ECMWF – Computing & Forecasting System

iCAS 2015, Annecy, Sept 2015

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ECMWF

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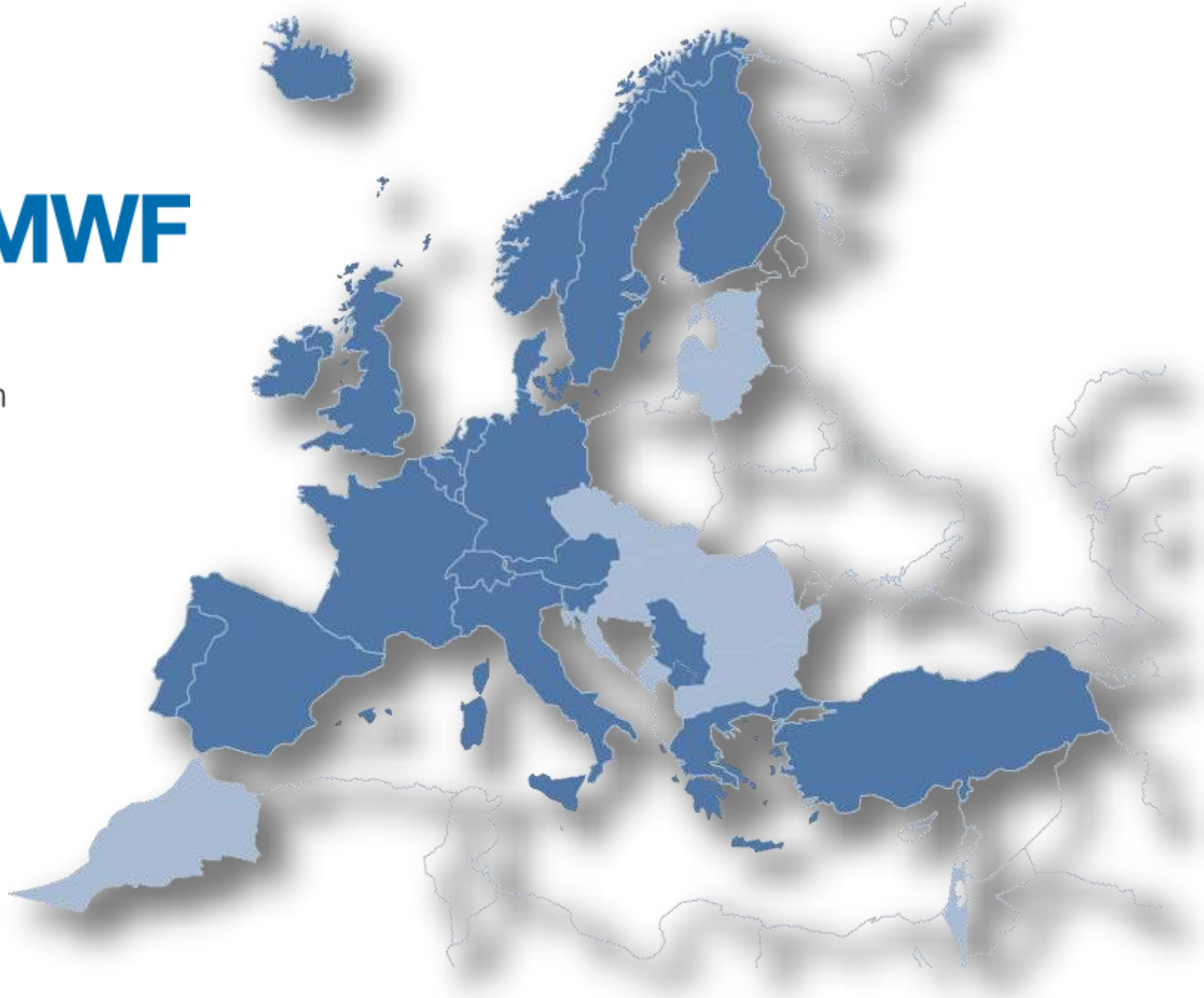
40 YEARS

