The Scalability Programme

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What on Earth is Scalability?
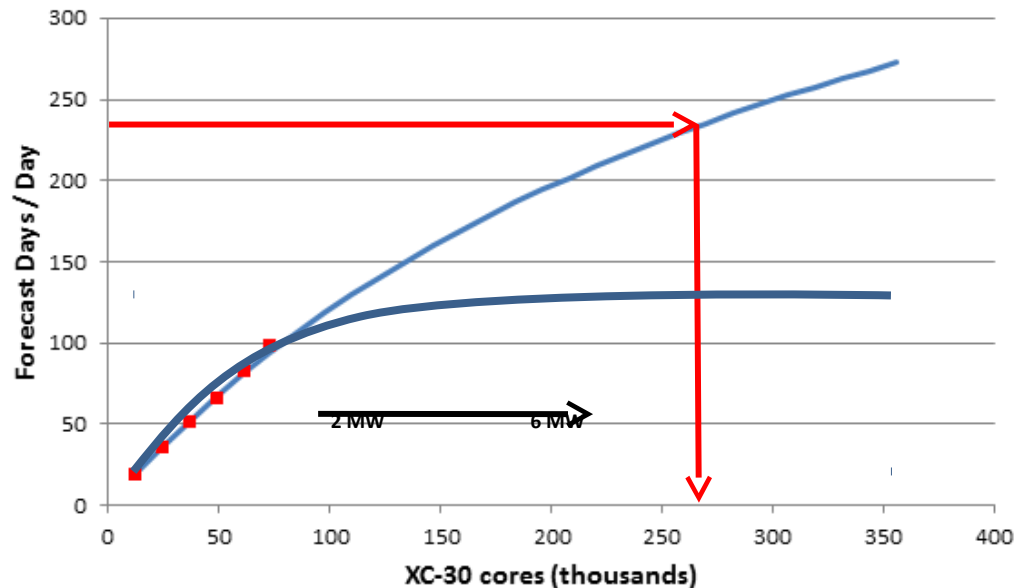
Scalability is the ability of a system, network, or process to handle a growing amount of work in a capable manner or its ability to be enlarged to accommodate that growth
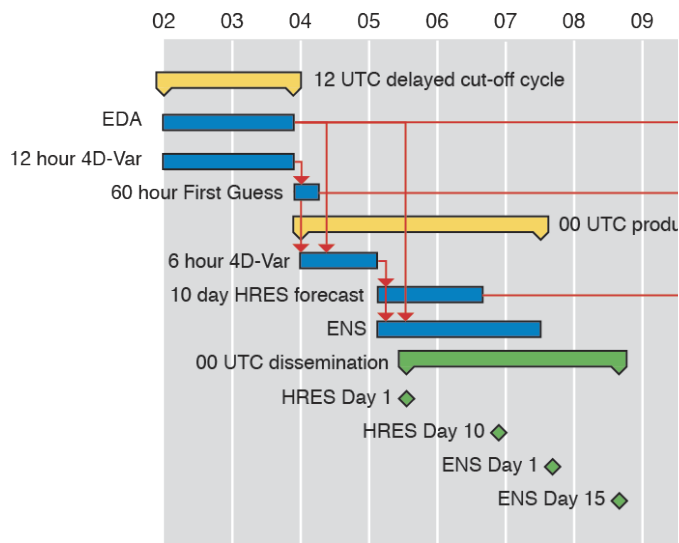
WIKIPEDIA
The Free Encyclopedia

→ **Scalability Programme** will allow running complex systems **with acceptable cost**

→ **Scalability Programme** will allow running complex systems **within allocated time**

ECMWF production workflow

| | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 |

12 UTC delayed cut-off cycle

EDA

12 hour 4D-Var

60 hour First Guess

00 UTC produ...

6 hour 4D-Var

10 day HRES forecast

ENS

00 UTC dissemination

HRES Day 1

HRES Day 10

ENS Day 1

ENS Day 15

- **12h EDA**: 10 members, 2 outer loops, inner loops w/ iterations, 6h integrations, low resolution
- **6/12h 4DVAR**: 3 outer loops, inner loops w/ iterations, 6h integrations, high/low resolution, wave coupling
- Observation DB incl. feedback, ML and PL output

