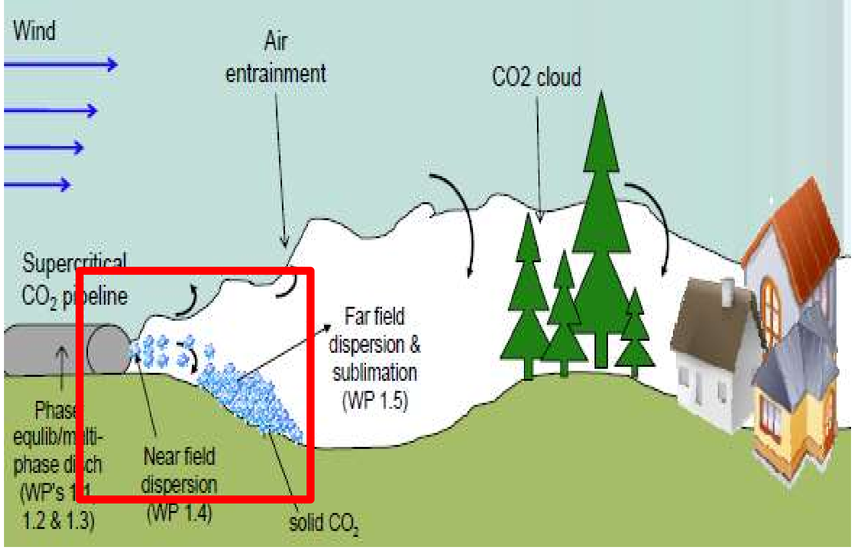
Carbon capture and storage, the short term option for reducing CO_2 emissions, is likely to proceed with transportation from source to storage along high-pressure dense phase pipelines

- Pipelines fail. Complex CFD simulations can validate pragmatic approaches used for quantified risk assessment (QRA).
- Leeds: near-field sonic dispersion of carbon dioxide (CO_2) from high pressure pipelines
  - Examples
  - Thermodynamic model
  - Recent developments
- Requirements for impurities



Venting: COOLTRANS dense phase

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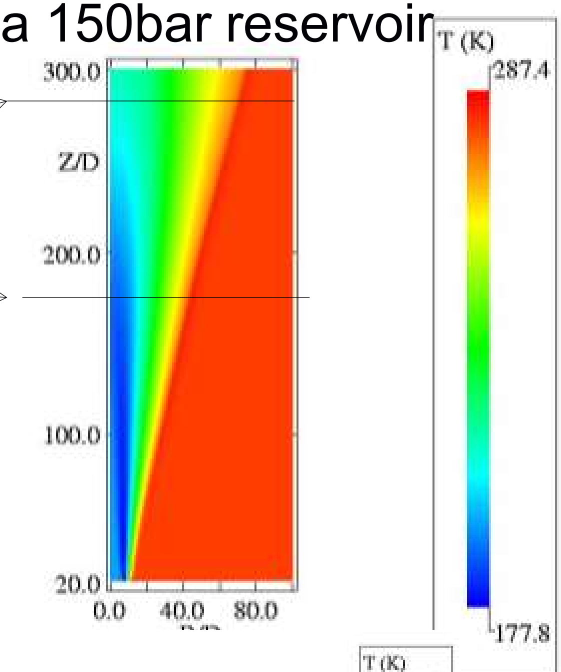
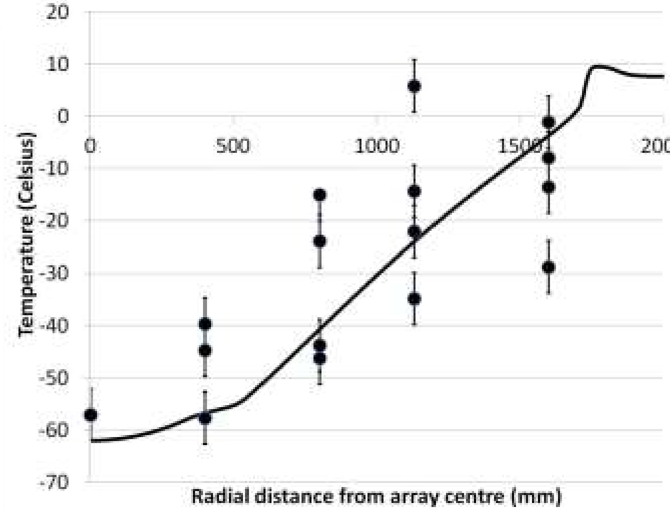
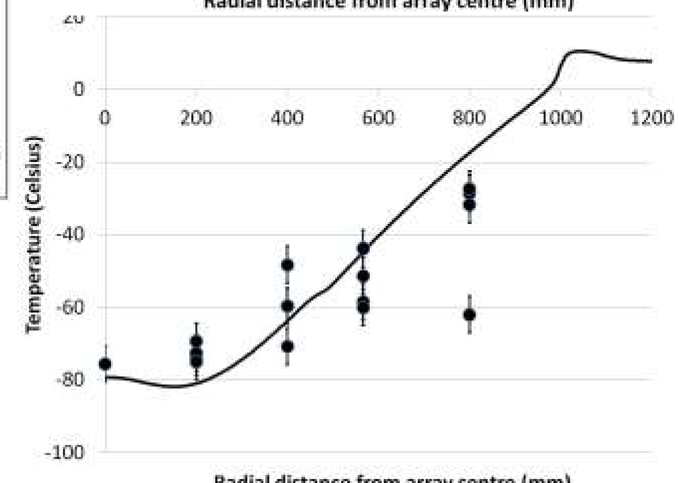
Dense phase release from a 150bar reservoir through a 25mm ventpipe

