...almost ready for primetime

VVM

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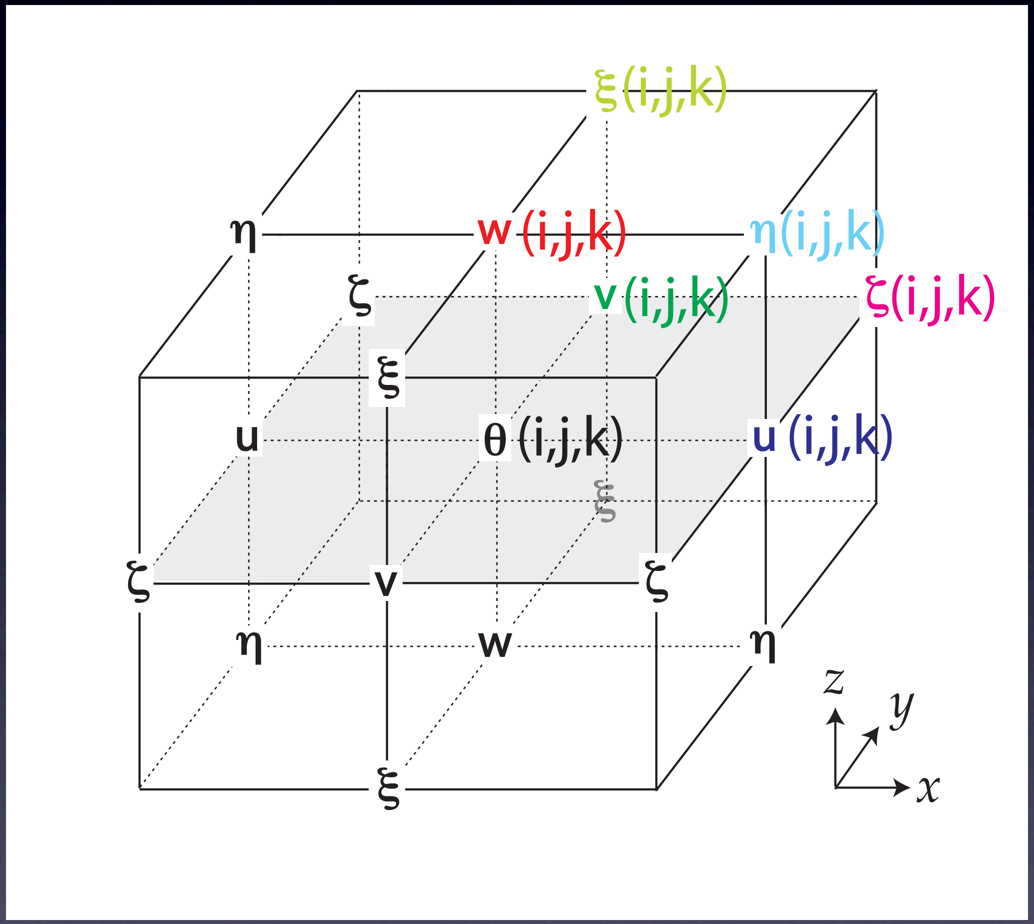
VVM review



- The predicted dynamical field is the three-dimensional vorticity vector. From this the winds can be diagnosed.
- Physics to permit prediction of thermodynamic and moisture variables: RRTMG radiation; microphysics.

VVM transition

```
      COMMON/CONST2LD/C(80),IC(60),LC(40)
      LOGICAL LC

      LOGICAL START
      EQUIVALENCE ( ITTMAX, IC(1) ),( ITINIT, IC(16) ),
     $            ( START, LC(8) ), ( NXS, IC(15)),
     $            ( ITTADD, IC(19) ),( NRESTART, IC(7) )
      EQUIVALENCE ( A, C(1) ),( B, C(2) ),( DT, C(3) )
```

- Prior to this work the code was Fortran 77 without any kind of parallelization.
- Obsolescent features such as common blocks, EQUIVALENCE, binary I/O

