Weather and Forecasting

From development to production

With Allinea tools

16th Workshop on High Performance
Computing in Meteorology

Agenda

- Weather and forecasting : challenges

- How to reach the highest quality of service with Allinea?

  - Illustrated with a real-life case study

- Summary

Weather and Forecasting Challenges

- **Results quality and accuracy**

  - Lack of scalability negatively impacts the size & resolution of meshes

  - Achieving mesh invariance and solution stability is difficult

- **Time to result**

  - Not enough runs per day

  - Pace of research is slowed down by the lack of machine availability

- **New systems : migration and reliability**

  - Code migrations generate software problems

  - Hardware issues need to be identified and solved quickly

Allinea

- **HPC tools company since 2002**

  - Leading in HPC software tools market worldwide

  - Large customer base in Weather and Forecasting

    - ECMWF, Met Office, DKRZ, DWD, Meteo France, AEMET, BOM, NOAA…

- **Helping the HPC community design the best applications with Allinea Unified environment**

  - Increase the scale of applications fearlessly

  - Reach the highest level of performance

- **Helping HPC users make the most of their allocations with Allinea Performance Reports**

  - Increase the efficiency of your cluster

  - Identify hardware and software problems in production

Allinea Unified environment

- **A modern integrated environment for HPC developers**

- **Supporting the lifecycle of application development and improvement**
  - **Allinea DDT :** Productively debug code
  - **Allinea MAP :** Enhance application performance

- **Designed for productivity**
  - Consistent easy to use tools
  - Enables effective HPC development

- **Improve system usage**
  - Fewer failed jobs
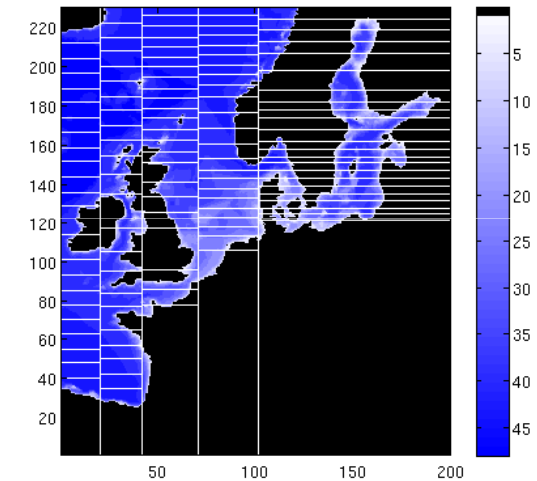 - Higher application performance
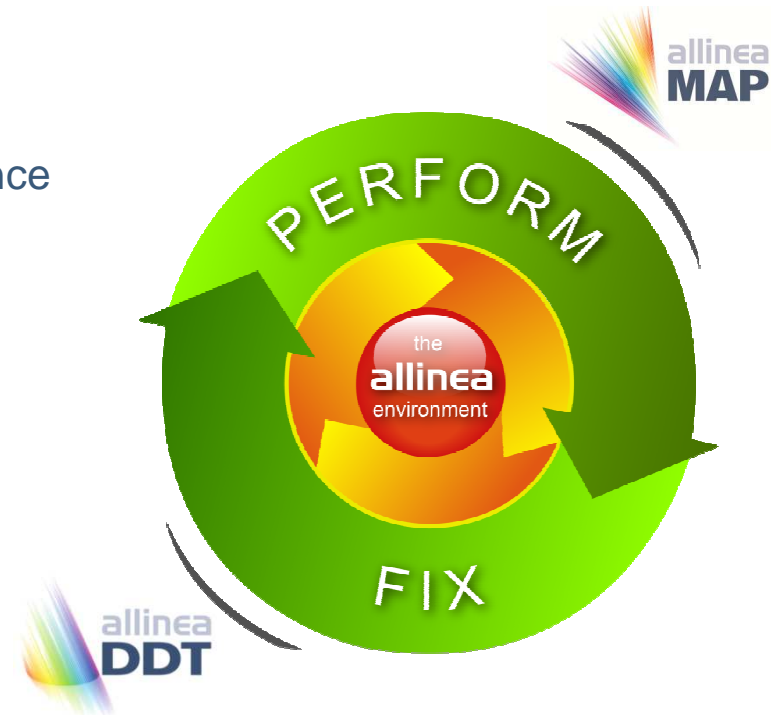
A real life example
Coupled models: CCLM, CICE, TRIM and Oasis3

