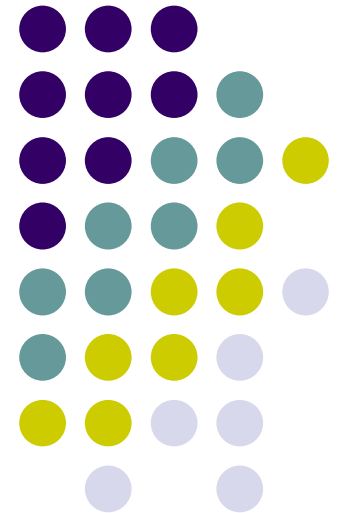
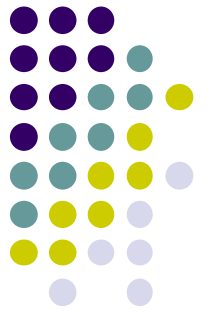


OpenFOAMによる 軸対称流の解析2 第5回オープンCAE初心者勉強会

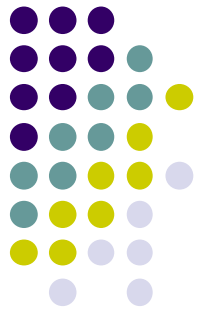
IT, 2011年6月18日





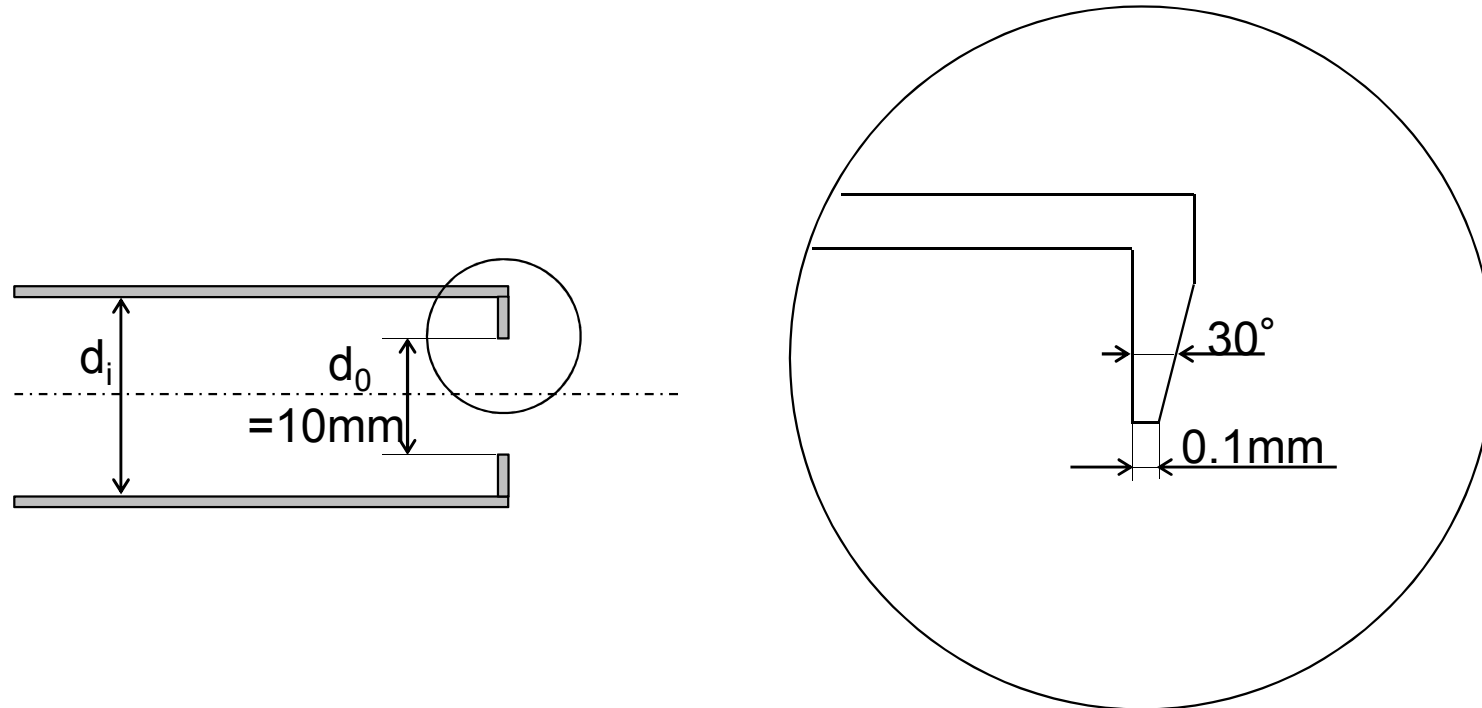
発表内容

- 解析対象
- wedgeにおける注意点
 - checkMeshで見つかったエラー
- 計算ケース
- 解析結果
- 今後の予定
- 参考情報



解析対象

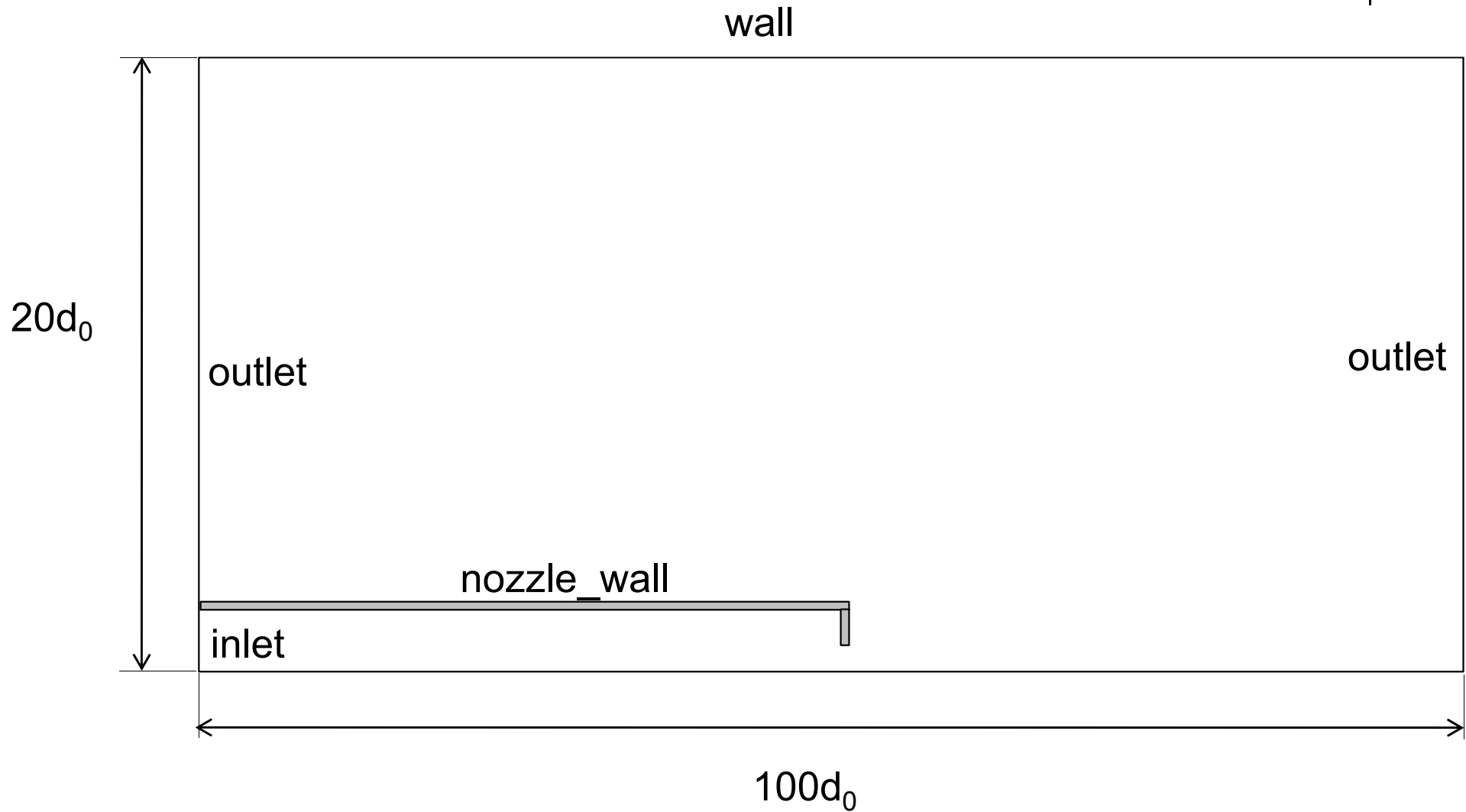
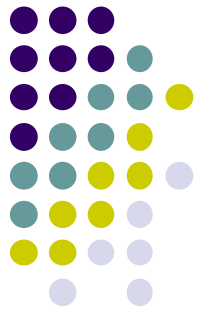
- オリフィスノズルの流動解析



- 実験結果:オリフィス自由噴流の流動解析 機論(B)74巻737号(2008)
- 絞り面積比CR (d_0/d_i)=1.00(pipe), 0.67, 0.44, 0.11
- $Re = u_m \cdot d_0 / \nu = 3000, 5000, 7000, 10000, 15000$

解析対象

- 計算領域



wedgeにおける注意点

checkMeshの抜粋

Checking geometry...

Overall domain bounding box (-0.5 0 -0.00872388) (0.5 0.19981 0.00872388)

Mesh (non-empty, non-wedge) directions (1 1 0)

Mesh (non-empty) directions (1 1 1)

Wedge wedge_back with angle 2.49999 degrees

***Wedge patch wedge_back not planar. Point (-0.5 0.179829 -0.00785149) is not in patch plane by 3.32641e-08 meter.

Boundary openness (-1.67935e-18 -2.7211e-15 -1.11438e-13) OK.

