The new Met Office/NERC Cloud model

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Why a new model?

- **Met Office** have identified that the Large Eddy Model (LEM), an in-house cloud model requires a significant technical upgrade in order to meet future parametrisation needs

- **NCAS** have identified that community supported cloud modelling capability in the UK is limited
  - particularly impacts observational and instrumental researchers

- MONC project funded by **JWCRP** to develop new model
  - project runs from 1st Jan 2014 to 31st August 2015

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Examples of UK cloud models

- 1D/2D kinematic models e.g.
  - Kinematic Driver (KiD) model
  - Aerosol-Cloud-Precipitation Interaction Model (ACPIM)
- 2D & 3D dynamic models e.g.
  - Met Office LEM

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Kinematic Driver (KiD) Model

- Simple microphysics interface to a common dynamical core
  - Developed at Met Office to facilitate consistent and constrained comparison of various microphysics codes
- KiD model highlights the usefulness of a community model
  - Used in the Met Office by Atmospheric Processes and Parametrisations (APP) and Observational Based Research (OBR)
  - Used by NCAS scientists in Leeds and Manchester University
- Although useful, the KiD model is limited as it uses prescribed flows, which are not influenced by cloud microphysics and thus lead to the inability to investigate important cloud feedbacks

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Met Office LEM

- High-resolution 3D large eddy simulation model with various cloud microphysics schemes and the Edwards-Slingo radiation code

- A principal tool for conducting atmospheric process research in the UK

- The LEM is fundamental in the development and testing of UM parameterisations such as
  - the UM boundary layer scheme;
  - the Abel and Shipway (2007) fall-speed parameterisations;
  - the UM decoupled temperature diagnostics

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Met Office LEM (2)

- The LEM is regularly used by NERC researchers - numerous publications
- The LEM code has been ported to & is running on
  - IBM power 7 in the Met Office, MONSOON, ECMWF, HECToR
  - Exeter University, University of Manchester and UEA clusters/HPC
- Limitations of LEM
  - Build process and code management method archaic
  - Code structure seriously limiting domain size and/or length of simulations