- **10d HRES**: 10d integrations, high resolution (radiation low resolution), wave coupling
- ML and PL output

- **15/32d ENS**: 15/32d integrations, lower resolution (radiation low resolution), ocean-wave coupling,
- (2 t-steps ML and) PL output

- Data management
- Dissemination via RMDCN

Post-processing, archiving

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Scalability: Main issues

Analysis

- Spatial resolution
- Sequential nature of variational data assimilation (iterations)
- Inhomogeneous data distribution
- Coupling (waves, ocean, sea-ice)

Forecast

- Spatial resolution
- Communication of global fields (spectral), multiple grids
- Additional prognostic variables (atmospheric composition)
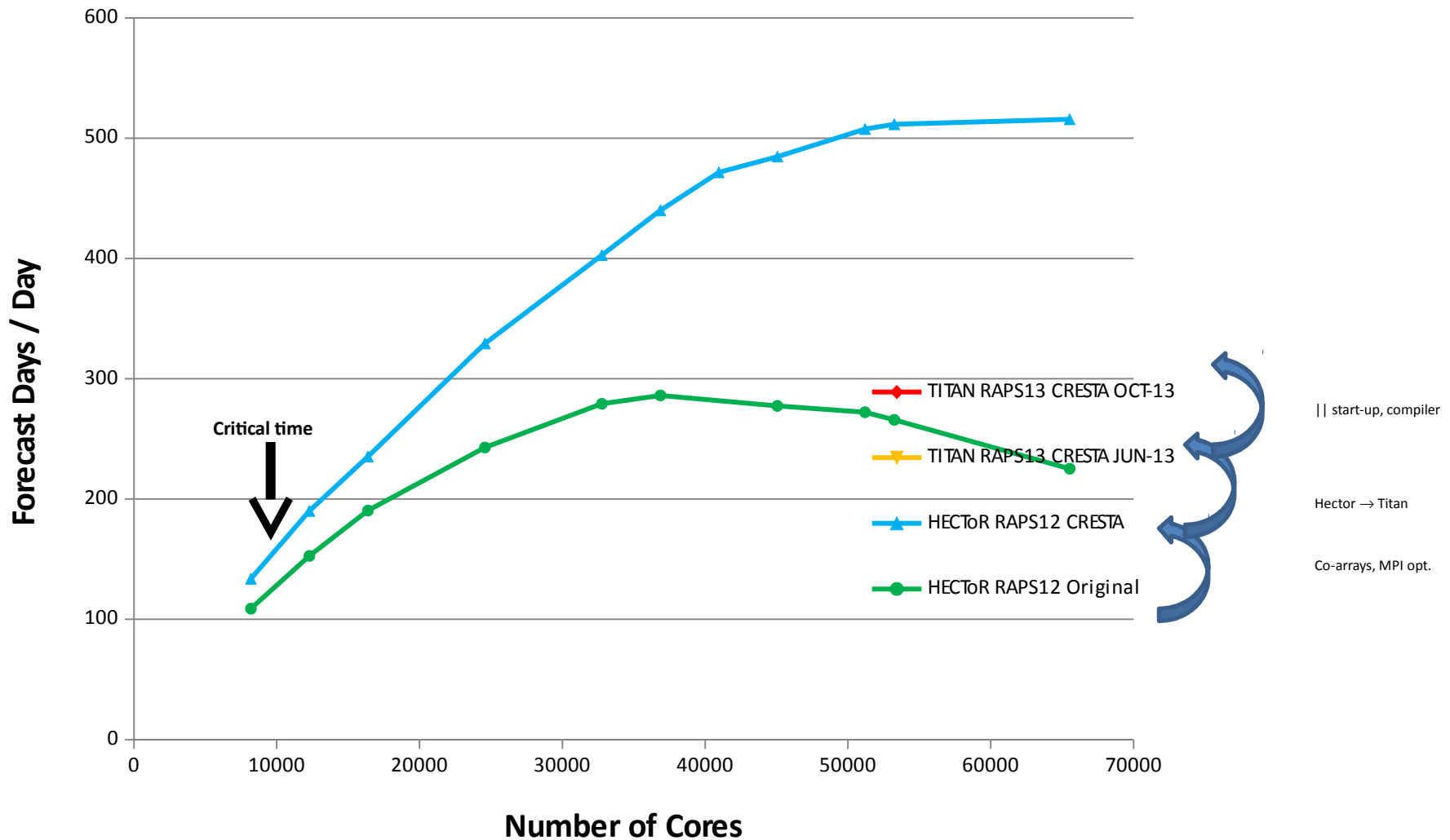- Coupling (waves, ocean, sea-ice)