Max cell openness = 3.09437e-16 OK.

Max aspect ratio = 39.3702 OK.

Mininum face area = 1.21049e-09. Maximum face area = 0.000169954. Face area magnitudes OK.

Min volume = 2.99493e-13. Max volume = 8.49768e-07. Total volume = 0.00174288. Cell volumes OK.

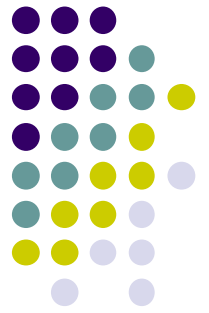
Mesh non-orthogonality Max: 3.26561e-05 average: 0

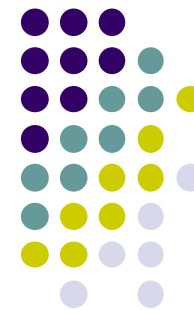
Non-orthogonality check OK.

Face pyramids OK.

Max skewness = 0.330796 OK.

Failed 1 mesh checks.End





```
convertToMeters 0.001;
```

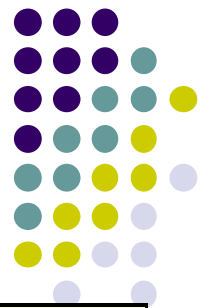
```
Vertices
```

```
(  
  (-500 0 0)//0  
  (-500 4.995241 -0.218096)//1  
  (-500 5.994289 -0.261716)//2  
  (-500 99.904822 -4.361938)//3  
  (-400 0 0)//4  
  (-400 4.9952411079 -0.2180969368)//5  
  (-400 5.9942893295 -0.2617163242)//6  
  (-400 99.9048221582 -4.3619387365)//7  
  (-400 199.8096443164 -8.7238774731)//8  
  (0 0 0)//9
```

