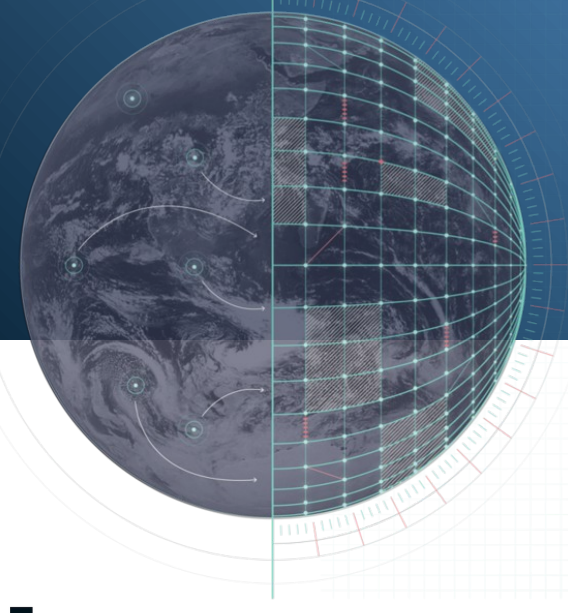




Implementing Reduced Precision in the ICON model

D. Kierans (DKRZ), A. Peinado (MPIM)

Motivation

Reducing from double to single-precision:

- ½ memory usage
- ½ required bandwidth
- 2x computational throughput*
- Limited fp64 support in future hardware

ICON is memory bound, so **expected 2.0x speedup** from double to single-precision.

Reducing working precision

```
2 USE, INTRINSIC :: ISO_C_BINDING, ONLY : sp => c_float, dp=> c_double
3 !
4 #if defined (_SINGLE_PRECISION)
5   INTEGER, PARAMETER :: wp = sp   !< selected working precision
6   INTEGER, PARAMETER :: vp = sp   !< selected variable precision
7 #elif defined (_MIXED_PRECISION)
8   INTEGER, PARAMETER :: wp = dp   !< selected working precision
9   INTEGER, PARAMETER :: vp = sp   !< selected variable precision
10 #else
11   INTEGER, PARAMETER :: wp = dp   !< selected working precision
12   INTEGER, PARAMETER :: vp = dp   !< selected variable precision
13 #endif
```

Required Modifications

- Reduced precision can cause loss of accuracy
 - Avoid computing RBF coefficients for interpolation
 - Double-precision prognostic rho, exner, theta
 - Compute MIURA3 advection coefficients in double-precision
- Reduced floating point range can cause underflows and overflows
 - Minor algebraic adjustments

Validation and Testing

Experiment list:

- Infrastructure & unit tests - MPI, IO, etc
- Dynamical core - DCMIP Jablonowski Williamson baroclinic instability
- Tracer advection - DCMIP Tracer Hadley for tracer advection
- Tracer advection - DCMIP Tracer deformational flow
- Full physics – bubble & aquaplanet

Performance

CPU speedup – 10km aquaplanet on 256 CPU nodes:

total_avg(s)	dp	sp	speedup
dycore	28599	13435	2.13
advection	9766	6390	1.53
radiation	16795	10950	1.53
turbulent mixing	14247	9730	1.46
cloud microphysics	2922	1599	1.83
Total	80866	47976	1.69