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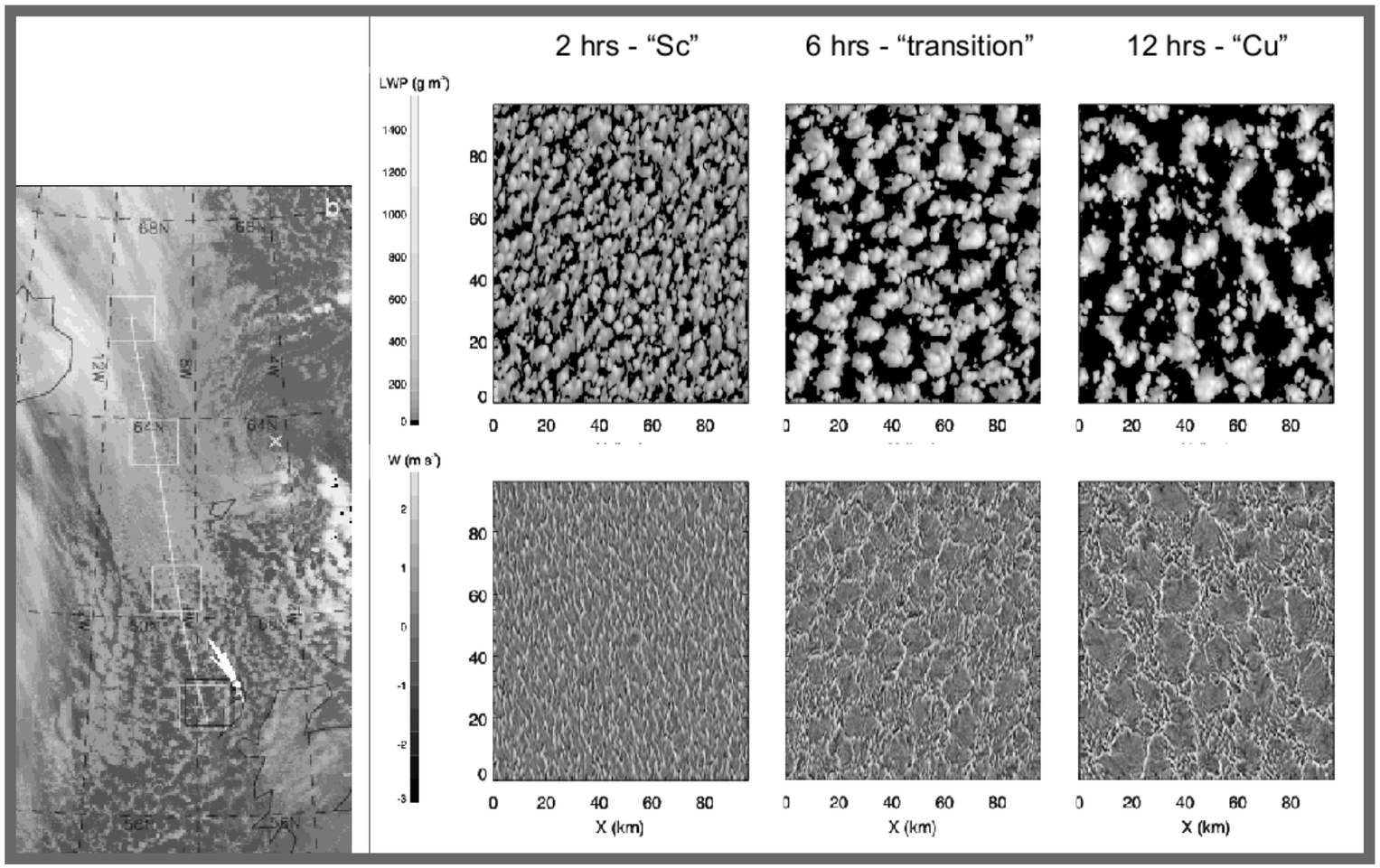
Example case: cold air outbreak

(see http://appconv.metoffice.com/cold_air_outbreak/constrain_case/home.html)

- LEM simulation limited to 100 km horizontal domain with dx, dy = 250 m due to memory issues on HPC.

- 15 hour simulation took 3 weeks on 192 processors

- Higher resolution with big domain required to simulate across the grey-scale and inform NWP