小数点以下6桁では、前スライドのエラーが出る。

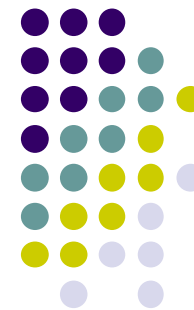
小数点以下10桁であれば、エラー出ない

計算ケース CR:1.00



	RANS model	fvSchemes	fvSolution	relaxationFactors	Result
case1-1	Standard k-epsilon	upwind	GAMG	0.3, 0.7, 0.7, 0.7	converged
case1-2a	Standard k-epsilon	linear, limitedLinear	GAMG	0.3, 0.5, 0.4, 0.4	converged
case1-2b	Standard k-epsilon	linear	GAMG	0.1, 0.1, 0.1, 0.1	not converged
case1-3	Standard k-epsilon	TVD	GAMG	0.3, 0.7, 0.7, 0.7	converged
case1-4	RNG k-epsilon	upwind	GAMG	0.3, 0.7, 0.7, 0.7	converged
case1-5	RNG k-epsilon	linear	GAMG	0.3, 0.5, 0.4, 0.4	diverged
case1-5a	RNG k-epsilon	linear, limitedLinear	GAMG	0.3, 0.5, 0.4, 0.4	converged
case1-5b	RNG k-epsilon	linear	GAMG	0.1, 0.1, 0.1, 0.1	diverged
case1-6	RNG k-epsilon	TVD	GAMG	0.3, 0.7, 0.7, 0.7	converged
case1-7	Realizable k-epsilon	upwind	GAMG	0.3, 0.5, 0.4, 0.4	not converged
case1-8a *1	Realizable k-epsilon	linear, limitedLinear	GAMG	0.3, 0.5, 0.4, 0.4	not converged
case1-8e *2	Realizable k-epsilon	upwind	GAMG	0.3, 0.5, 0.4, 0.4	converged
case1-9	Realizable k-epsilon	TVD	GAMG	0.3, 0.7, 0.7, 0.7	not converged
case1-10	k-omega SST	upwind	GAMG	0.3, 0.7, 0.7, 0.7	converged
case1-11	k-omega SST	linear	GAMG	0.3, 0.5, 0.4, 0.4	converged
case1-11a	k-omega SST	linear, limitedLinear	GAMG	0.3, 0.5, 0.4, 0.4	converged
case1-12	k-omega SST	TVD	GAMG	0.3, 0.7, 0.7, 0.7	converged

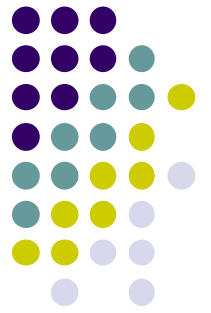
*1 mapFields case1-8e, *2 mapFields case1-1



計算ケース CR:0.11

	RANS model	fvSchemes	fvSolution	relaxationFactors	Result
case4-1	Standard k-epsilon	upwind	GAMG	0.3, 0.7, 0.7, 0.7	converged
case4-2a	Standard k-epsilon	linear, limitedLinear	GAMG	0.3, 0.5, 0.4, 0.4	converged
case4-7	Realizable k-epsilon	upwind	GAMG	0.3, 0.5, 0.4, 0.4	converged
Case4-10	k-omega SST	upwind	GAMG	0.3, 0.7, 0.7, 0.7	converged
Case4-11	k-omega SST	linear	GAMG	0.3, 0.5, 0.4, 0.4	converged
case4-11a	k-omega SST	linear, limitedLinear	GAMG	0.3, 0.5, 0.4, 0.4	converged
Case4-12	k-omega SST	TVD	GAMG	0.3, 0.7, 0.7, 0.7	converged

divSchemes- upwind, linear



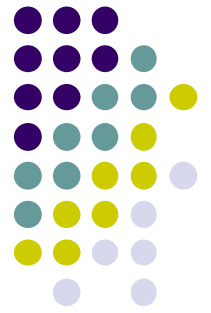
```
divSchemes
{
  default      none;
  div(phi,U)   Gauss upwind;
  div(phi,k)   Gauss upwind;
  div(phi,epsilon) Gauss upwind;
  // div(phi,omega) Gauss upwind;
  div((nuEff*dev(grad(U).T()))) Gauss linear;
}
```

upwind

```
divSchemes
{
  default      none;
  div(phi,U)   Gauss linear;
  div(phi,k)   Gauss linear;
  div(phi,epsilon) Gauss linear;
  // div(phi,omega) Gauss linear;
  div((nuEff*dev(grad(U).T()))) Gauss linear;
}
```

linear

divSchemes- limitedLinear, TVD



```
divSchemes
{
  default      none;
  div(phi,U)   Gauss linear;
  div(phi,k)   Gauss limitedLinear 1;
  div(phi,epsilon) Gauss limitedLinear 1;
  // div(phi,omega) Gauss limitedLinear 1;
  div((nuEff*dev(grad(U).T()))) Gauss linear;
}
```

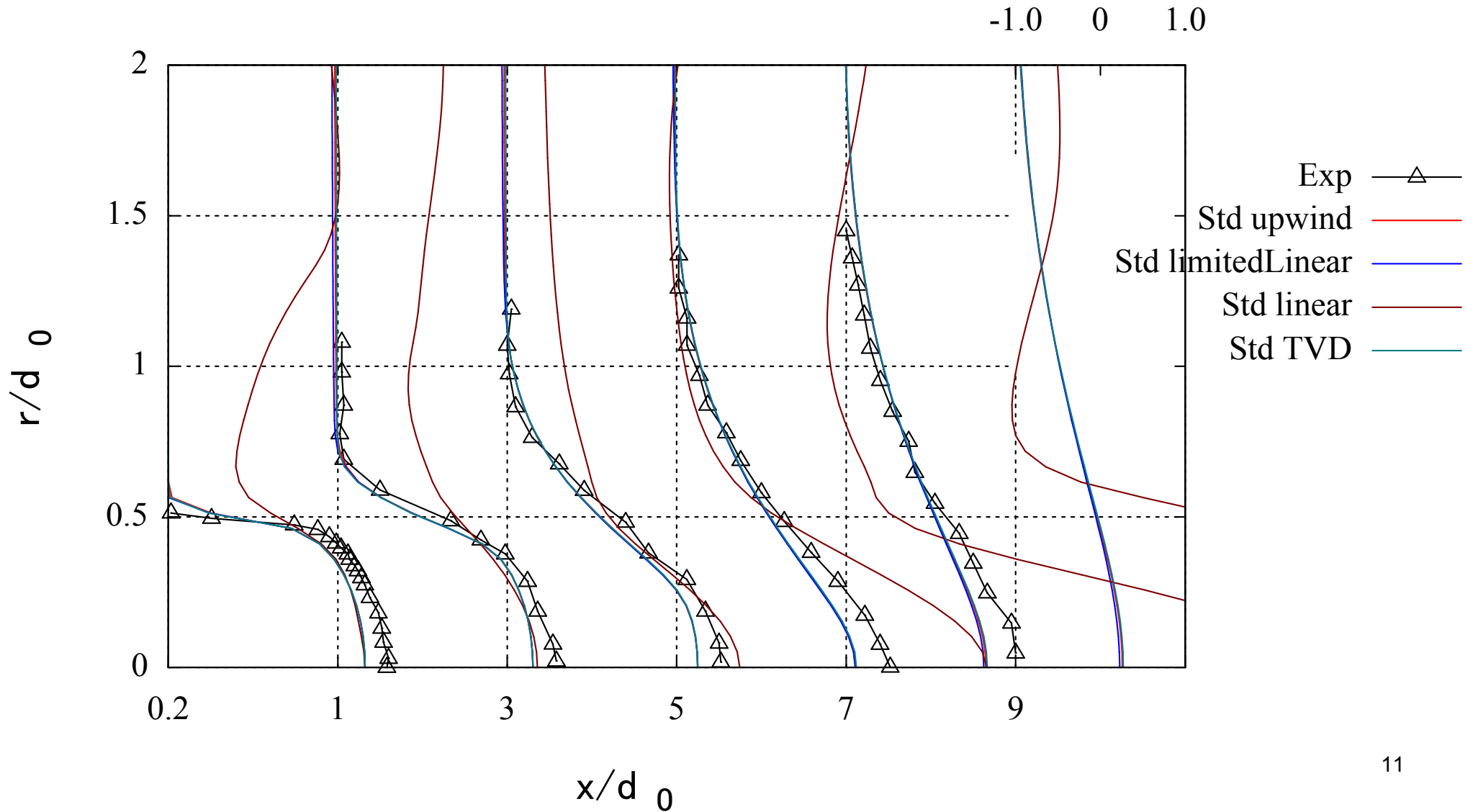
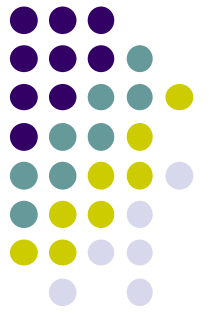
Linear +
limitedLinear

```
divSchemes
{
  default      none;
  div(phi,U)   Gauss limitedLinearV 1;
  div(phi,k)   Gauss limitedLinear 1;
  div(phi,epsilon) Gauss limitedLinear 1;
  // div(phi,omega) Gauss limitedLinear 1;
  div((nuEff*dev(grad(U).T()))) Gauss linear;
}
```