of Advancing
Global Numerical
Weather Prediction



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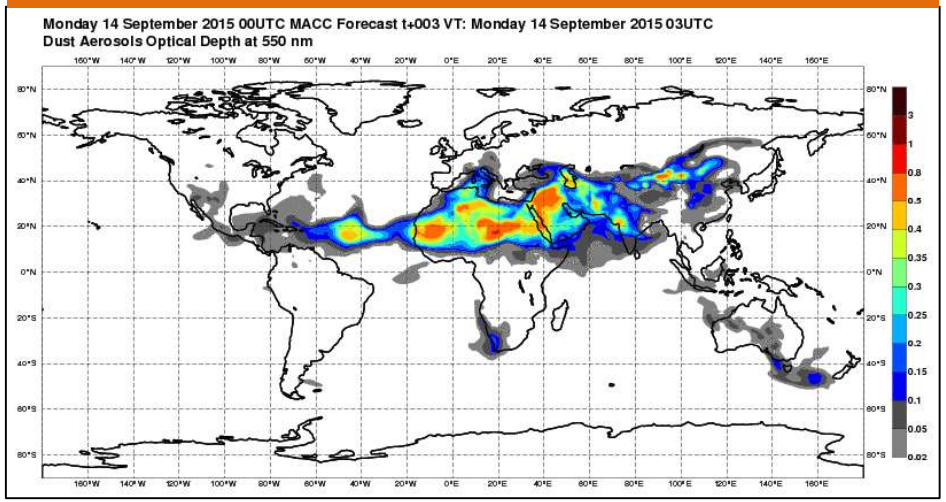
40 YEARS

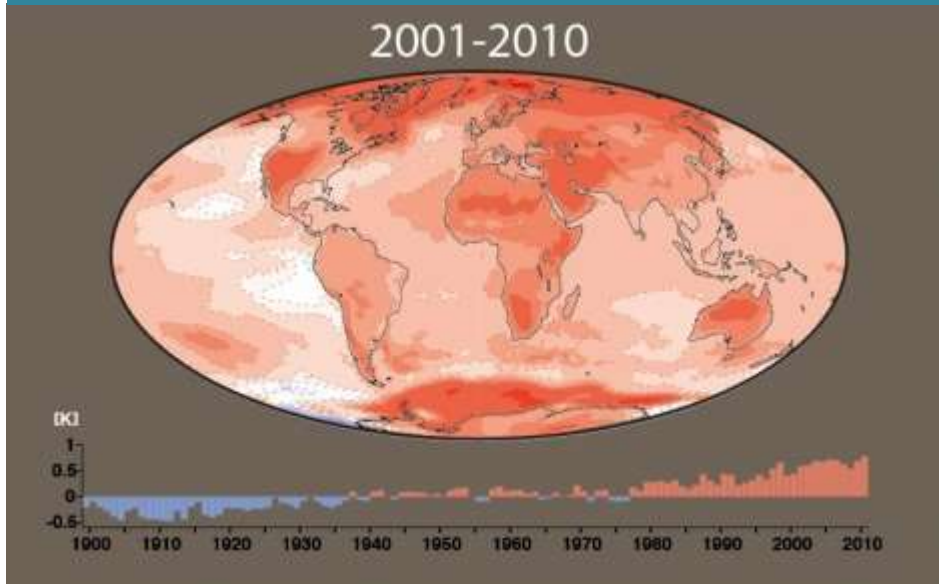
of Advancing
Global Numerical
Weather Prediction

opernicus
Europe's eyes on Earth

ATMOSPHERE MONITORING SERVICE



CLIMATE CHANGE SERVICE



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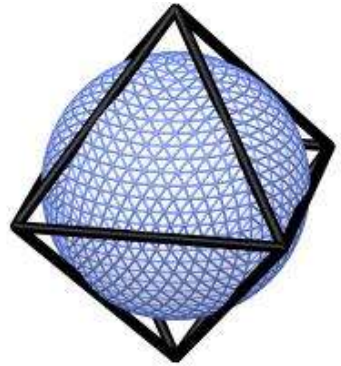
The operational forecasting system 2015