- **Once upon a time : new experimental runs in production**

  – New coupling of models in the hope to improve the time to results

  – Scaling up the runs to increase the accuracy of the results
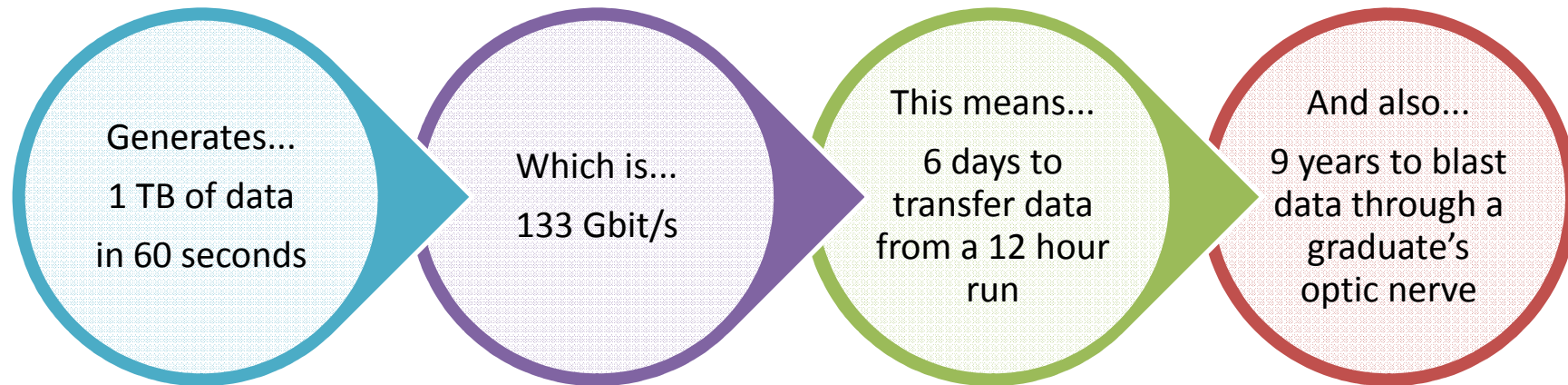
- **And during a profiling workshop at DKRZ…**

  Detection of a workload imbalance within TRIM

- **Follow-up plan**

  – Creation of a support ticket : major performance problem of the model

Profiling large scale codes

## Application running at 16k procs with a tracer

Generates... 1 TB of data in 60 seconds

Which is... 133 Gbit/s

This means... 6 days to transfer data from a 12 hour run

And also... 9 years to blast data through a graduate's optic nerve

```c
void do_math(int i)
{
    const double dtime = 0.3;
    const double c = 1.0;
    const double dx = 1.0;
    double tau, sqtau;

    tau = (c * dtime / dx);
    sqtau = tau * tau;
    newval[i] = (2.0 * values[i]) - oldval[i]
        + (sqtau * (values[i-1] - (2.0 * values[i]) + values[i+1]));
}
```