TVD

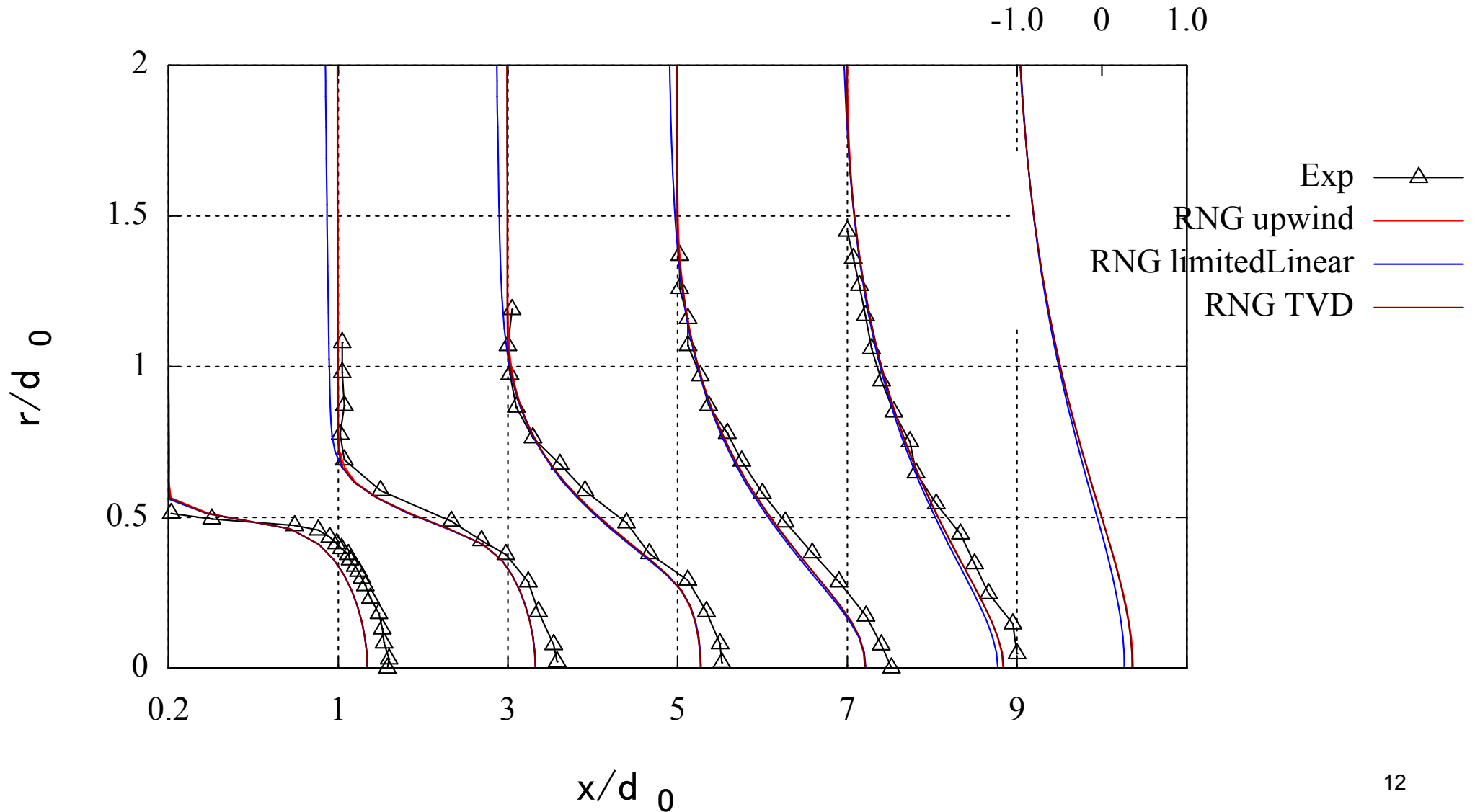
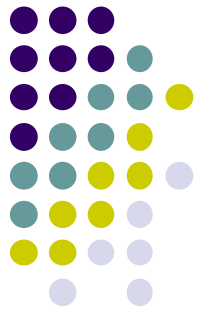
解析結果

