PROJECT DYAMOND

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Synopsis

Project DYAMOND (DYnamics of the Atmospheric general circulation Modeled On Non-hydrostatic Domains) describes a framework for the intercomparison of an emerging class of atmospheric circulation models that, through their resolution of the major modes of atmospheric heat transport, endeavor to represent the most important scales of the full three-dimensional fluid dynamics of the atmospheric circulation. Phase 0 of DYAMOND will compare at least two models (ICON and NICAM). The project is, however, open to all and several groups from the US have indicated their interest in participating. Simulations will be performed for a forty day period with the goal of: (i) identifying similarities and differences that emerge at storm resolving scales (1 km to 5 km) as compared to traditional (hydrostatic-scale) representations of the atmospheric circulation; and (ii) to better define the frameworks and protocols for subsequent, and scientifically more ambitious, phases.

1. Protocol

(1) Simulations will be initialised on 1 August 2016 so as to encompass the NARVAL2 tropical field study which started on 10 August 2016, and to encompass a number of Typhoons in the Western Pacific where conditions were favourable. The initialisation will be from a common (ECMWF) atmospheric analysis, and run for forty days with specified sea-surface temperatures. Groups are left free to initialise soil moisture according to their sense of best practice.
(2) To participate the host model must be run at a grid scale of 5 km or less and not incorporate a parameterised representation of atmospheric deep convection. The vertical domain should extend to well above the troposphere (25 km or higher), and the convening participants are targetting model versions with about 75 levels.
(3) Models are expected to be of a form capable of representing the actual atmospheric general circulation, and thereby incorporate a full representation of fine-scale physical processes (microphysics, radiation, small-scale turbulence) as well as a realistic topography.
(4) Analysis will be split into a ten day spin-up period and a thirty day analysis period, with two and three dimensional output as discussed below (see also Tables 1,2,3).

Date: November 28, 2017.

2. Model output and data policy

Data archiving and access, including provision of and access to input data, will be provided through the DKRZ, supported and disseminated by the DKRZ led Centre of Excellence in Simulation of Weather and Climate in Europe (ESiWACE). All simulation output will be made publicly available as quickly as is technically possible.

Preliminary estimates based on IFS and ICON suggest that for a 2.5 km global model, each 2D field is about 300 MB. Considering hourly output of 2D fields, this implies 1000 output times, and assuming 30 fields, this is about 10 TB for the 2D hourly output. 3D data on 75 levels written for about three times fewer variables and six times less frequently implies about three times more output. Based on this a rough estimate is that the output archive per model would be 50 TB for each participating model. Resources have been applied for within the framework of the ESiWACE project, the project will also set up a coordination page to share this protocol and establish points of contact. Variable lists will be exchanged before any group begins production.

Internal discussions at MPI have focused on a trying for this first intercomparison to minimise the provision of output. Thus we will make preliminary simulations with the output list specified in the Tables 1-3. Groups may have additional output that they may wish to provide, and depending on their microphysical representation different variables may be appropriate, or certain integral quantities may not be well defined (i.e., CAPE or CIN). Groups should try to conform to the specified output, and document what and how they provide output, but in recognition of the challenges in writing output from such large simulations conformance to the output requirements is left up to the individual group's best judgement. Yet to be decided is whether there is a recommendation as to how latitudes and longitudes are to be indexed and to what extent groups think to provide this on the native versus an equivalent resolution lat-lon grid.

Table 1. 3D Output (3 h interval). On model levels below 20 km

Variable	Long Name	Units
u	Zonal wind on model level	$\mathrm{m\,s^{-1}}$
v	Meridional wind on model level	$\mathrm{m\,s^{-1}}$
w	Vertical wind on model level	$\mathrm{m\,s^{-1}}$
T	Temperature on model level	K
P	Pressure on model level	Pa
q_{v}	Specific humidity on model level	$\mathrm{g\,kg^{-1}}$
q_{c}	Specific cloud water on model level	$\mathrm{g\,kg^{-1}}$
q_{i}	Specific cloud ice on model level	$\mathrm{g\,kg^{-1}}$

In addition some basic time-independent information about the grid, topographic height, surface roughness, and land fraction should be made available.

3. Tmeline & Next steps

The project timeline is given in Table 4, this includes a couple of action items that need to take place before the simulations can be started. One is the exact specification

TABLE 2. 2D Output (15 min interval). In ICON both CAPE and CIN are computed with respect to the mean properties of a surface layer parcel.