High level profiling
with Allinea MAP
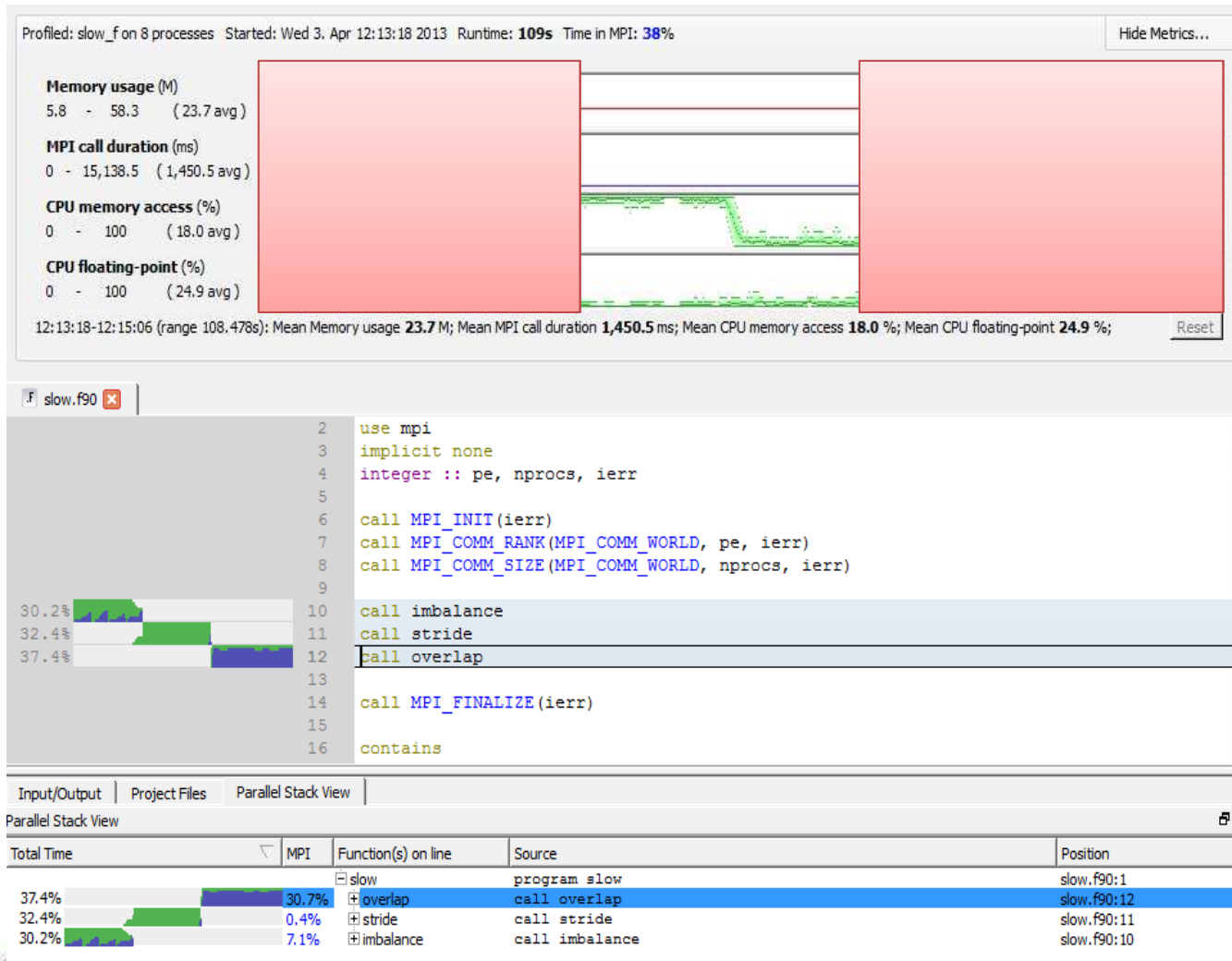
Common horizontal axis

↓

Aggregate across all processes and threads

↓

Highlight imbalance visually

↓

Always refer to **source code**

↓

Optional: **Target specific areas** for instrumentation

Statistic sampling or tracing ?
Complementary approaches

Optimize with Allinea MAP
- Characterize performance at-scale with a lightweight tool
- See which lines of code are hotspots
- Identify common problems at once

Prepare strategy with Allinea MAP
- Pass more obscure problems to an expert
- Identify loop(s) to instrument
- Identify performance counter(s) to record

Record traces
- Retrieve low level details
  - <u>without</u> generating huge traces
  - <u>without</u> huge overheads

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Back to our "performance" issue
Coupled models: CCLM, CICE, TRIM and Oasis3

- **The performance issue turned out to be a destructive bug**

  – Scaling up to 192 procs : crash !