- CR:1.00, Re=15000



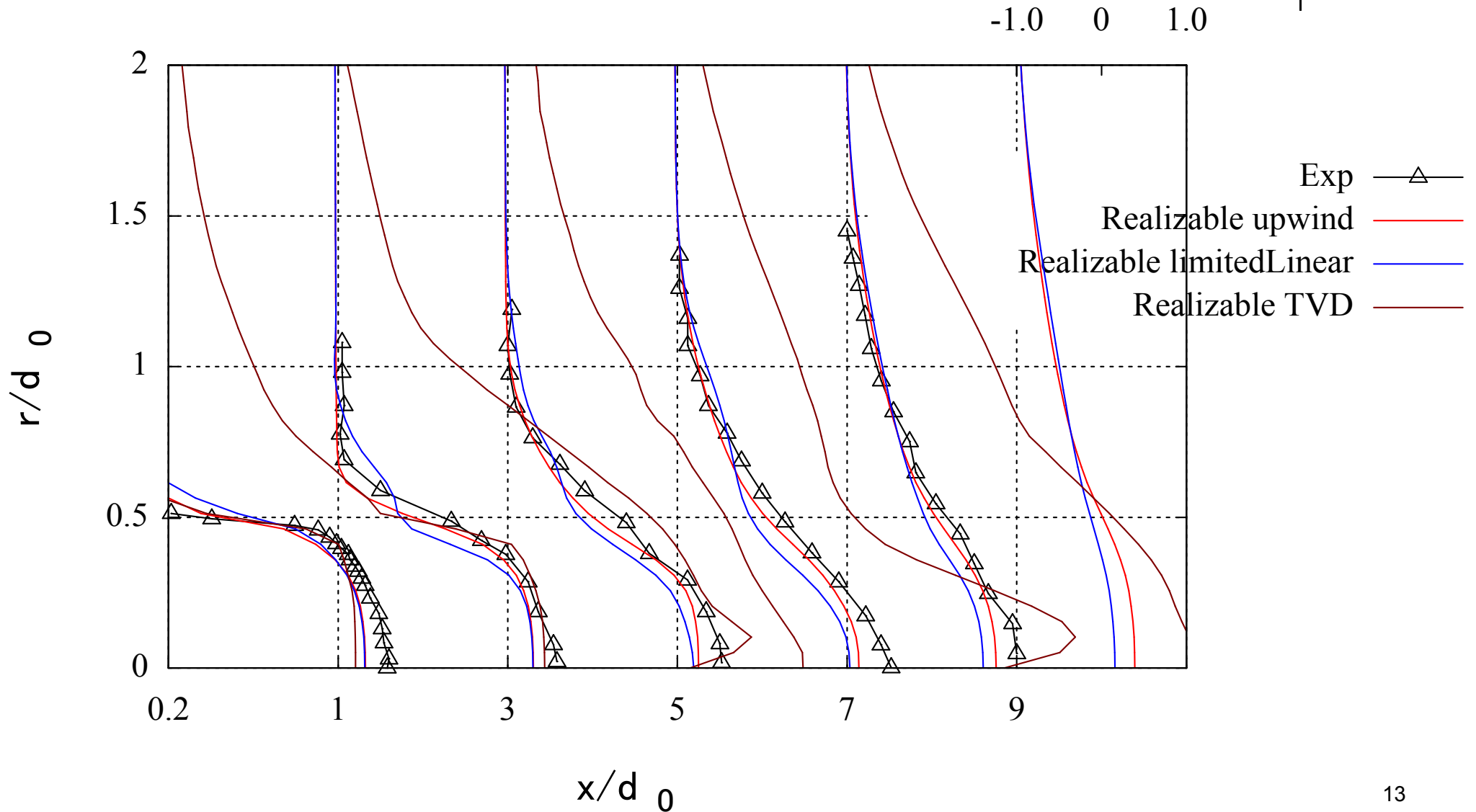
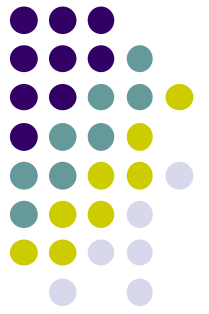
解析結果

- CR:1.00, Re=15000



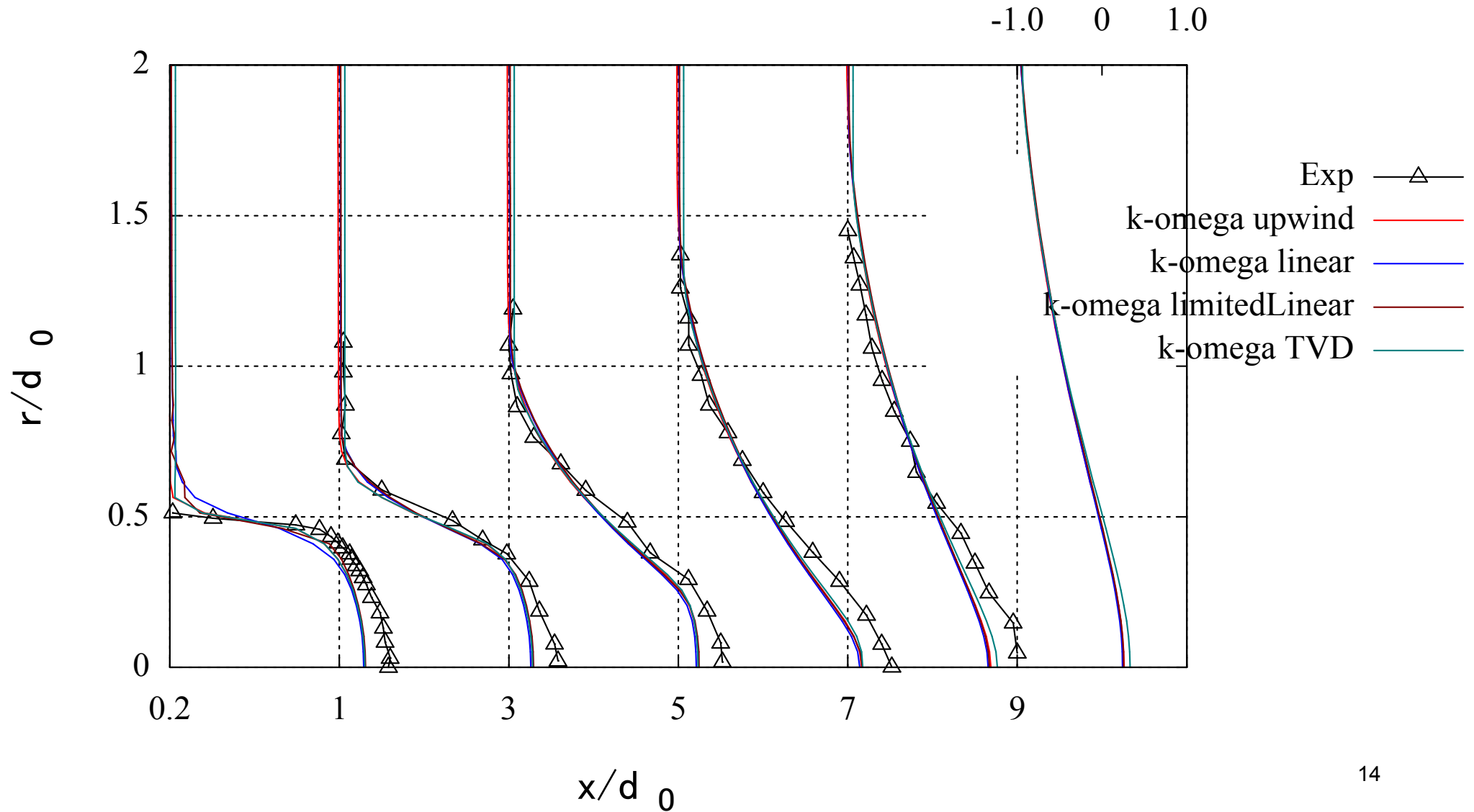
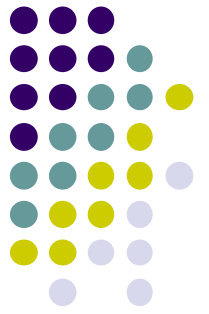
解析結果