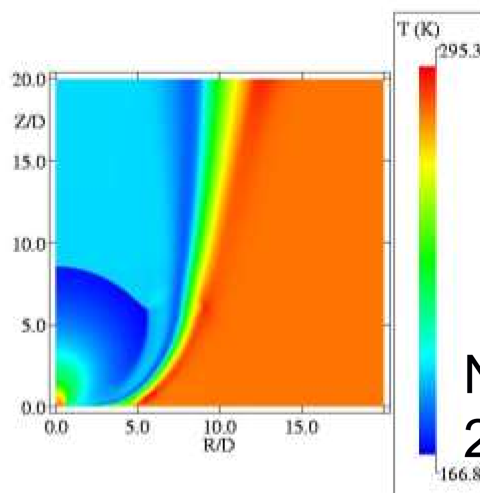
Measurements at:

- 4m (165D)
- 7m (288D)









Near-field shock containing region: 20D x 20D (0.5m x 0.5m)

COOLTRANS punctures and ruptures

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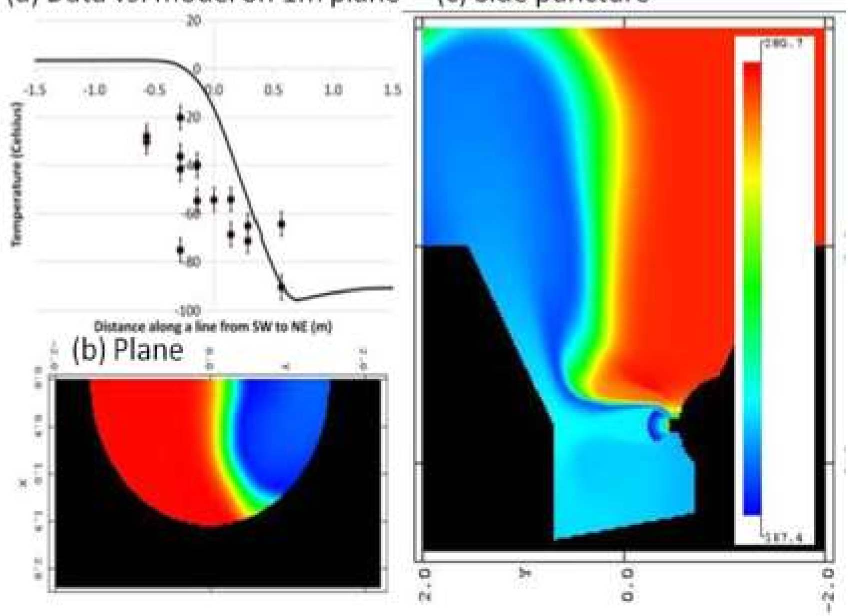
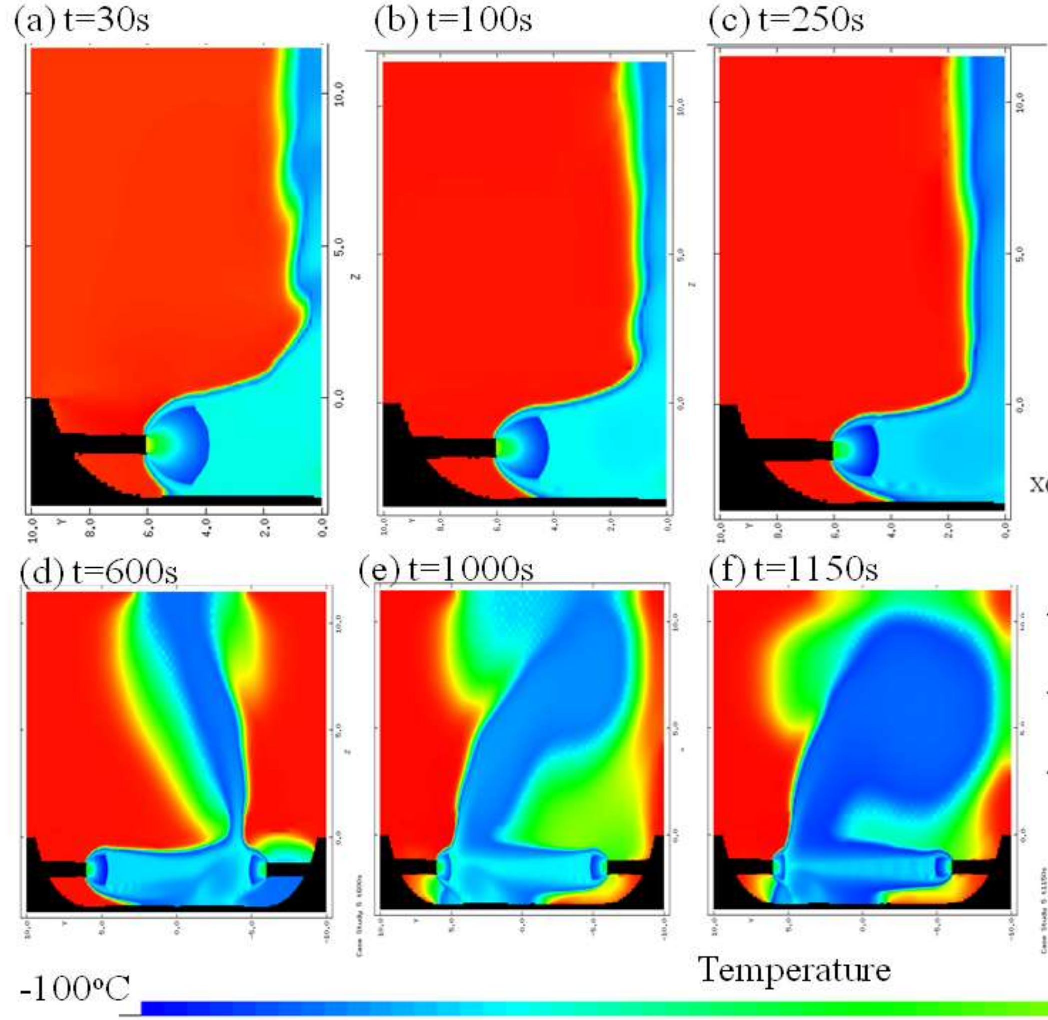
Rupture:

Puncture:





Near-field dispersion model (COOLTRANS & CO2PIPEHAZ)

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- Thermodynamic model: *(Wareing et al. 2013, AIChE Journal **59** 3928-3942)*
  - Near-field dispersion of pure CO_2 in the gas, liquid and solid phases into dry air.
  - Novel composite equation of state for pure CO_2 employing:-
    - the **Peng-Robinson** equation of state in the gas phase;
    - tabulated data derived from the **Span & Wagner** equation of state for the liquid phase and vapour pressure;
    - and **NIST/DIPPR data** for the solid phase and latent heat of fusion.
  - Calculations were undertaken using the **Helmholtz free energy** in terms of temperature and molar volume, as all other thermodynamic properties can be readily obtained from it.
  - Novel combination of the simple Peng-Robinson equation and tabulated data on the saturation line allows for crucially a **fast implementation numerically**, when updating tens of millions of grid cells per second.

Near-field dispersion model (COOLTRANS & CO2PIPEHAZ)

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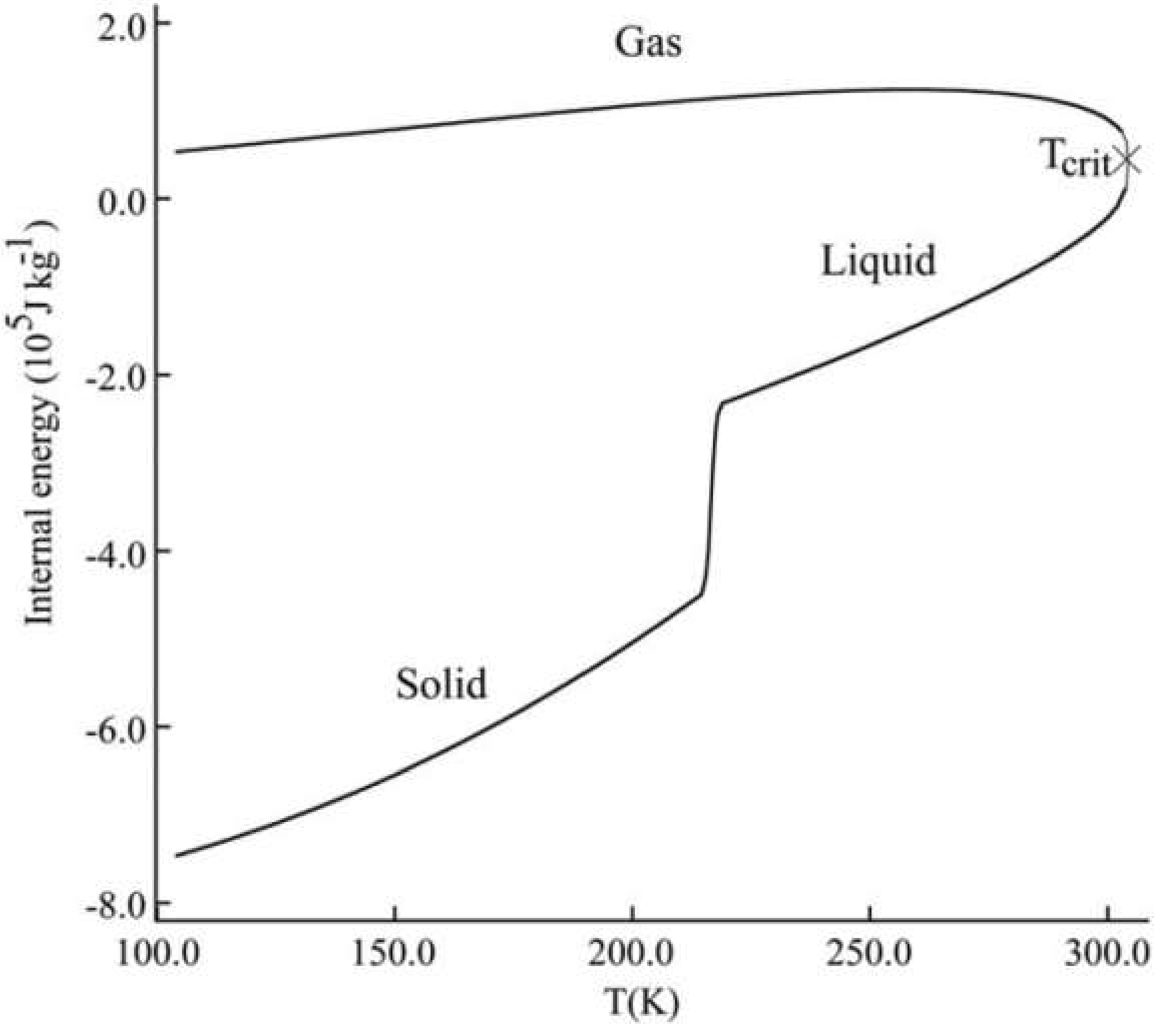
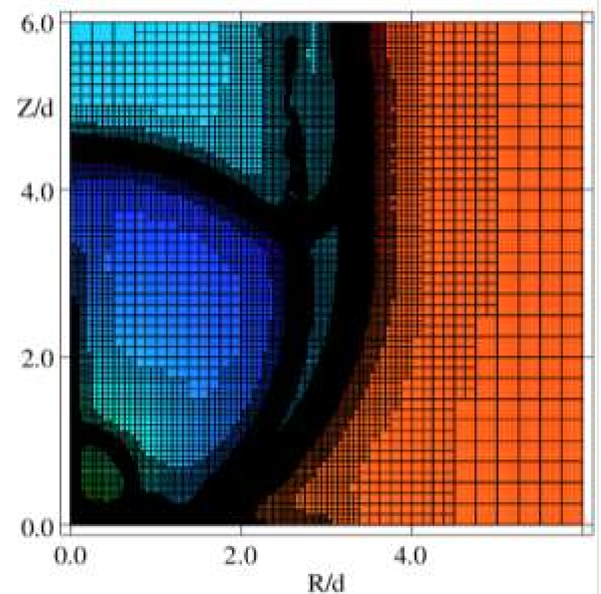
- Internal energy on the saturation line.