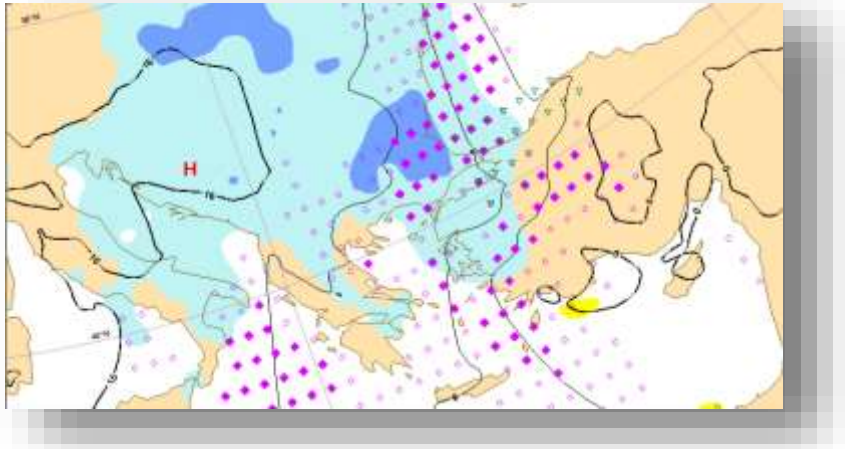
9 km ←
- High resolution forecast (HRES): twice per day
  16 km 137-level, to 10 days ahead

18/36 km ←
- Ensemble forecast (ENS): twice per day
  51 members, 32/64 km 91-level, to 15 days ahead

36 km ←
- Monthly ENS extension: twice a week (Mon/Thursdays)
  51 members, 64 km 62 levels, to 46 days ahead

- Seasonal forecast (SEAS): once a month (coupled to ocean model)
  41 members, 80 km 91 levels, to 7 months ahead
- Ocean wave forecasts (HRES, ENS and SEAS)
- Re-forecasts for calibration of ENS and SEAS
- Reanalyses for atmosphere and oceans





Upcoming resolution upgrade (spring 2016)

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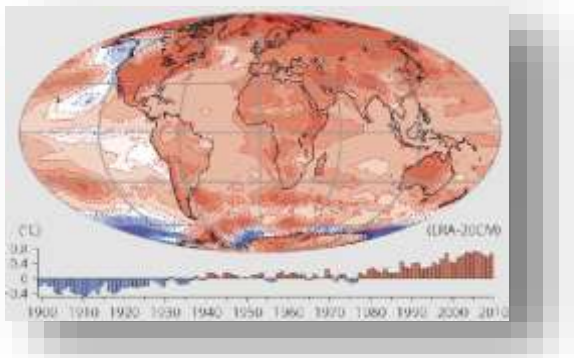
ECMWF planned reanalysis productions and data volumes

data
from different
observing
systems

consistent view
of global climate



Reanalysis productions	2014	2015	2016	2017	2018	2019
ERA-Interim **ERA-Interim/Land**	1979–NRT, 79km resolution				50Tb	
ERA-20C **ERA-20CM** **ERA-20C/Land**	20th-century atmospheric reanalysis 1900–2010, 125km resolution				300Tb	
ERA5 **ERA5/Land**		ERA-Interim successor 1979–NRT, 31km resolution				1.5Pb
CERA-20C **CERA-20C/Carbon**			20th-century atmos / ocean reanalysis 1900-2010, 125km/1x1		5Pb	
ERA6 **ERA6/Carbon**				ERA5 successor coupled with ocean?		10Pb

Source: Dick Dee

opernicus Climate Change Service (C3S)