- CR:1.00, Re=15000



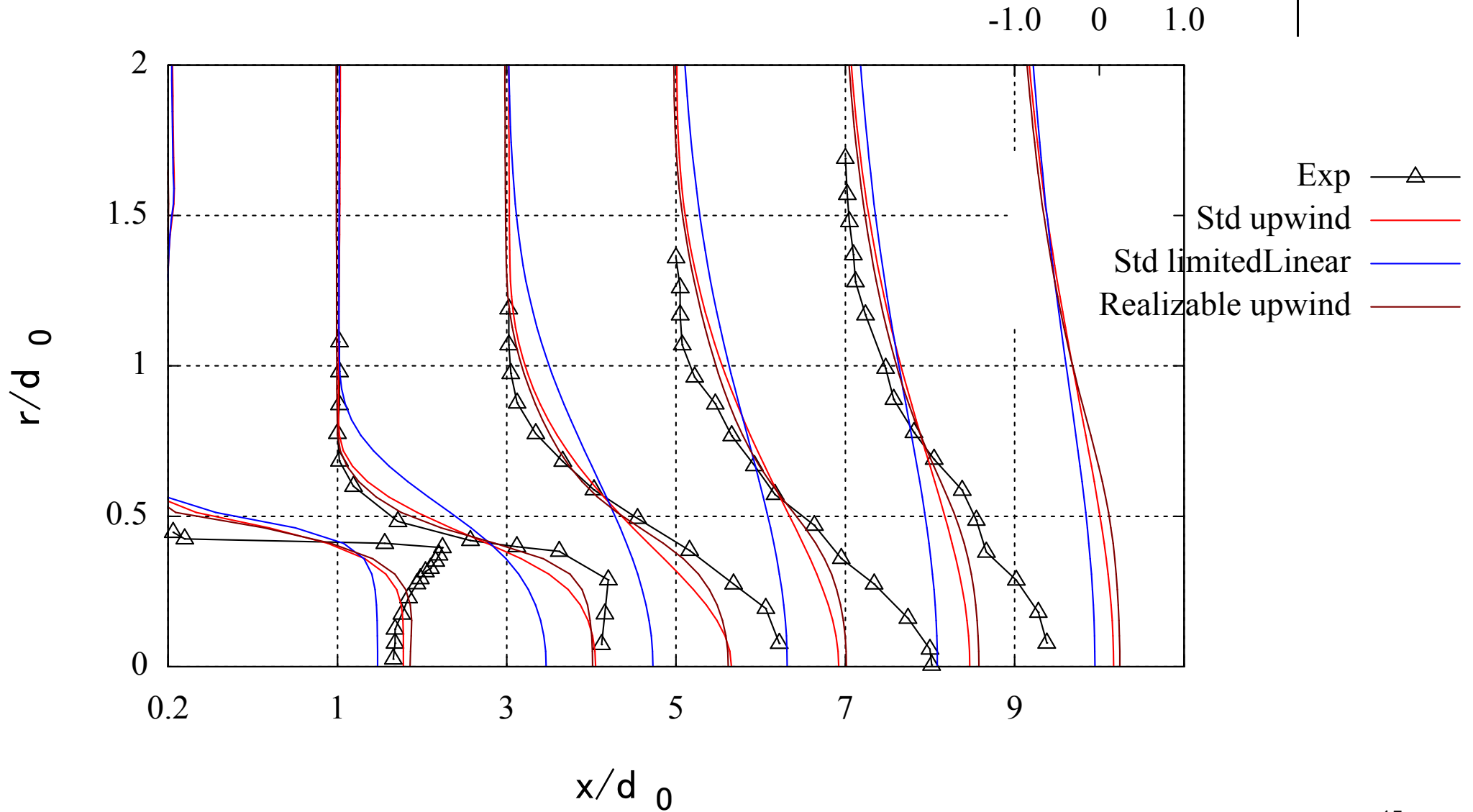
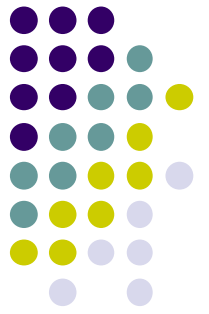
解析結果