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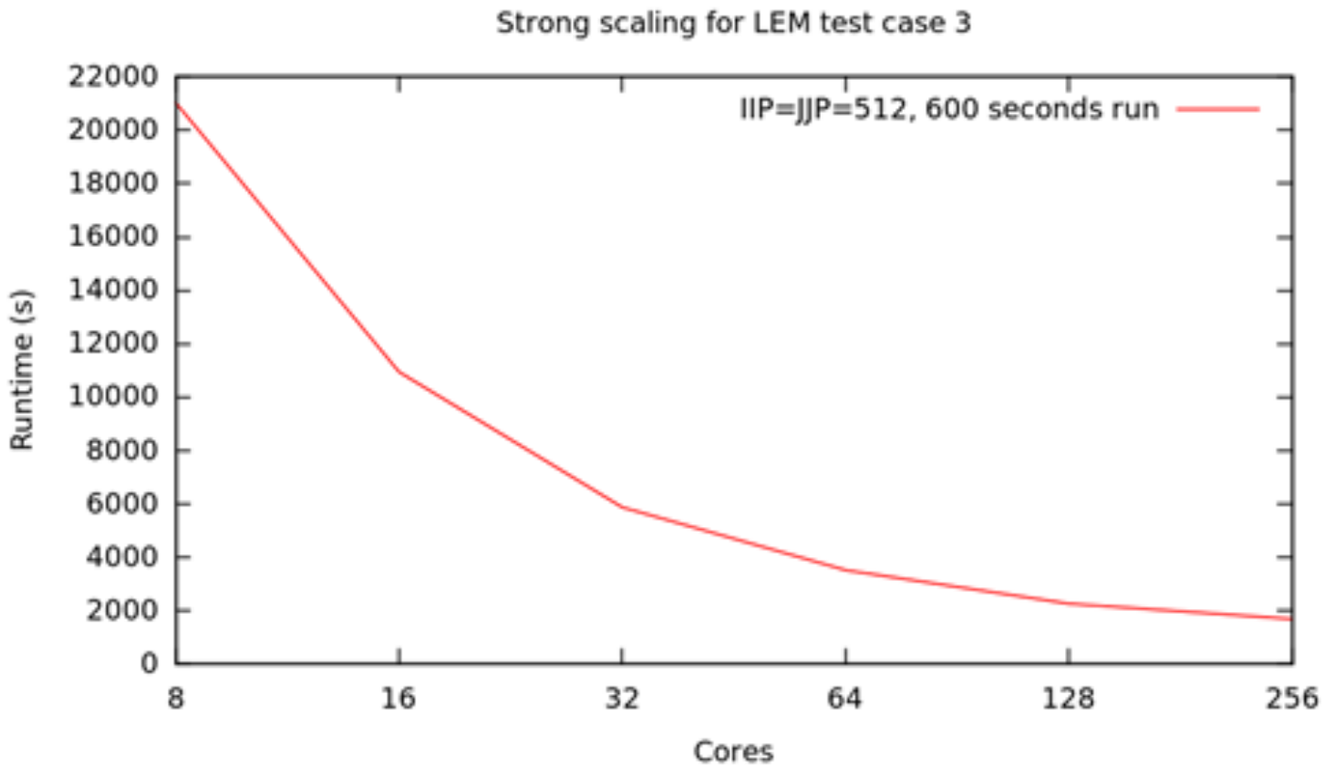
LEM profiling on HECToR

Test case 3: FIRE stratocumulus

non-precipitating moist processes and interactive radiation with high vertical resolution

Cores	Speed up	Parallel efficiency
8	1	1
16	1.92	0.96
32	3.59	0.90
64	6	0.75
128	9.36	0.58
256	12.58	0.39



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LEM profiling on HECToR (2)

Cores	LEM	MPI	Other
8	89.8%	3.2%	7.0%
16	87.7%	5.4%	6.8%
32	85.1%	8.9%	5.9%
64	78.3%	16.5%	5.1%
128	68.4%	27.1%	4.4%
256	55.6%	41.1%	3.3%

blocking sends/recvs, plus barriers

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Why use LEM as basis for new model?

- Tried and tested, involved in model inter-comparisons since 1996
  - very well understood and validated code
- Regularly used for parametrisation development and fundamental research by NERC and Met Office scientists
- NCAS and Met Office scientists have already coupled numerous microphysics schemes to the LEM
  - do not want to throw away that work

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Aims of MONC

- MONC will be a very **high resolution** (~2 to 50 m), **flexible**, **portable** cloud modelling framework, supported and administered through collaboration between NCAS and the Met Office

- MONC will address the shortcomings of the LEM by **upgrading** and **modernising** the structure of the LEM
  - from FORTRAN 77 to Fortran 2003, from GCOM to MPI
  - modular structure

- MONC will act as a focus for Met Office/NERC cloud, convection and aerosol-cloud process research enabling effective collaboration between observation scientists and model developers