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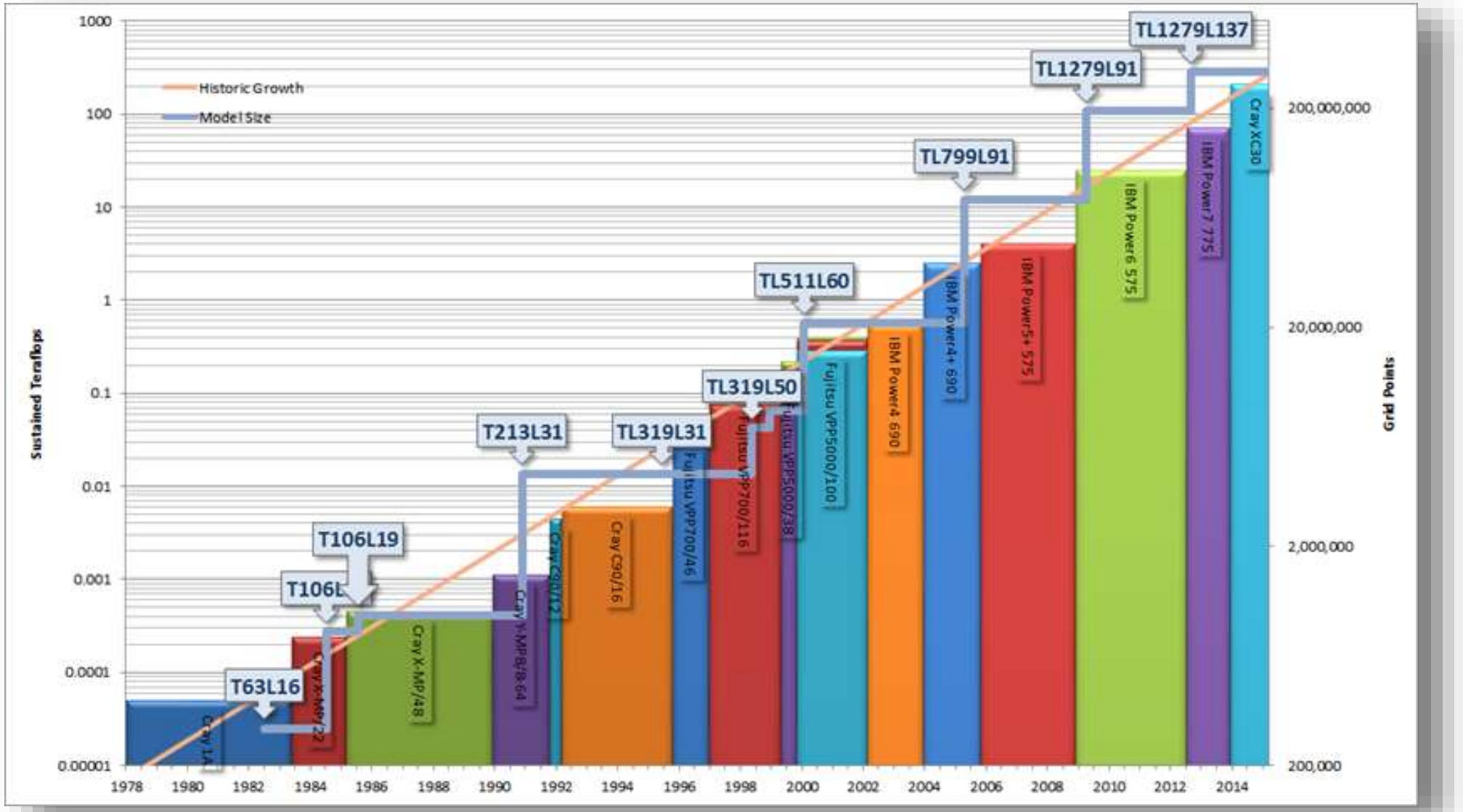