Pre-/post-processing

- Diversity/volume of observational data
- Volume/rate of high resolution model output

Computer hardware

- Architecture of CPU/accelerators/vector units, compilers
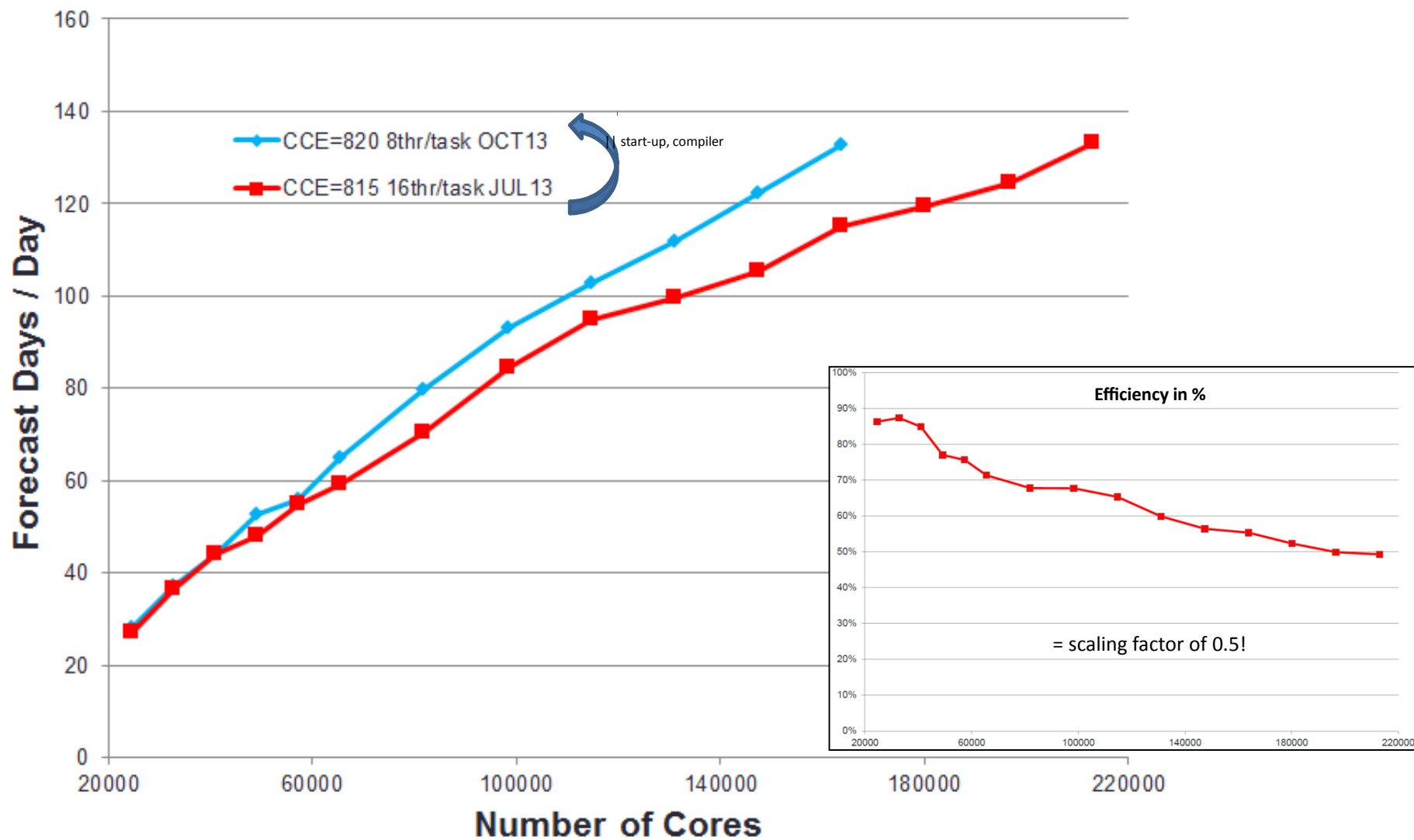- Implications on code design
- Implications on work flow