- CR:1.00, Re=15000



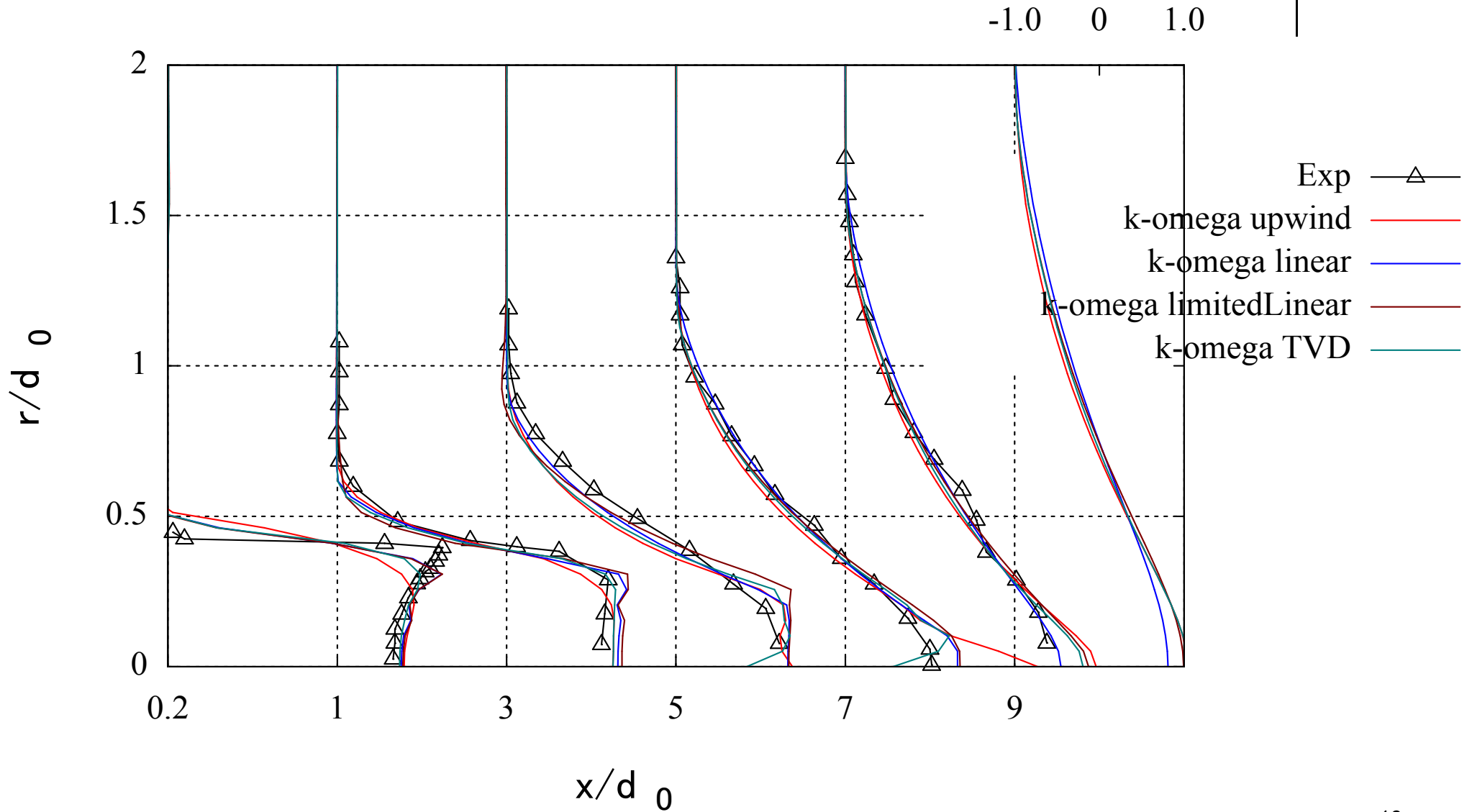
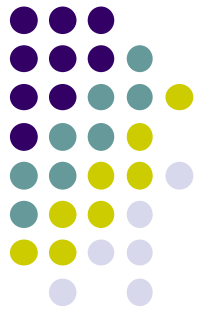
解析結果

- CR:0.11, Re=15000



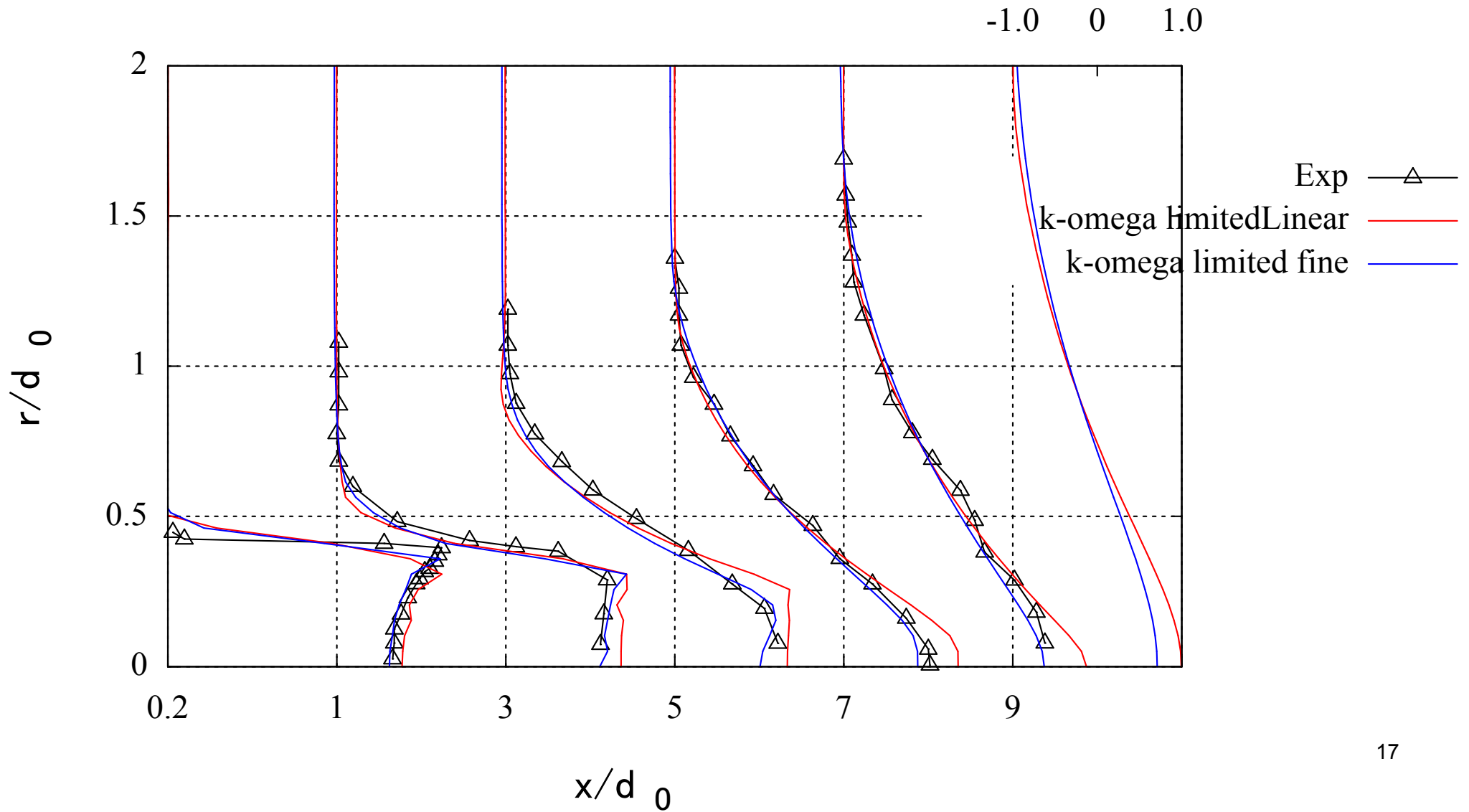
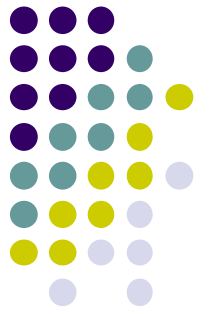
解析結果