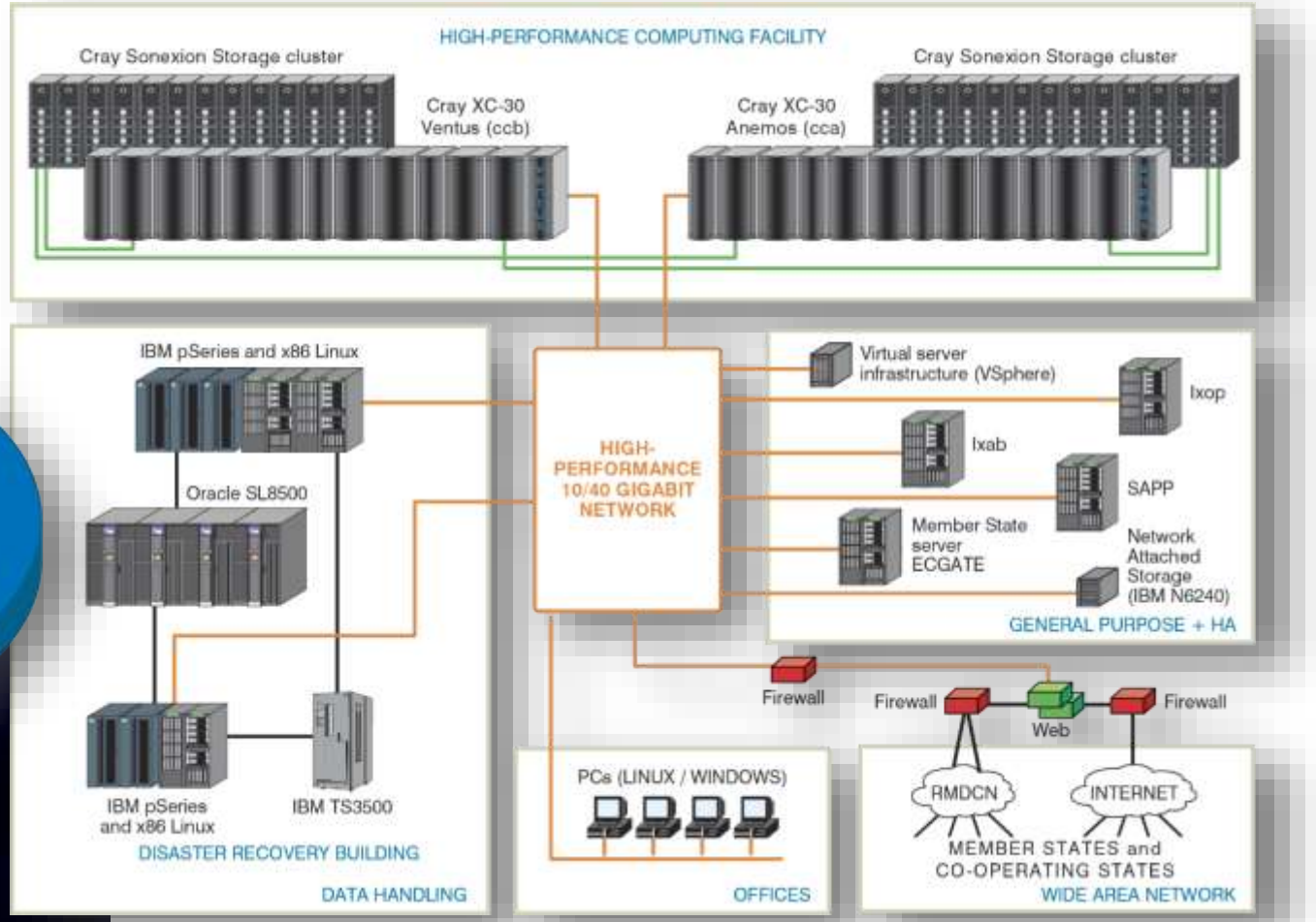
ERA CLIM → ERA CLIM 2