Scalability of computing: The good …

T2047L137 (10 km)
RAPS12 (CY37R3, on HECToR), RAPS13 (CY38R2, on TITAN)

Forecast Days / Day vs Number of Cores

- TITAN RAPS13 CRESTA OCT-13
- TITAN RAPS13 CRESTA JUN-13
- HECToR RAPS12 CRESTA
- HECToR RAPS12 Original

Critical time

|| start-up, compiler

Hector → Titan

Co-arrays, MPI opt.

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Scalability of computing: … the bad

T3999L137 (5 km)

Scalability of computing: … and the ugly

4DVAR (T1279c outer loops, T255/T399/T399l inner loops,

12-hour window)
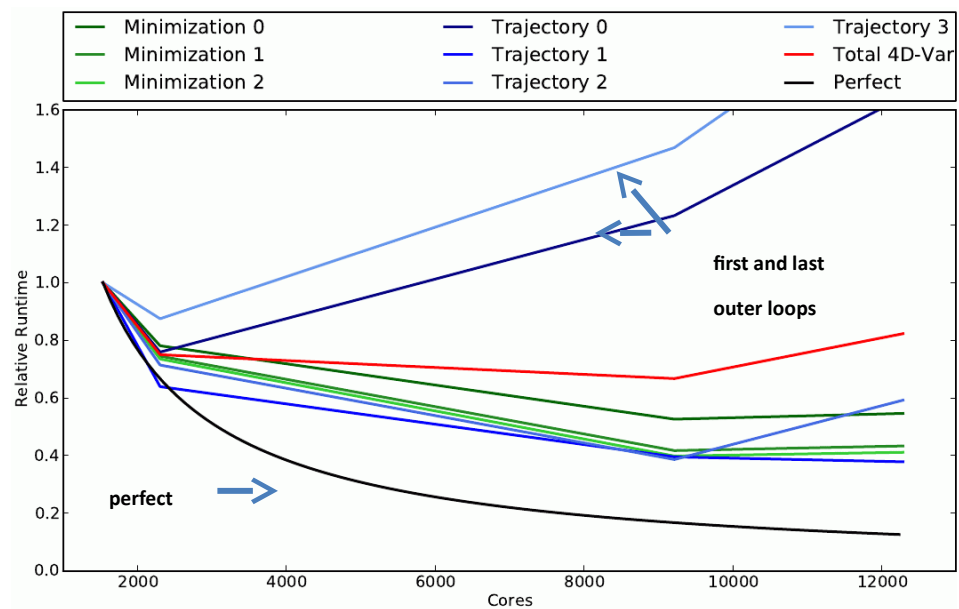
Scalability Programme: Objectives

New capabilities :

- A flexible framework for scientific choices +

  maximum achievable parallelism.

- Portable code structures ensuring efficiency and code readability exploiting future technologies.

- Metrics and framework for quantitative assessment of scalability.

Success metrics: - efficiency gains in Watts/FLOP

  - efficiency gains in Gbyte/s and Pbyte

$\longrightarrow$ The Scalability Programme provides science **support**!

