The Panel:

What does the future look like for NPW application development?

17th ECMWF Workshop on High Performance Computing in Meteorology

16:00-17:30

27 October 2016

Panelists

- John Michalakes (UCAR, USA)
- Mark Govett (NOAA, Boulder, USA)
- John Goodacre (Univ of Manchester, UK)
- Ulrich Schattler (DWD, Germany)
- Paul Selwood (MetOffice, UK)
- Carlos Osuna (MeteoSwiss)
- Peter Bauer (ECMWF)
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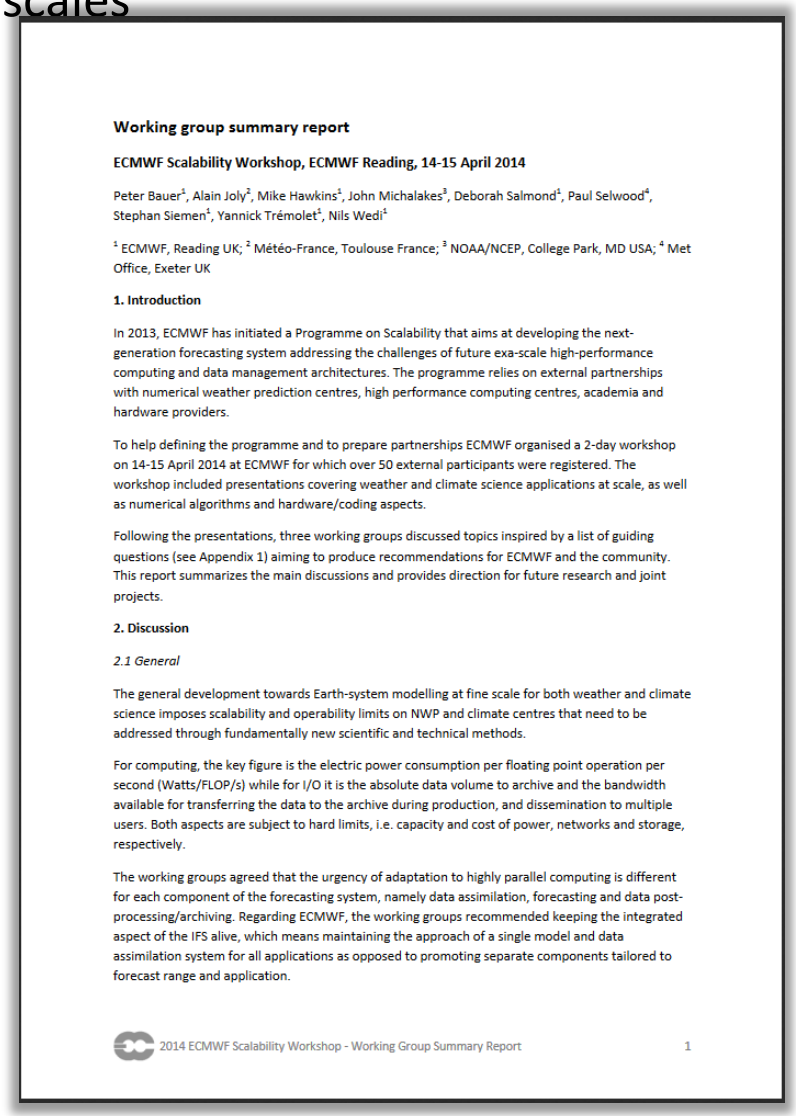
- You all →

Agenda

15 min	Introduction (including this)
45 min	Future of NWP Application Devel.
30 min	Other topics NVRAM, Deep Learning

- Requirements for Future NWP application Development
  - Better prediction over multiple time scales
    - Higher resolutions
    - More ensemble members
    - Better physics
    - Better data assimilation
    - Analysis and products
- Challenges/opportunities
  - Scalability
    - Computing, I/O, Energy
    - Capability vs. Capacity
  - Heterogeneity
    - Processors, programming models
    - Models (coupled systems)
  - Software engineering
    - Processes
    - Frameworks
  - Community
    - R2O (and O2R)
    - Education



Working group summary report

ECMWF Scalability Workshop, ECMWF Reading, 14-15 April 2014

Peter Bauer[1], Alain Joly[2], Mike Hawkins[1], John Michalakes[3], Deborah Salmond[1], Paul Selwood[4], Stephan Siemen[1], Yannick Trémolet[1], Nils Wedi[1]

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1. Introduction

In 2013, ECMWF has initiated a Programme on Scalability that aims at developing the next-generation forecasting system addressing the challenges of future exa-scale high-performance computing and data management architectures. The programme relies on external partnerships with numerical weather prediction centres, high performance computing centres, academia and hardware providers.

To help defining the programme and to prepare partnerships ECMWF organised a 2-day workshop on 14-15 April 2014 at ECMWF for which over 50 external participants were registered. The workshop included presentations covering weather and climate science applications at scale, as well as numerical algorithms and hardware/coding aspects.

Following the presentations, three working groups discussed topics inspired by a list of guiding questions (see Appendix 1) aiming to produce recommendations for ECMWF and the community. This report summarizes the main discussions and provides direction for future research and joint projects.

2. Discussion

2.1 General

The general development towards Earth-system modelling at fine scale for both weather and climate science imposes scalability and operability limits on NWP and climate centres that need to be addressed through fundamentally new scientific and technical methods.

For computing, the key figure is the electric power consumption per floating point operation per second (Watts/FLOP/s) while for I/O it is the absolute data volume to archive and the bandwidth available for transferring the data to the archive during production, and dissemination to multiple users. Both aspects are subject to hard limits, i.e. capacity and cost of power, networks and storage, respectively.