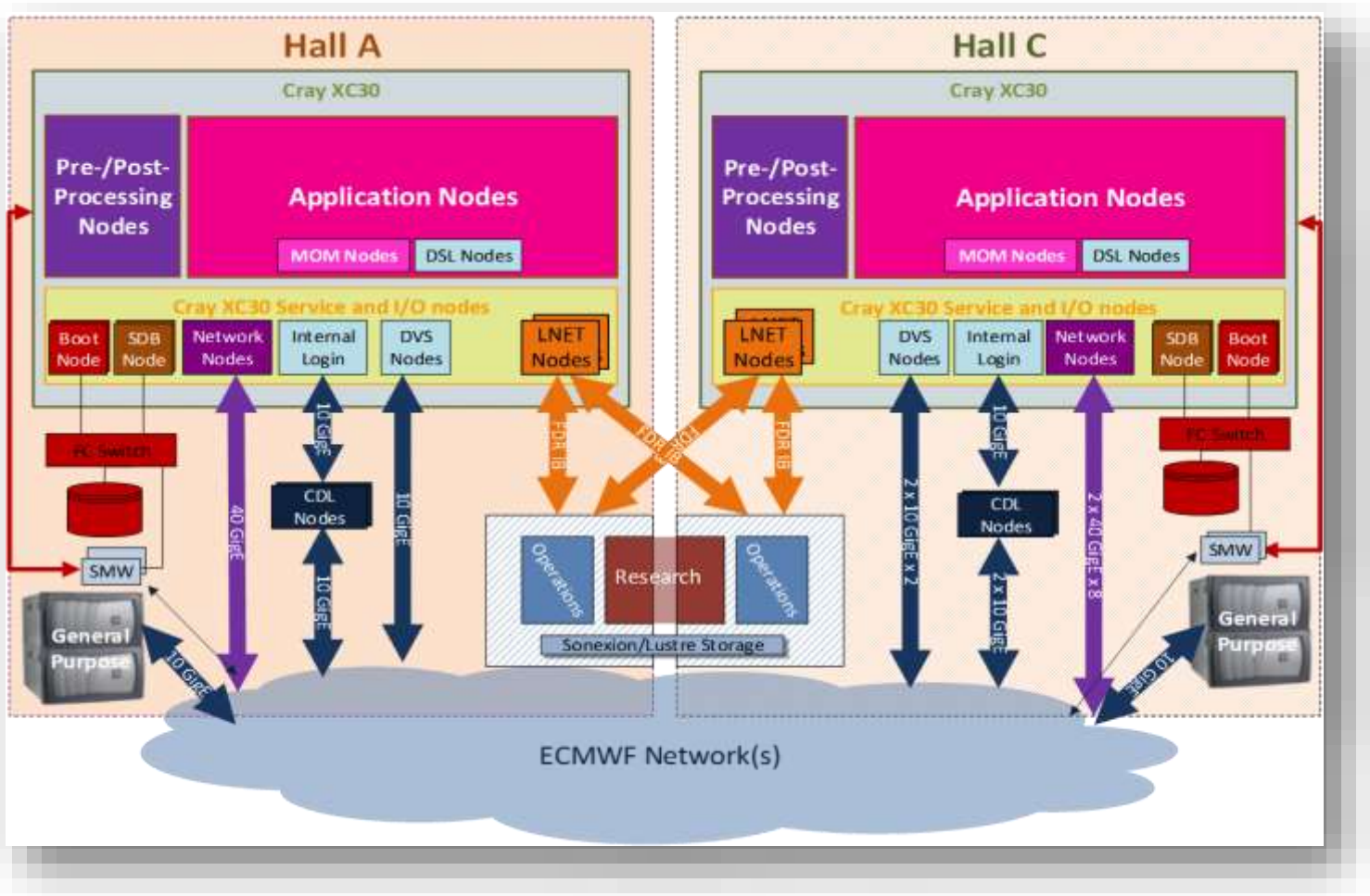
Evolution of model resolution and HPC sustained performance