- T_{crit} marks the critical temperature.
- The triple point can be identified by the steep connection between the liquid and solid phases – the latent heat of fusion.
- Numerical method, with unstructured AMR



Comparative performance

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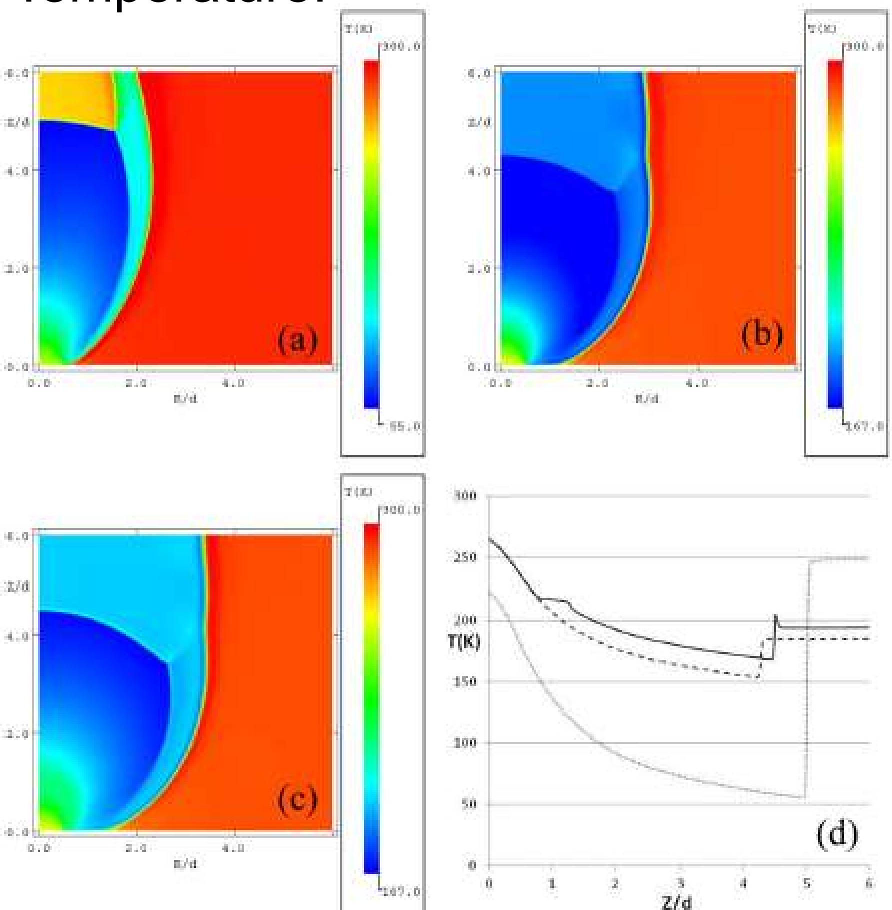
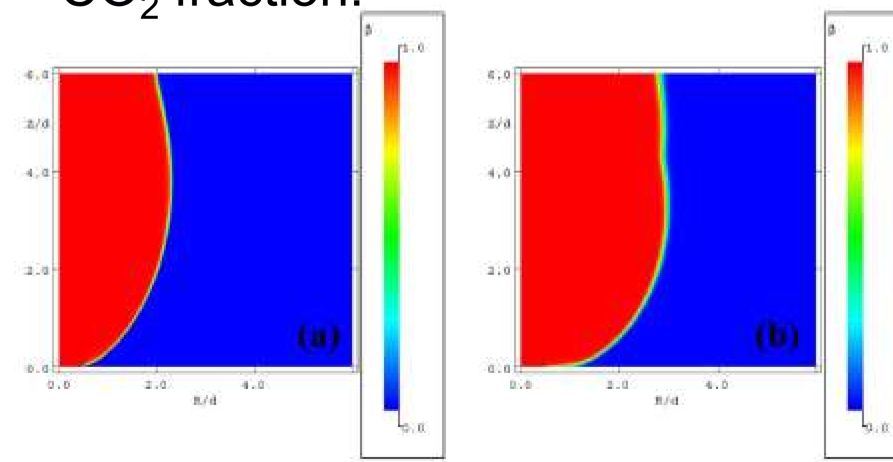
- Comparison of ideal, Peng-Robinson and composite EoSs

Temperature:-

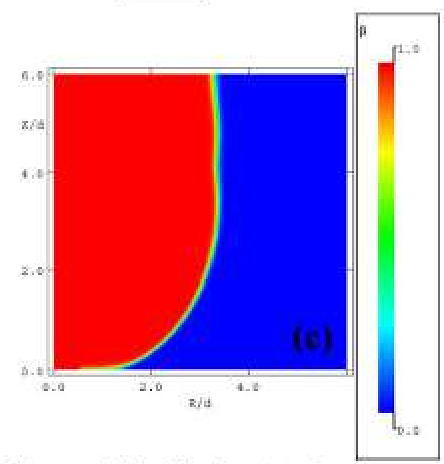


Temperature in the near-field of the flow domain.

CO_2 fraction:-



(a) Ideal
(b) P-R
(c) Composite



Concentration of CO_2 in the near-field of the flow domain.