First step - a more modern code

```
MODULE const1d

! This file contains profiles that do not vary across the domain and
!   model parameters.

! HISTORY:
!  2010.02.09 -DD- Converted to an f90 module from const1d.com

   USE kinds
   USE parms1d

IMPLICIT NONE
PRIVATE

!*****************************
!  formerly common/points1d/

   REAL (KIND=dbl_kind), DIMENSION(nk3), PUBLIC ::       &
      zz,     & ! height at the level position (m)
      zt,     & ! height at the layer position (m)
      zu,     & ! height at the layer position (m) = zt
      zw        ! height at the level position (m) = zz
! The equivalence of zz and zw, and of zt and zu is removed. A copy is added
!   in the initialization routine INI_3D.
```

- The dynamical core was rewritten to use Fortran 90 features such as modules, CASE construct.
- Fortran 90 provides superior error-checking during compilation - this step uncovered several latent bugs.
- Impose some additional programming standards - IMPLICIT NONE

Step two - a new build system

```
#--------------------------------------------------------------------------
# Identify the operating system
#--------------------------------------------------------------------------
OS := $(shell uname)

#--------------------------------------------------------------------------
# Linux Cluster, optimized for saddleback
#--------------------------------------------------------------------------
ifeq ($(OS),Linux)
   CPP      = /usr/bin/cpp
   CPPFLAGS = -P -traditional -I$(BINDIR)
   SUF      = f
   ifdef PGI_COMP   # pgi compiler / linux clusters
     ifdef UNICOS   # NERSC franklin Cray xt4
       FC       = ftn
       FIXED    = -Mextend -r8
       FREE     = -Mfreeform
       INC = -I/usr/common/usg/netcdf/3.6.2/include -I$(CDECKS)
       ifdef DEBUG
```

```
advec_3d_module.o: kinds.o PARMSLD.o CONSTLD.o CONST3D.o PROFOUTLD.o

bound.o: kinds.o PARMSLD.o CONST3D.o domain_decomposition.o

buoyf_module.o: kinds.o PARMSLD.o CONST3D.o CONSTLD.o

damping.o: kinds.o PARMSLD.o CONST3D.o CONSTLD.o PROFOUTLD.o
```

- More advanced elements of Gnu Makefile incorporated - variables to choose compiler, debug option. More platform versatility.
- Dependencies added to the makefile.
- Able to chose specific case studies.