Variable	Long Name	Units
$U_{10\mathrm{m}}$	Zonal wind at 10 m	$\mathrm{m\,s^{-1}}$
$V_{10\mathrm{m}}$	Meridional wind at 10 m	$\mathrm{m\,s^{-1}}$
$T_{2\mathrm{m}}$	Temperature at 2 m	K
P_{sfc}	Surface pressure	K
$q_{\mathrm{v,2m}}$	Specific humidty at 2 m	$\mathrm{g\,kg^{-1}}$
$\int q_{\mathrm{v}}\rho\,\mathrm{d}z$	Vertically integrated specific humidity	$\mathrm{kg\,m^{-2}}$
$\int q_{\mathrm{c}}\rho\,\mathrm{d}z$	Vertically integrated cloud water	$\mathrm{kg\,m^{-2}}$
$\int q_{\mathrm{i}}\rho\,\mathrm{d}z$	Vertically integrated cloud ice	$\mathrm{kg\,m^{-2}}$
$\int q_{\mathrm{r}}\rho\,\mathrm{d}z$	Vertically integrated rain water	$\mathrm{kg\,m^{-2}}$
$\int q_{\mathrm{s}}\rho\,\mathrm{d}z$	Vertically integrated snow	$\mathrm{kg\,m^{-2}}$
$\int q_{\mathrm{g}}\rho\,\mathrm{d}z$	Vertically integrated graupel	$\mathrm{kg\,m^{-2}}$
C	Vertically projected cloud cover	–
$\rho l_{\mathrm{v}}\overline{w'q'_{\mathrm{v}}}$	Surface latent heat flux	$\mathrm{W\,m^{-2}}$
$\rho c_p\overline{w'T'}$	Surface sensible heat flux	$\mathrm{W\,m^{-2}}$
$\rho\overline{w'u'}$	Surface zonal momentum flux	$\mathrm{N\,s^{-1}\,m^{-2}}$
$\rho\overline{w'v'}$	Surface meridional momentum flux	$\mathrm{N\,s^{-1}\,m^{-2}}$
R	Surface precipitation (accumulated)	$\mathrm{kg\,m^{-2}}$
T_{g}	Ground temperature (land)	K
q_{g}	Surface specific humidity (land)	$\mathrm{g\,kg^{-1}}$
$F_{\mathrm{sfc}}^{\mathrm{sw,net}}$	Surface net shortwave (accumulated)	$\mathrm{J\,m^{-2}}$
$F_{\mathrm{toa}}^{\mathrm{sw,net}}$	TOA net shortwave (accumulated)	$\mathrm{J\,m^{-2}}$
$F_{\mathrm{sfc}}^{\mathrm{sw,d}}$	Surface downward shortwave (accumulated)	$\mathrm{J\,m^{-2}}$
$F_{\mathrm{sfc}}^{\mathrm{lw,net}}$	Surface net longwave (accumulated)	$\mathrm{J\,m^{-2}}$
$F_{\mathrm{toa}}^{\mathrm{lw,net}}$	TOA net longwave (accumulated)	$\mathrm{J\,m^{-2}}$
$F_{\mathrm{sfc}}^{\mathrm{lw,d}}$	Surface downward longwave (accumulated)	$\mathrm{J\,m^{-2}}$
CAPE	Convective available potential energy	$\mathrm{J\,m^{-2}}$
CIN	Convective inhibition	$\mathrm{J\,m^{-2}}$

TABLE 3. Output (15 min interval) on select pressure levels (500 Pa, 850 Pa, and 700 Pa)

Variable	Long Name	Units
RH	Relative humidity	–
ω	Pressure velocity	$\mathrm{Pa\,s^{-1}}$

of the output data, the other is the provision of the initial data. As the first group gets ready to start production it is proposed that they share with other participants their proposed output lists and frequencies, and give the groups and participants a few days to comment on the specific choices made. Barring that we will agree to finalise the output lists as indicated in the table.

4. Perspective

Project DYAMOND will work toward an intercomparison of global storm $\mathcal{O}(3\,\mathrm{km})$ resolving model representations of the atmospheric circulation on the decadal time scale. It will explore the ability of such models to better represent the atmospheric general circulation, and its sensitivity to surface temperature, as compared to traditional approaches, which use a statistical respresentation of major modes of convective heat transport. One pressing question is whether changes in clouds, precipitation and cloud controlling factors is similar to what has been gleaned from cruder (traditional) models of the atmospheric circulation.

Table 4. Project DYAMOND Phase 0 Timeline

Date	Action to be completed
03.11.2017	Finalisation of initial protocol
26.11.2017	Input prepared
04.12.2017	Finalisation of output lists & release of web page
30.04.2018	Completion of simulation
25.04.2018	Possible presentation of first results at EGU
17.05.2018	Initial discussion of simulations at 5th ESiWACE/ENES HPC workshop
15.10.2018	DYAMOND Workshop (Hamburg) & finalisation of publication
01.01.2019	Phase I Kickoff
25.02.2019	HD(CP)^2 Final Meeting – Berlin

5. Specific Open Questions

(1) Do we need to specify the treatment of sea-surface temperature, also its time evolution?
(2) Should we remove CAPE and CIN from the input list? (Probably yes)
(3) Do we want to specify things about the output grid, i.e., native grid or latitude-longitude, and should the levels be indexed from top to bottom or bottom to top? Probably staying with the native grid and native output and providing weights for interpolating to lat-lon is sufficient; we might be able to arrange a CDO tool.

Acknowledgements: Daniel Klocke (DWD), Luis Kornblueh (MPI), Philipp Neumann (DKRZ) are thanked for their input to the technical and experimental design.