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Scalability Programme: Structure

Board:

Chair: DF

Members: DR,DC, AD, Météo-France, ALADIN, HIRLAM, Met Office, DWD, MeteoSwiss

Projects:

Observation processing	Data assimilation	Numerical methods	Data processing

Budget 2014

Budget 2014

Budget 2014

Budget 2014

Budget 2015

CoE

CHANCE

ESCAPE

High-SPACE

NextgenIO

Earthserver2

IFS code adaptation

Computer architecture support

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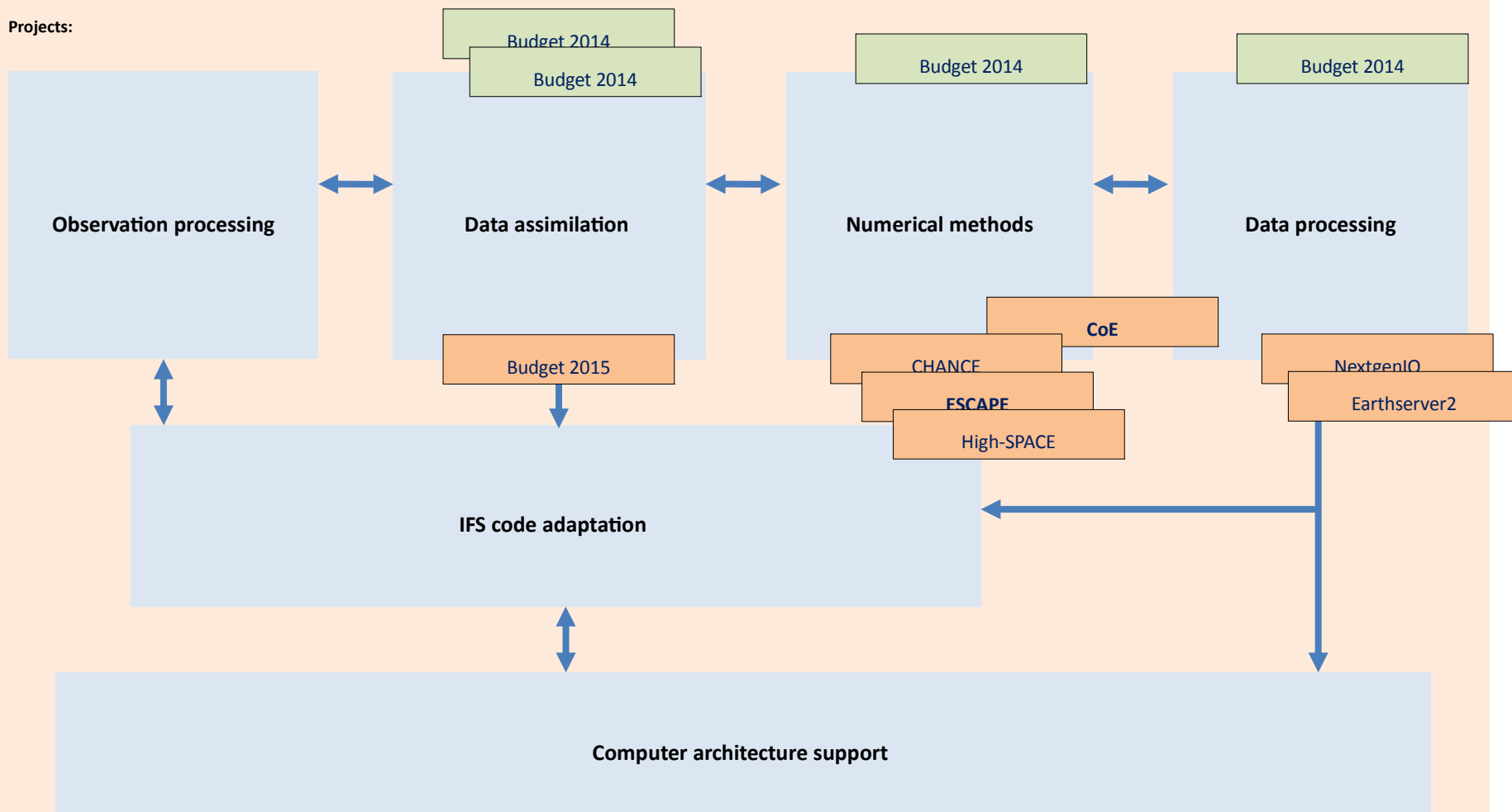
Scalability & Science: OOPS & 4D-Var
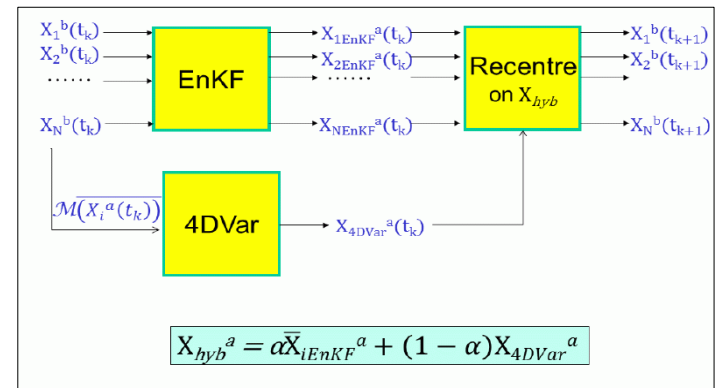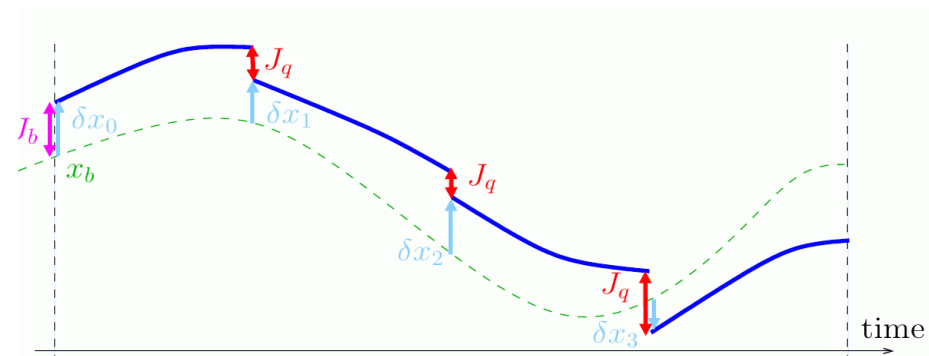
OOPS