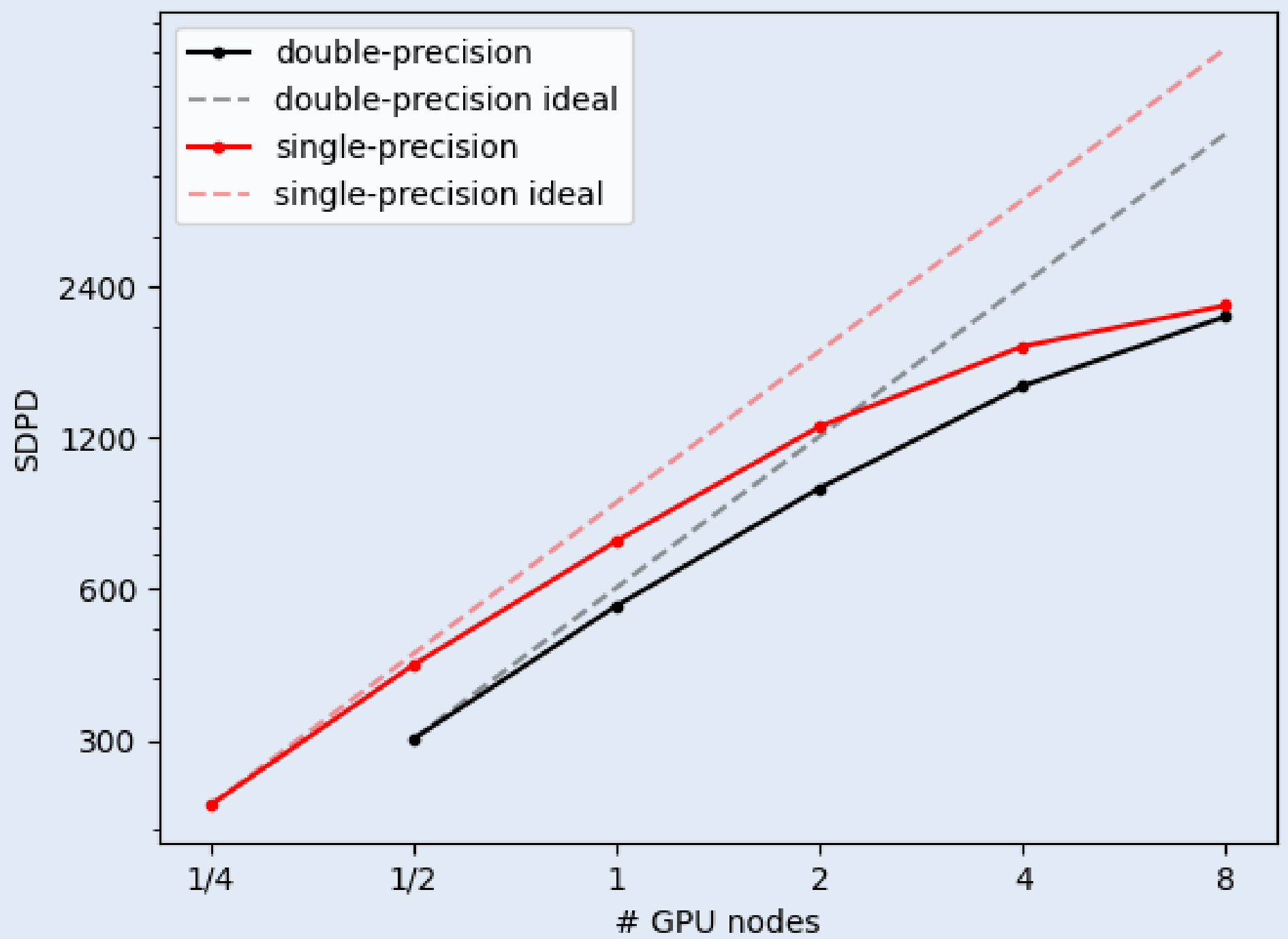
GPU speedup – 10km aquaplanet on 8 GPU nodes:

total_avg(s)	dp	sp	speedup
dycore	874.91	644.22	1.36
advection	351.74	260.01	1.35
radiation	500.75	330.76	1.52
turbulent mixing	316.82	239.51	1.32
cloud microphysics	41.08	26.56	1.55
Total	2328.71	1677.76	1.38

Memory consumption	dp	sp	relative
	65.96 GB	33.88 GB	0.52

Strong Scaling

40km aquaplanet



Results

Climate statistics for 10km aquaplanet

Single-Precision falls within
model variability