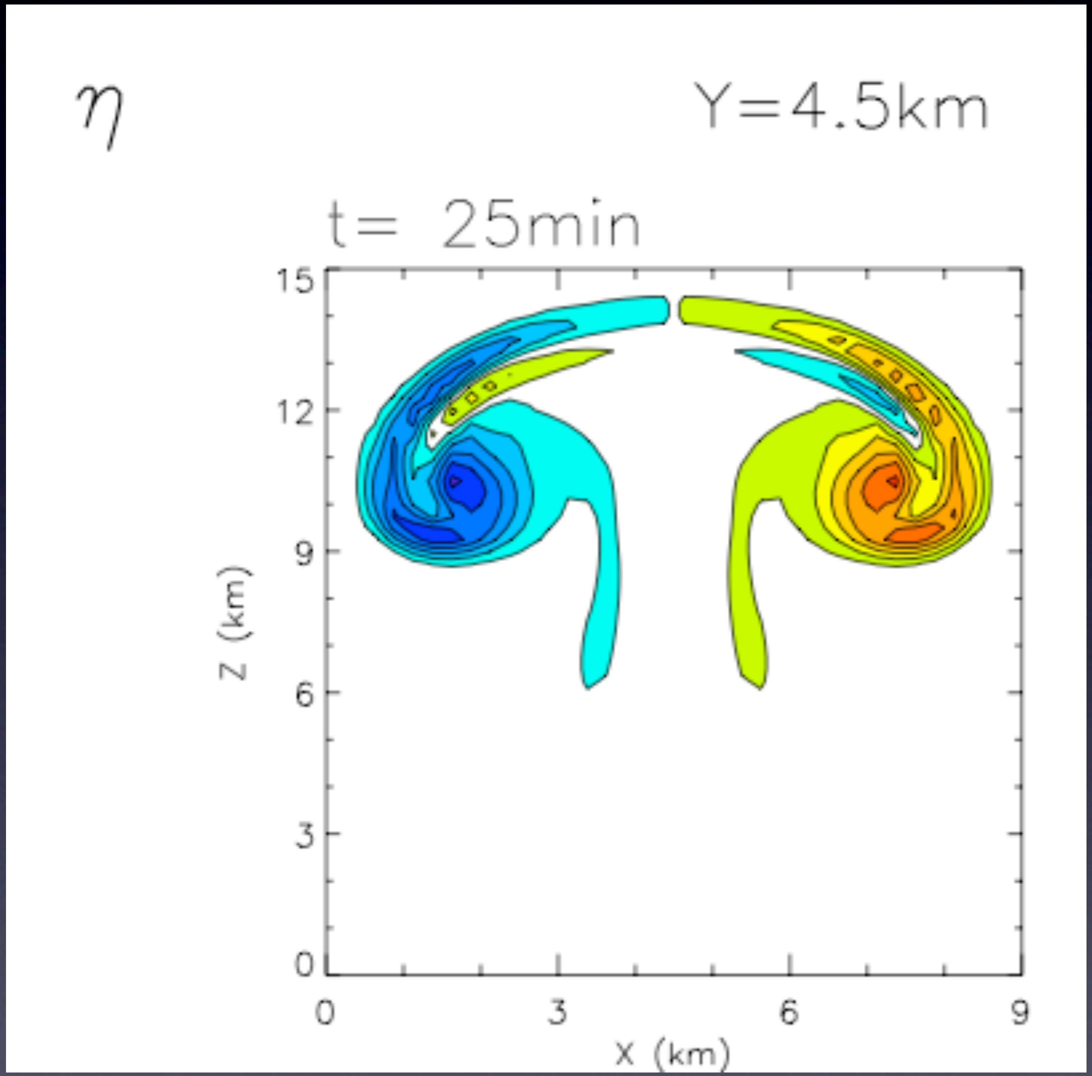
Step three - create a repository

- Subversion used to create a code and data repository.
- History of code development is preserved.
- Provide a means for users to get baseline version of code.