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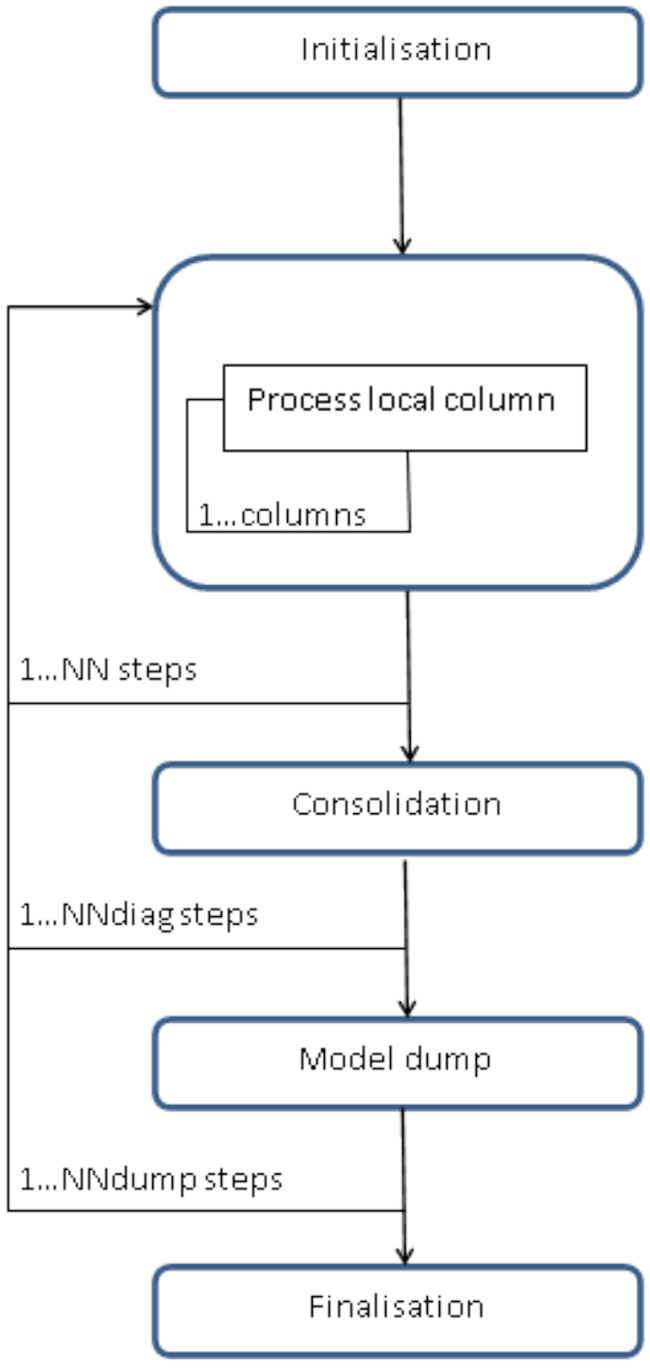
MONC architecture

- Made up of distinct components which implement some functionality

- Each can be called at different times at

1. initialisation
2. each time step
3. consolidation stages
4. model dumping
5. finalisation



Initialise model, either from an IC file or a model dump. Determines decomposition, appropriate data structures etc...

Individual timesteps with integrations performed for each local column

CFL check, timestep and diagnostics calculations. Checks for termination conditions and exists if appropriate

Model dump into checkpoint file(s)

Close model down and finalise all aspects as required

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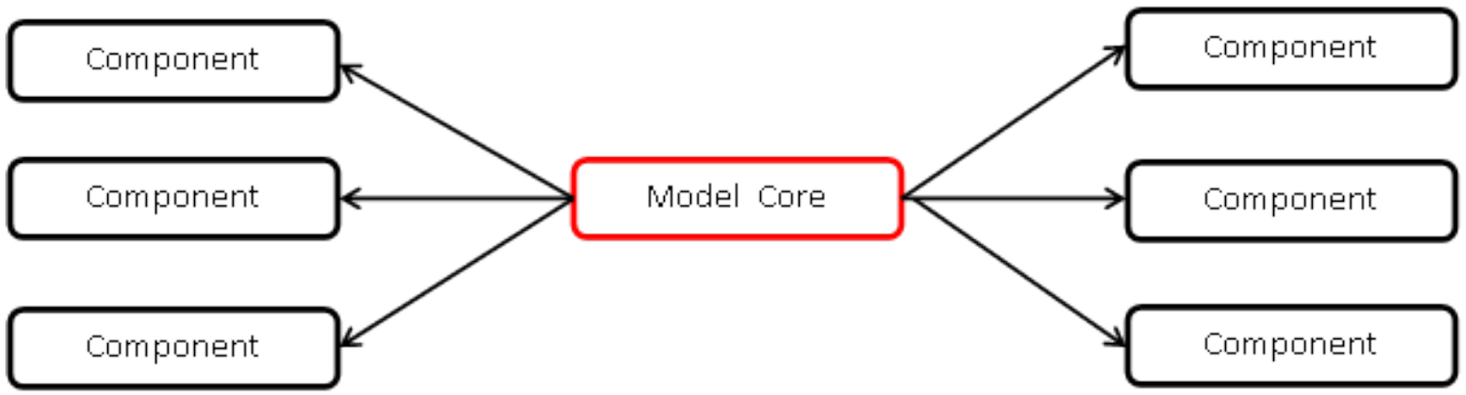
MONC architecture (2)