- Object-oriented design and call structure

- Top-level control level with abstract building blocks
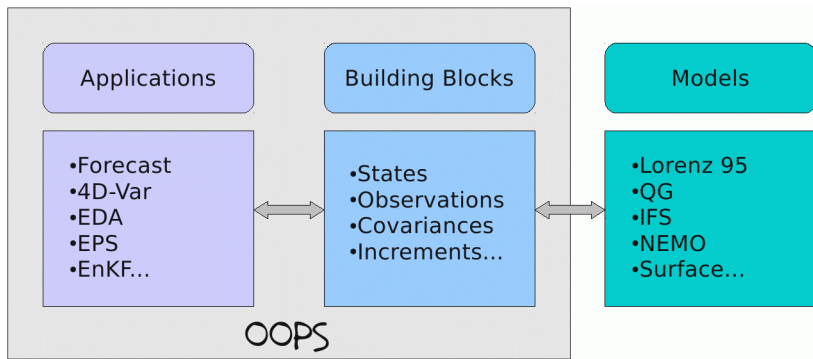
(Hybrid) 4D-Var

- Model error formulation

- Saddle-point algorithm

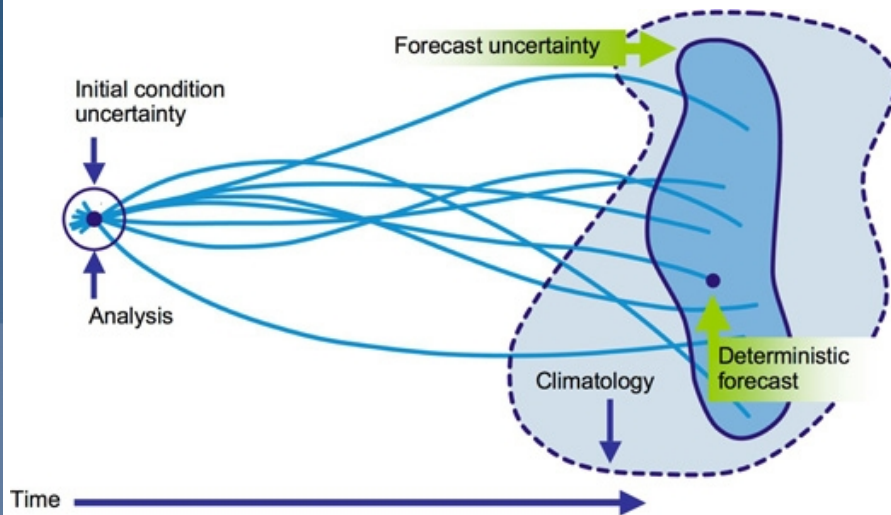- Hybrid ensemble – variational formulation

$$X_{hyb}{}^a = \alpha \overline{X}_{iEnKF}{}^a + (1 - \alpha) X_{4DVar}{}^a$$

- … long-window 4D-Var, EnKF, EnVar, coupled data assimilation
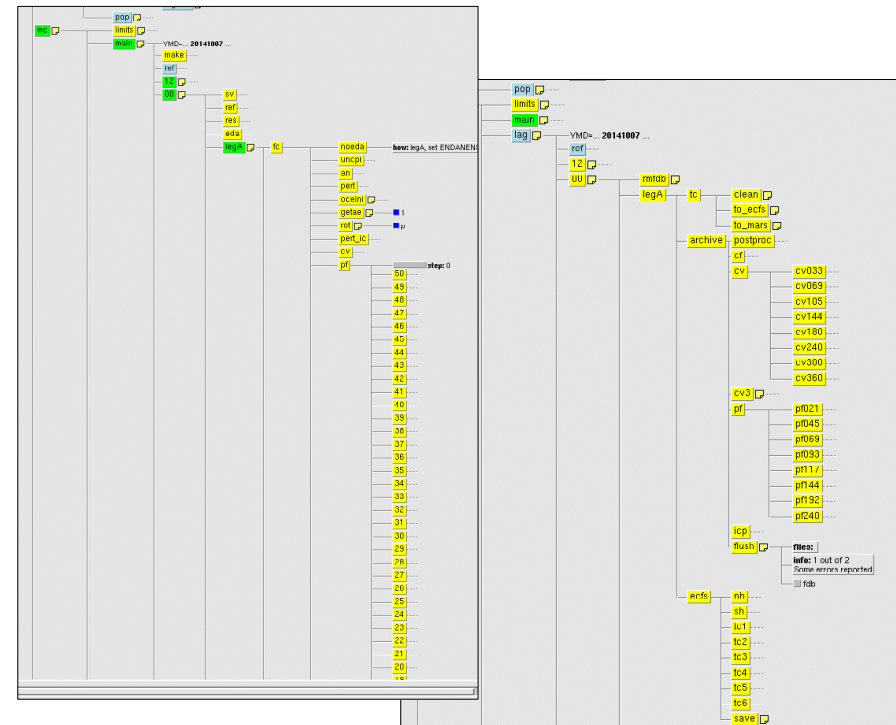
Scalability & Science: ENS & HERMES