Step four - create a test suite

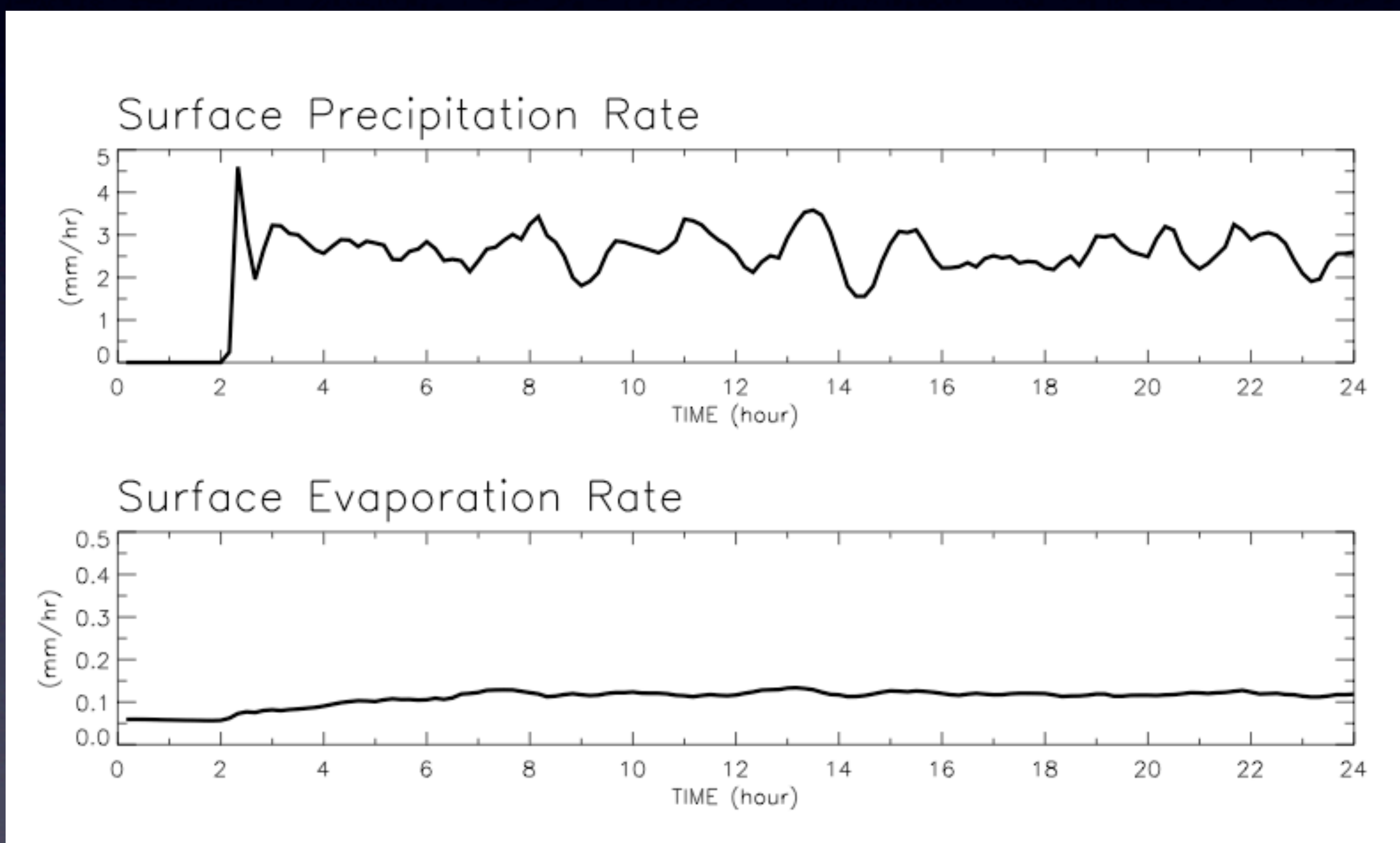
- Along with code we provide a suite of test cases.
- Figures from a baseline version of the model.
- Diagnostic codes to generate corresponding figures from user's run.

Test case 1 - Idealized Bubble



- Domain initialized with a buoyant bubble. No moist physics, adiabatic.
- Test of dynamical core.
- Cheapest case to run (30 minute simulation)