  – Only happened in this context, on one particular task

- **Bug analysis at large scale can be difficult**

  – Core files were useless

    ▪ Crash not related to the actual bug location

  – Print statements : unusable

    ▪ Scale of the program was too high

    ▪ Location of the bug was unknown
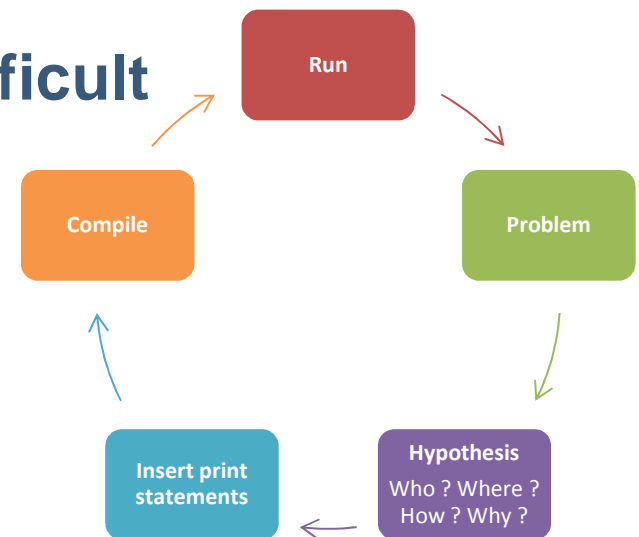
Allinea MAP & Allinea DDT
One Unified Solution

allinea
MAP

allinea
DDT

- Use Allinea MAP to find a bottleneck
- Flick to Allinea DDT to understand it
- Compare variables, expressions, call paths
- High memory usage? Use Allinea DDT !
- Common interface and settings files

Allinea DDT helps to understand

- **_Who_ had a rogue behavior ?**

  – Merges stacks from processes and threads

- **_Where_ did it happen?**

  – Allinea DDT leaps to source automatically

- **_How_ did it happen?**

  – Detailed error message given to the user

  – Some faults evident instantly from source

- **_Why_ did it happen?**

  – Unique "Smart Highlighting"

  – Sparklines comparing data across processes

Resolving the TRIM issue
Looking at ocean domain decomposition

Resolving the TRIM issue
Looking at ocean domain decomposition

With Allinea Unified environment…
## Helping developers and support teams

- **… Results quality and accuracy**

  - Resolve scalability issues to increase the size and resolution of meshes

  - Reach the highest level of performance at scale with minimum efforts

- **… Time to result**

  - Increase the amounts of runs per day and the productivity of the system

  - Free machine time to increase the research pace

- **… Migrations and experiments**

  - Resolve bugs and performance issues quickly with Allinea tools

 **In this case : resolution in a few minutes instead of 1 day.**

HPC is not just about development

- **Optimization is not always synonym of efficiency**

  - Cluster productivity vs cluster usage

- **Possible efficiency needs during production**

  – Define and enforce best practices (scale, parameters…)