- The ***core*** contains the MONC entry point, registry functionality and some utility modules

- Each component is called by the core and the only interaction between component and core is through a “model state” type.

- Keeping components independent means that experimental functionality can be included at no cost to the mature, well tested, aspects.



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Parallel Decomposition

- The LEM currently limits decomposition to **one dimension**, each process must hold at least **two slices** due to limitations in the halo swapping code and data size on each process must be equal.
  - this limits the amount of parallelism available
- MONC will support decomposition in both the **x** and **y** dimension (columns) with at least one column per process
  - number of columns can be distributed unevenly
  - improved decomposition means more parallelism to be exploited
  - asynchronous MPI

IO server

- nodes are getting “fatter”, under-populating to satisfy memory needs is not uncommon

- model dumping is independent of computation

- use empty cores on a under-populated node to do useful work
  - pass work (in this case IO) to offload server
  - continue computation, while model dump is handled by IO server

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Test driven development

- Using *Fruit* (Fortran Unit Test Framework) for unit testing
  - framework written to automate this, generates HTML report
  - currently run manually, will eventually run automatically at check-in

MONC Unit test results

Revision number 42 *(docs)*, run at 10/03/2014 19:54:19

Overall test run: ***159/159***✓ GNU: *53/53*✓ Cray: *53/53*✓ Intel: *53/53*✓

	GNU	Cray	Intel
MONC build	Pass	Pass	Pass
checkpointer	5/5	5/5	5/5
core-collections	14/14	14/14	14/14
core-conversion	17/17	17/17	17/17
core-logging	2/2	2/2	2/2
core-optionsdatabase	5/5	5/5	5/5
core-registry	6/6	6/6	6/6
terminationcheck	3/3	3/3	3/3