The working groups agreed that the urgency of adaptation to highly parallel computing is different for each component of the forecasting system, namely data assimilation, forecasting and data post-processing/archiving. Regarding ECMWF, the working groups recommended keeping the integrated aspect of the IFS alive, which means maintaining the approach of a single model and data assimilation system for all applications as opposed to promoting separate components tailored to forecast range and application.

http://www.ecmwf.int/sites/default/files/elibrary/2014/13800-workshop-scalability-2014-worksing-group-summary-report.pdf

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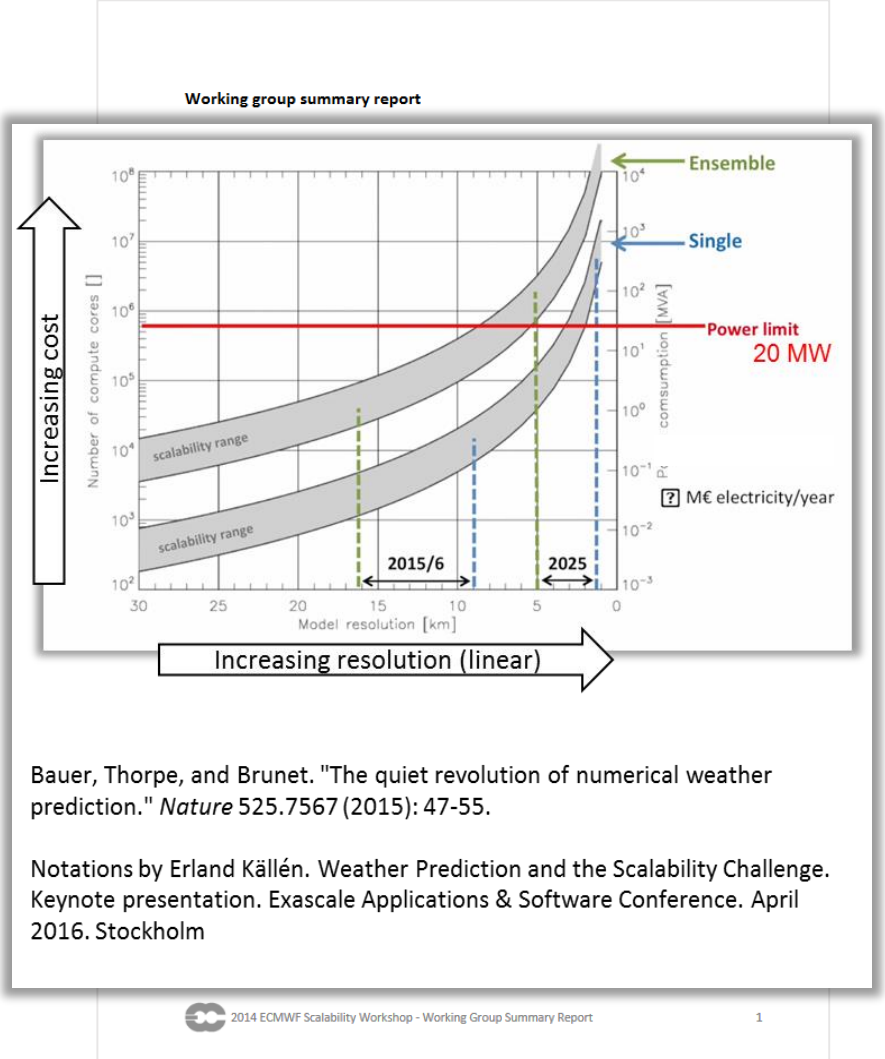

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Topic: Future of NWP App. Development

- Application landscape
  - Models, including physics, chemistry, oceans
  - Assimilation, post-processing, analysis and visualization, data handling
  - Unification of weather and climate
    - Shared technology (computing and data)
    - Shared strategies for strengthening funding
- Hardware landscape
  - Performance and Power considerations

    "5 MW to move 1 exabyte of data 5 mm on a chip" – Goodacre
  - Processing architectures: CPU, Many-/Multi-core, ARM, GPU, Optysys
  - What new possibilities and expanded capabilities does NVRAM offer?
  - What is co-design and how do we as a scientific community practice it?

Topic: Future of NWP App. Development

- Programmming models and languages
  - Are weather and climate models a good fit for next generation archictures? Plus: lots of parallelism and societal importance. Minuses: low C.I., large memory footprint, big I/O, flat profiles, multi-phasic, load imbalanced. New methods to improve?
  - Is performance portability being adequately satisfied by the current mix of programming models: OpenMP, OpenACC, CUDA, MPI, GridTools, OCCA, PSyclone
  - What is needed in a modern programming model and/or language to adequately express parallelism and complex memory hierarchies from which compilers can generate efficient code
  - Task parallelism: what programming models and methods are needed?
  - What have we learned already from the successful and less successful efforts to adapt models to accelerators?
  - Do we have critical mass to support development and the will to adopt new programming models for weather and climate? What are the costs and benefits? How much improvement is needed to justify what level of disruptive overhaul?

Topic: Future of NWP App. Development

- Trade-off between scientific and computational requirements. E.g. Accuracy versus performance
- Managing development in the face of disruptive/intrusive technology
  - Efficient and effective transitioning to operational systems
  - Balancing advanced technology against the next procurement
  - Training domain scientists
  - Entraining computer scientists

- Deep/Machine learning?
  - Rapid classifiers for radar/observations (from Phillip Brown's presentation)
  - Pattern recognition in model outputs
  - Infilling/smoothing model outputs

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