  – Provision and validate cluster upgrades and changes

  – Quickly detect & resolve hardware or software faults impacting performance

- **Effortless one-touch reports with Allinea**

  – Generates explicit and readable reports with metrics and explanations

  – Understand optimized HPC applications effortlessly
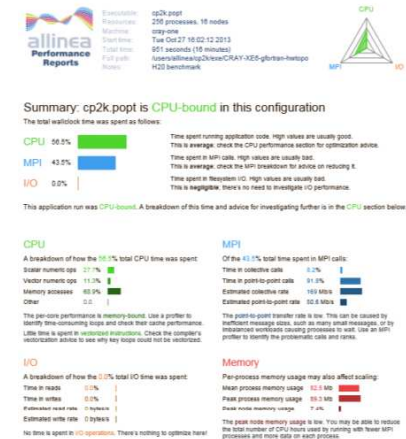
Designed for better runs, quickly
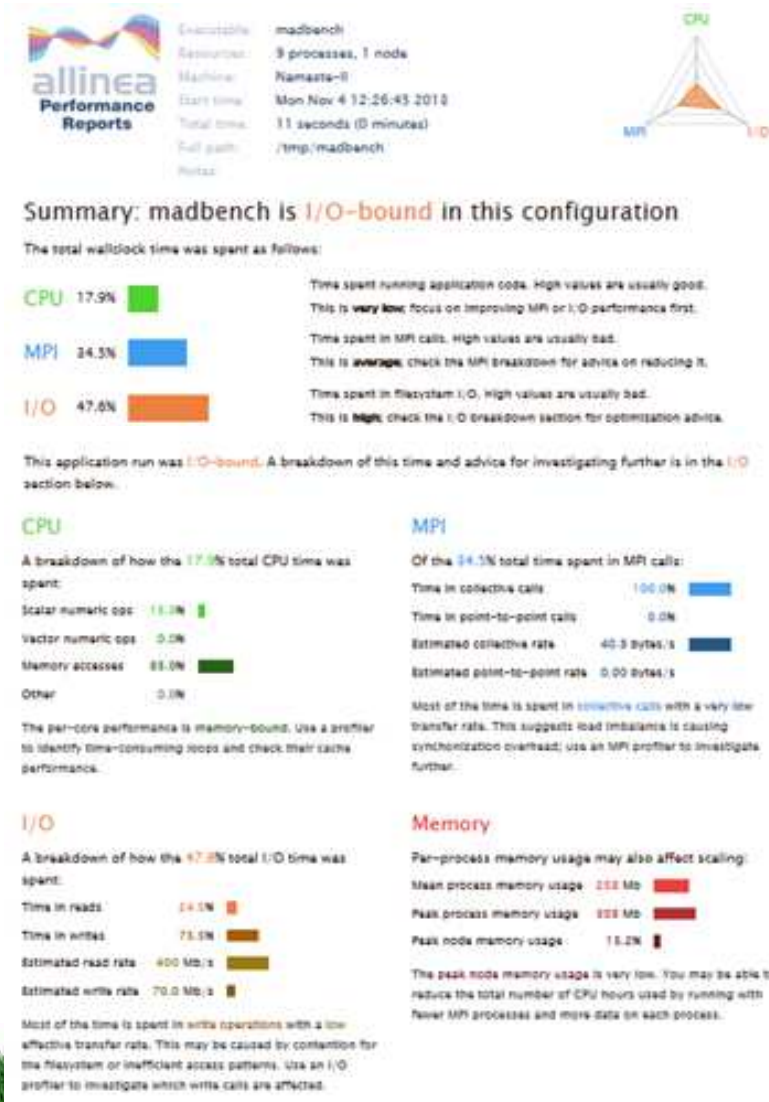
- No instrumentation needed
- No source code needed
- No recompilation needed
- Less than 5% runtime overhead
- Fully scalable
- Run regularly – or in regression tests
- Explicit and usable output
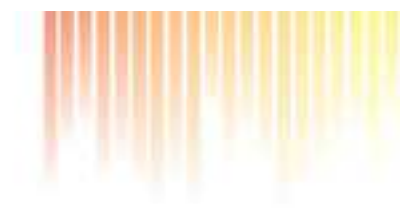
With Allinea Performance Reports…
Helping managers, support teams

- **… Retrieve free time on the cluster**

  - Detect heavy demanding users to help them

  - Generate quick feedback on various tweaks and configuration settings

  - Detect software bottlenecks limiting solver performance

- **… Migrations and experiments**

  - Find significant improvements without purchasing extra hardware

  - Determine what type of system or upgrades will benefit research

  - Run and validate codes on new systems in less time

Summary
With Allinea tools

- **Better results quality & accuracy**

  – Improve application scalability to resolve bigger and better scientific problems

  – Achieve mesh invariance and solution stability more easily

- **Better time to result**

  – Squeeze more jobs within a given time frame

  – Improve the research pace by freeing machine time without hardware investment

- **Easier migration, experimentation and systems validation**

  – Resolve quickly code migrations and experimentations problems

  – Identify and resolve hardware issues quickly by looking at the applications

Thank you !

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