Test case II - Idealized Gate Phase III

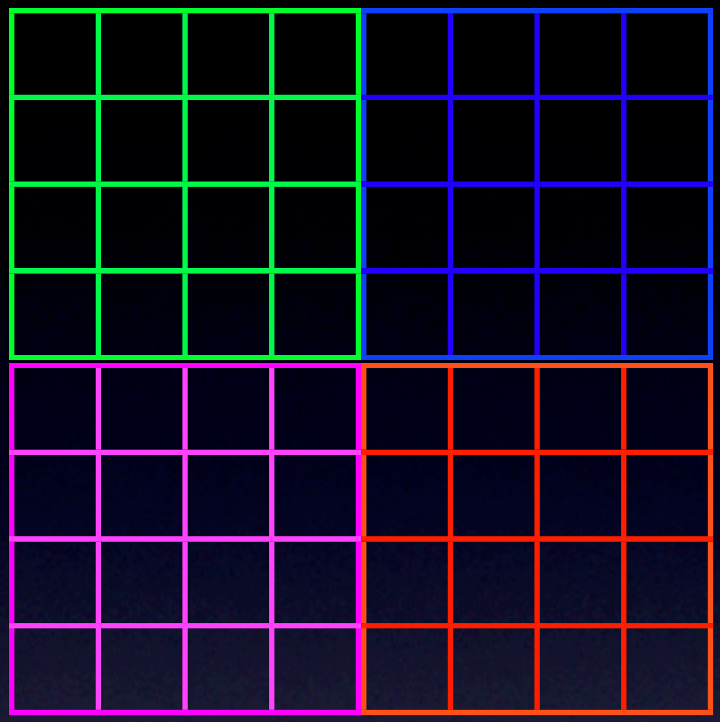


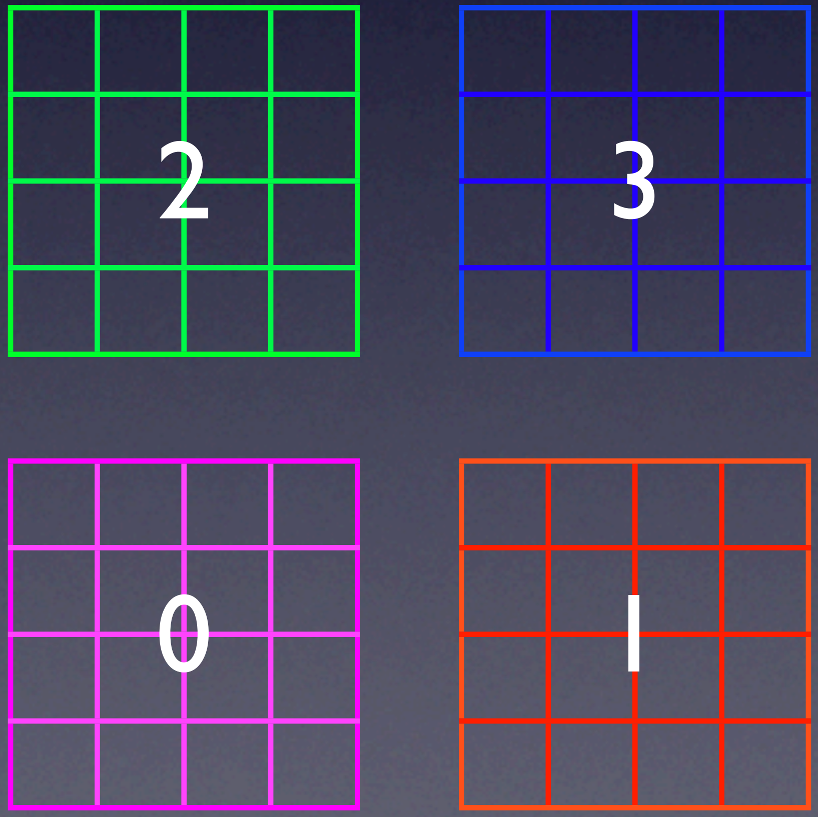
- Constant forcing of moisture and temperature. Radiative heating prescribed.
- Intended to test model microphysics in addition to dynamical core.
- Additional level of computational expense - 1 day simulation.

Test case III - TWP-ICE

- Full physics including interactive radiation; time-varying forcing of temperature and moisture.
- Test of full model.
- Deep tropical convection case.
- Expensive!

