The WRF Single-Moment 6-Class Microphysics' (WSM6) Performance Optimization

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Introduction:

WSM6 = **W**eather Research Forecasting **S**ingle-Moment 6-class **M**icrophysics.

The "microphysics" scheme is a physical parametrization that simulates processes in the atmosphere that cause precipitation of rain, snow, graupel, water vapor, cloud water, cloud ice.

Methodology:

1.Basic Loop Analysis
- Understand loop behavior
- Loop sizes
- Data dependency

2. Simple Optimization
- Add compiler flags: qopenmp, qopenmp-simd and architecture dependent FLAGS
- Basic timing
- Align array to 64-byte (compiler flag)
- Add OpenMP (OMP) directives

3. Profiling & Vectorization
- Advisor, Vtune, compiler optrpt
- Identify non-vectorized loop
- Re-write code for auto vectorization

4. Threading & Directives Analysis
- Understand directives overhead
- Apply appropriate directives to WSM6
- Code modification

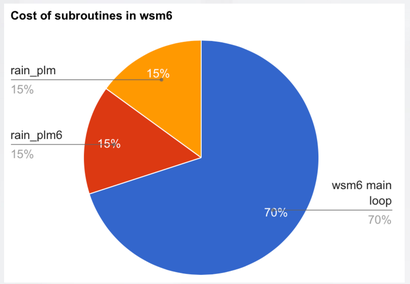
Vectorization Efforts:

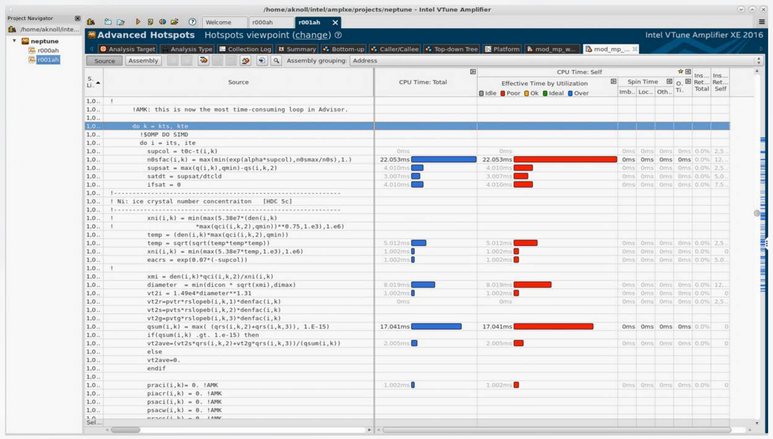
Initial addition of directives:
- **$OMP DO SIMD**
- **Alignment of arrays in code**
- !DIR$ ASSUME_ALIGNED
- !DIR$ ATTRIBUTES ALIGN
- **Other code changes (via vtune):**
  - removed initialization loop
  - removed outer timestep loop

SIMD results (VTune)

- Main wsm6 loop (70% of cost) vectorizes with OMP SIMD (AVX2) -- 28% efficiency
- rain_plm6 (15%), rain_plm(15%) did not vectorize with OMP SIMD
- Unaligned accesses remain (optrpts)

- **Overall 21% gain in performance over autovectorized code**





Results:

Directives' Overhead in µs

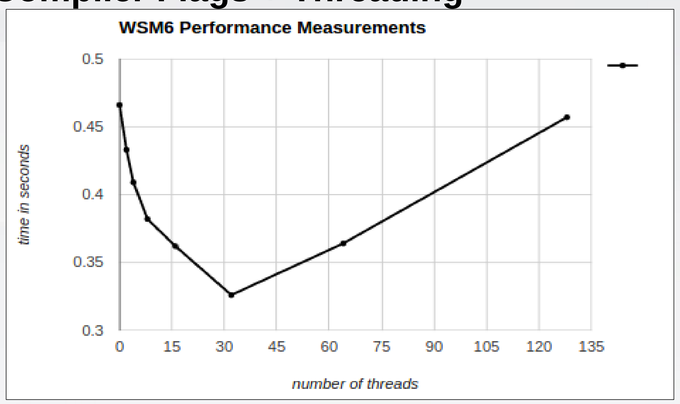
# Threads	2	4	8	16	32	64	128
Task	-15.6	6.75	14.79	12.98	12.98	8.98	10.65
Parallel Do	340.41	160.51	100.57	46.45	32.1	20.11	26.49
Do	-19.56	16.69	1.21	2.31	4.43	3.68	6.41

Compiler flags optimization

WSM6 measurement in s	
NO FLAGS	**1.96**
FLAGS (AUTO-VECTORIZATION)	**0.46**

NO FLAGS	FLAGS	PARALLEL
1.96	**0.46**	**0.33**

Compiler Flags + Threading



Future Work:

- Re-write loops to get vectorization
- Thread scalability and task parallelism
- Examine KNL performance

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