ENS

- High-resolution output on model levels

- On-the fly diagnostics of information content

- Reduction of degrees of freedom

HERMES

- Reduced data rates between tasks
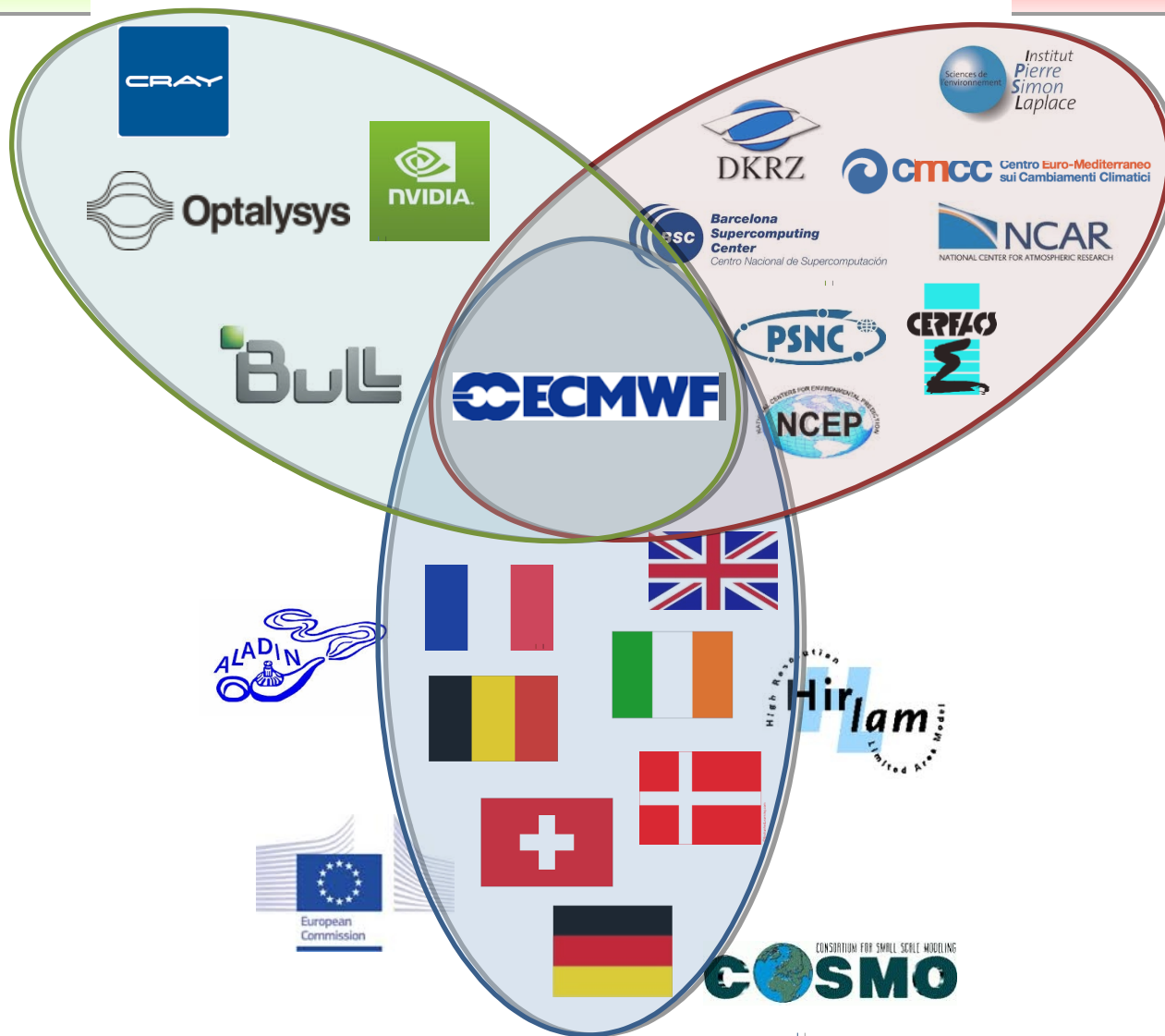
- Archiving of high-level information

- Fault awareness

- … advanced ensemble products

- … possible restart configurations for enhancing resilience

Scalability needs partnership

Scalability Programme: Timeline

2013

- Programme launched

- Request for 4 additional positions

2014

- April Workshop to gather community and Member States

- 4 recruitments completed (OOPS, PolyMitos, HERMES)

- 4 projects initiated, 2 integrated (OOPS and COPE)

- Programme Board established

- Externally funded projects being submitted to EC Horizon 2020

- Programme presented to Committees

- Request for 1 additional position for ocean (coupled) data assimilation

2015

- Full establishment of all projects

- Start of successful externally funded activities

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