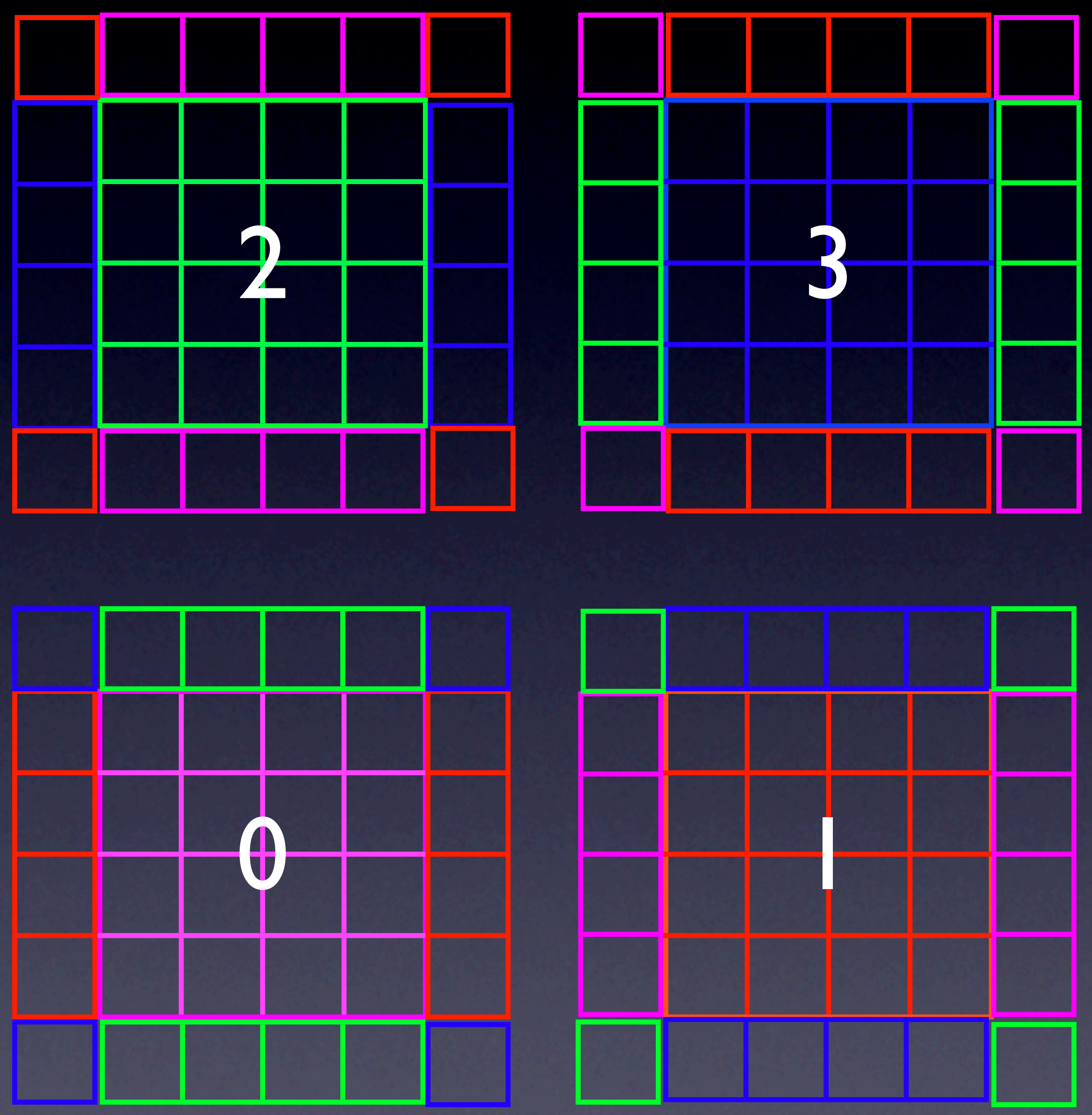
Step five - parallelize





- Domain size and length of simulation limited when code run serially.
- Introduce message-passing parallelism (MPI)
- The global horizontal domain is divided into rectangular subdomains of equal size. Subdomains are distributed among computer processors.
- Subdomains currently required to be of identical size.

Subdomains - the halo



Example: depth 1 halo

- A key part of each subdomain is the halo - those points that overlap with the neighboring domain.
- Baseline model fixed to have halo of depth one.
- Used this opportunity to generalize depth of halo. This will ease introduction of operators of higher orders of accuracy.

Step five - parallelize

176x176 TWP-ICE	
processors	wall clock (s)
1	1221.0
2	473.0
4	311.3
16	102.0
64	53.2

- Two basic operations that require message passing:
- Sending data at subdomain boundaries to neighboring subdomains. These are on different processors.
- Global reductions, such as sum.

Parallelization exceptions - I/O

- I/O - still gathered to one process into global size array.
- Have replaced binary I/O (except restart) with netcdf format. This will make sharing model data more community friendly.
- Next step is to add PIO (Parallel I/O) library calls to produce the netcdf output.

Parallelization exceptions - elliptic solvers

1024x1024	
processors	speedup over 1 processor
2	x1.4
4	x1.8
8	x3.7
16	x9.7
32	x18.9
64	x29.0

- Model features 2D and 3D elliptic equations solved using FFTs.
- A multigrid relaxation is coded for the 2D solver and has been tested offline. Serial case timing is of same order as FFT solver, but we scale and distribute memory.
- Multigrid 3D solver still being debugged.

Near future work

Result is Performance!

- Parallel netcdf I/O
- Get 3D multigrid solver working.
- Add more cases to test suite:
  - BOMEX - stratocumulus case
  - ARM SGP