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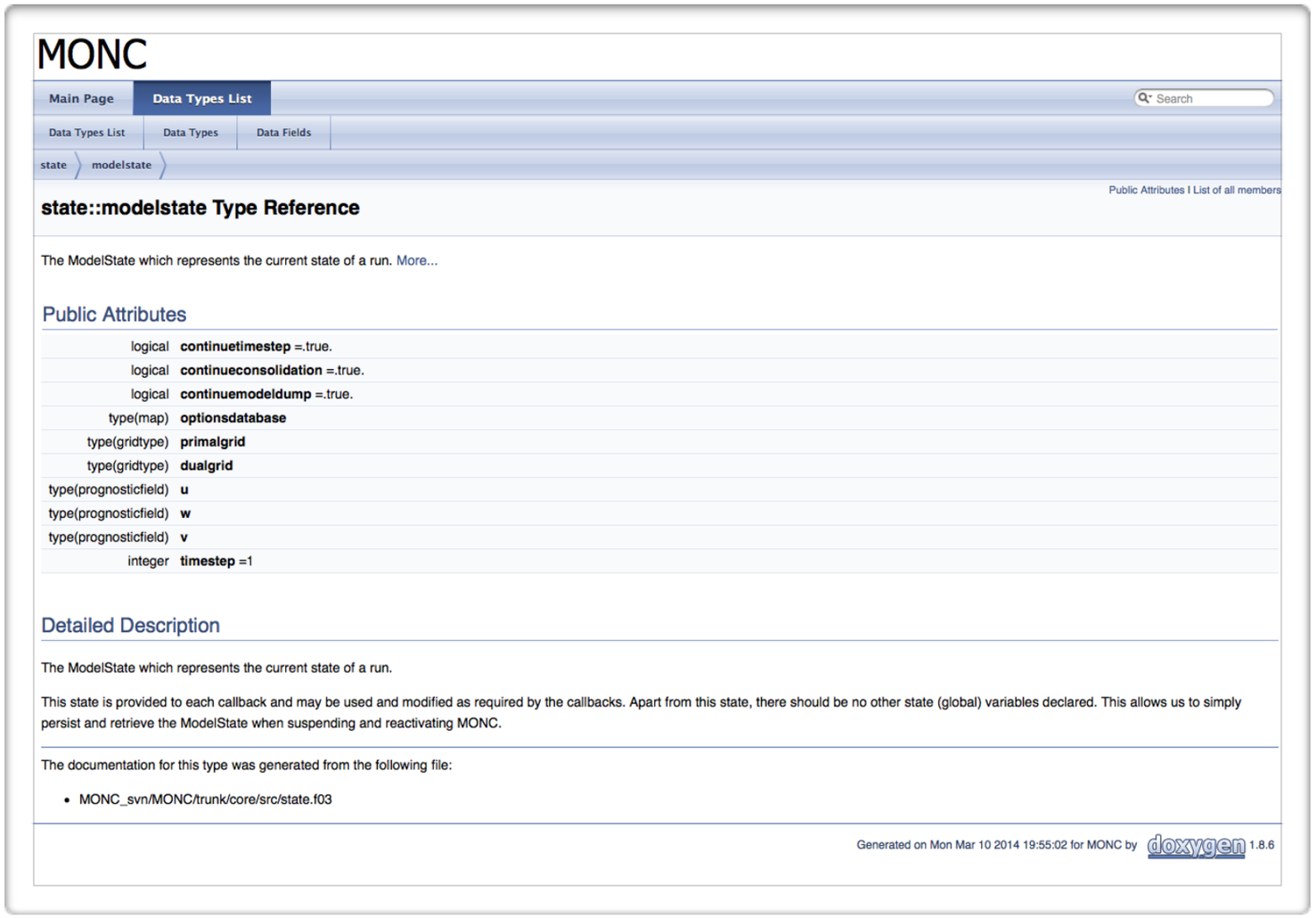
Documentation

- auto-generated from annotated source code
  - using Doxygen
- important for a community code to be well documented
  - encourages uptake and contributions



MONC

Main Page | Data Types List | Search

Data Types List | Data Types | Data Fields

state › modelstate

Public Attributes | List of all members

state::modelstate Type Reference

The ModelState which represents the current state of a run. More...

Public Attributes

logical	**continuetimestep** =.true.
logical	**continueconsolidation** =.true.
logical	**continuemodeldump** =.true.
type(map)	**optionsdatabase**
type(gridtype)	**primalgrid**
type(gridtype)	**dualgrid**
type(prognosticfield)	**u**
type(prognosticfield)	**w**
type(prognosticfield)	**v**
integer	**timestep** =1

Detailed Description

The ModelState which represents the current state of a run.

This state is provided to each callback and may be used and modified as required by the callbacks. Apart from this state, there should be no other state (global) variables declared. This allows us to simply persist and retrieve the ModelState when suspending and reactivating MONC.

The documentation for this type was generated from the following file:

- MONC_svn/MONC/trunk/core/src/state.f03

Generated on Mon Mar 10 2014 19:55:02 for MONC by doxygen 1.8.6

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Where are we now?

- Development started March 2014, currently 8,500 lines of code
- A kinematic version of MONC with a mature core and parallel framework
  - includes public “utility” modules such as logging, profiling, collections
- Next steps
  - IO server, diagnostics (August)
  - profile performance so far

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Questions?