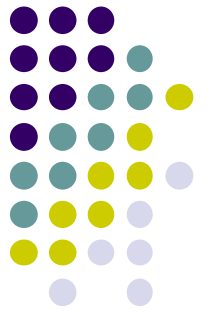
- CR:0.11, Re=15000



解析結果

- CR:0.11, Re=15000





まとめ

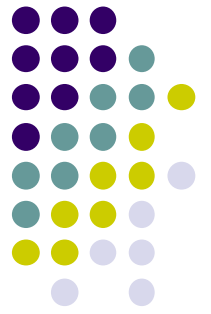
実験結果との比較

- CR: 1.00では、軸中心の軸方向速度の差が比較的大きい
 - 境界条件、メッシュの影響か
- CR: 1.00では、乱流モデルによる結果の差は、ほとんど無い
- CR: 0.11では、k-omega SSTが最も良い結果を示した
- CR: 0.11において、Standard, RNG, Realizableでは縮流による、噴流外縁の増速を予測できていない。

その他

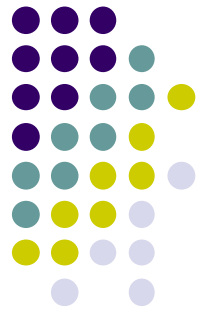
- k-omega SSTは収束しやすい
- Realizable k-epsilonは収束しにくい
 - 結果もあまり良くない

今後の予定



- kの分布の比較
- CR: 0.67, 0.44の解析
 - マクロを使ったblockMeshでのメッシュ作成

参考情報

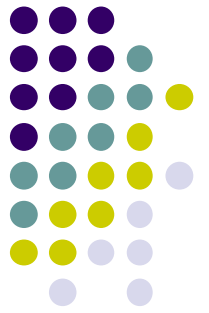


- pyFoam

http://openfoamwiki.net/index.php/Contrib_PyFoam



Adobe Acrobat
Document



参考情報

- FrontWorkBench

<http://www.ciss.iis.u->

[tokyo.ac.jp/project/rss/software/12_info.html](http://www.ciss.iis.u-tokyo.ac.jp/project/rss/software/12_info.html)

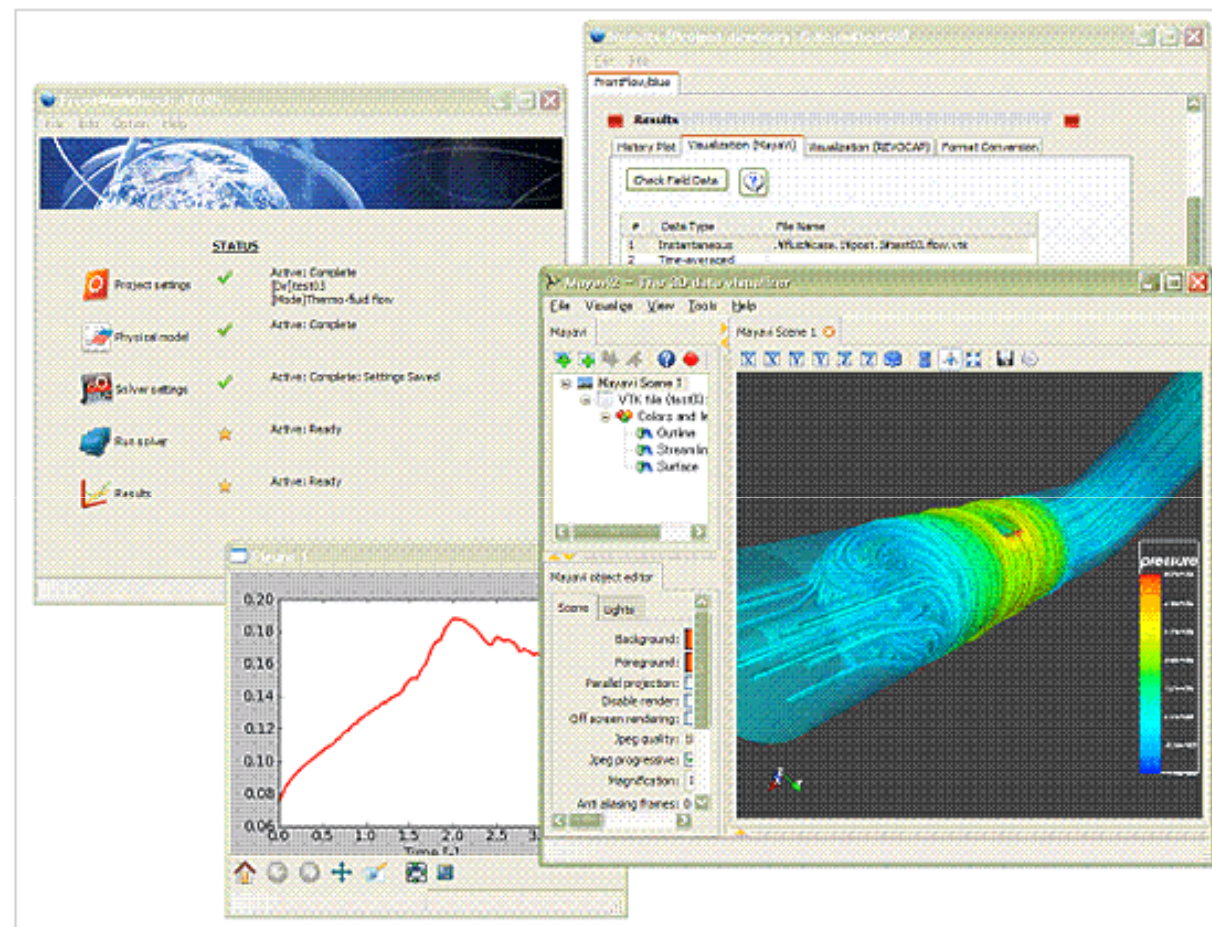
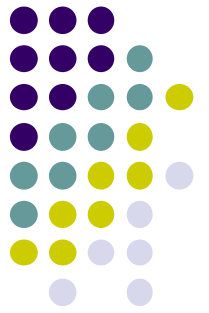


図2: FrontWorkBenchでの解析実行例

参考情報



- pythonFlu
<http://pythonflu.wikidot.com/>
- pythonを使って、解析処理を自動化できる
- pythonでOpenFOAM (C++)をwrappingできる
 - pythonでOpenFOAMのコードを呼び出せる
- SalomeとのIntegrationができる