Comparative performance

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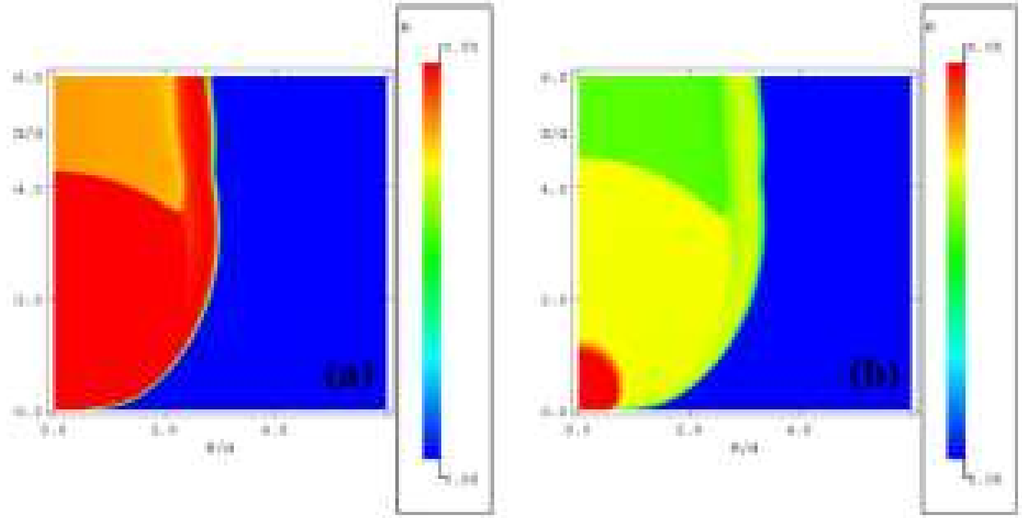
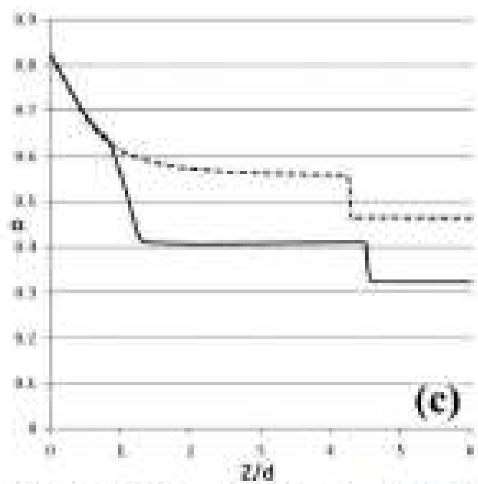
- Comparison of Peng-Robinson and composite EoSs

Condensed phase fraction:



(a) P-R
(b) Composite



Concentration of condensed-phase CO_2 in the near-field of the flow domain.

Recent developments

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- Different equations of state
  - Solid phase. Now able to run with tables generated from Jager and Span – C_p and internal energy are very different. Also considered the Trusler solid phase EoS.
  - Gas and liquid phases. Several equations of state under consideration and comparison:-
    - Physical Properties Library (SAFT/pcSAFT) from the National Research Centre for Physical Sciences, Greece.
    - Tables based on Span and Wagner
    - Tables based on Richard Graham's work.
    - New considerations of EOS-CG.
  - Have previously considered PRSV, PRSV2, Yokozeki, PROPATH & others and discounted them for our use.

Requirements for impurities (CO2QUEST)

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- EITHER a simple fast equation of state that can be directly embedded (advantages of speed and solutions over a wide range).
- OR a complex equation that can generate tables (disadvantage – solvers routinely require solutions outside the tabular ranges).
- Mixing rules with known interaction parameters for e.g. N_2, O_2, Ar, H_2S.
- Pipeline spec.: 96% CO_2, 4% impurities (<2% N_2, <2% O_2 + trace).

Temperature range: 50K – 400K. Pressure range: 0.01 to ~20 MPa.

- Options:-
  - A simple option: e.g. Peng-Robinson. But, there are known issues (incorrect densities, speed of sound, etc. noted again at GHGT12)
  - Trust a library function e.g. PPL. Current issues under investigation.
  - More complex option: EOS-CG in tabular form. Possible issues with H_2O (presented at GHGT12)?

Thank you for listening. Discussion?