ECMWF's High Performance Computing Facility



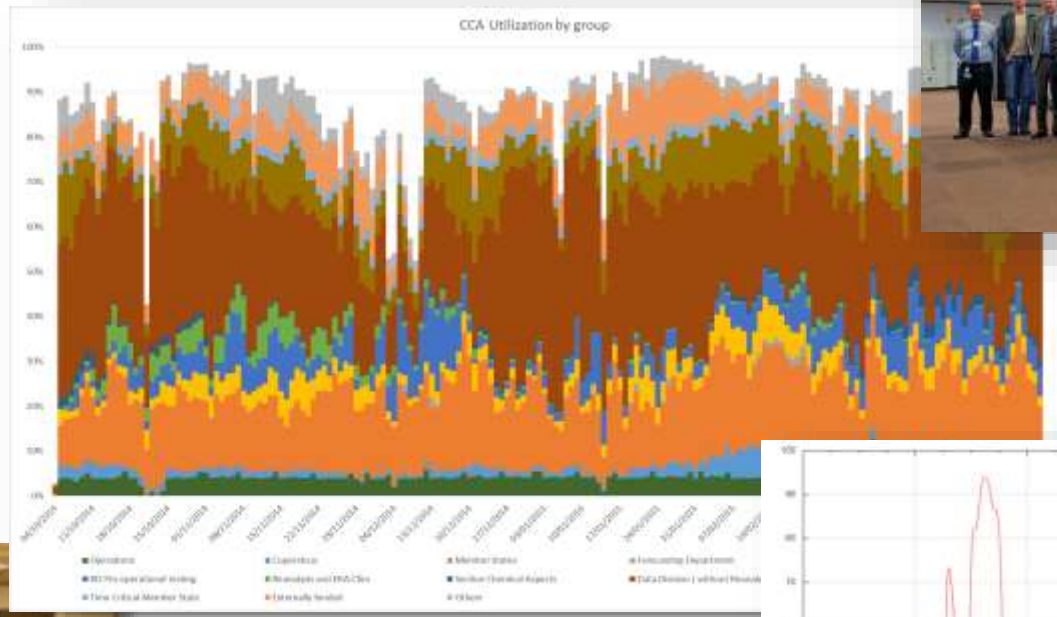
HPCF Configuration – Cray XC-30

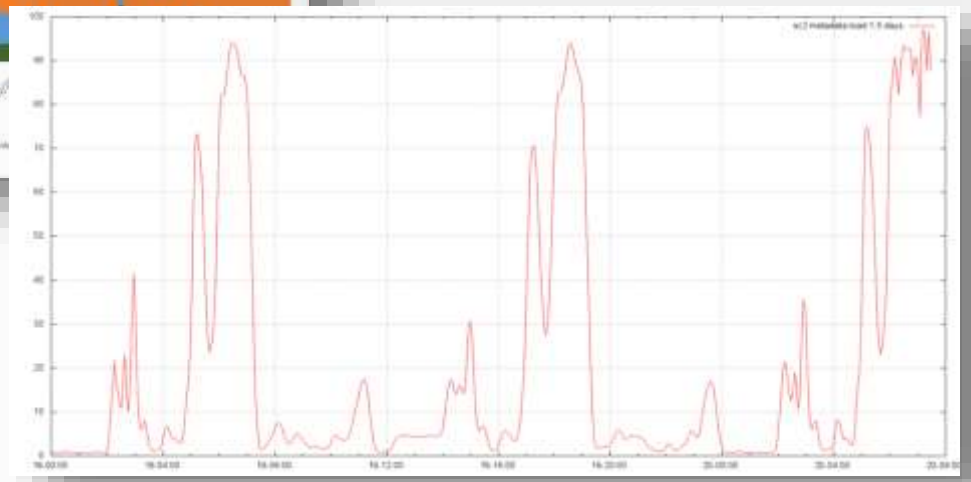


Compute clusters	2
Sustained performance on ECMWF codes (teraflops)	200
EACH COMPUTE CLUSTER	
Parallel Compute nodes	3,400
Pre-/Post-processing	100
Compute cores	84,000
High Performance Parallel Storage (petabytes)	7
General-purpose storage (terabytes)	38
EACH COMPUTE NODE	
Memory in compute node (gibibytes)	64 (60 x 128, 4 x 256)
Processor type	Intel E5-2697v2 “Ivy Bridge”
CPU chips per node	2
Cores per CPU chip	12
Clock frequency (gigahertz)	2.7

Migration to the new HPC

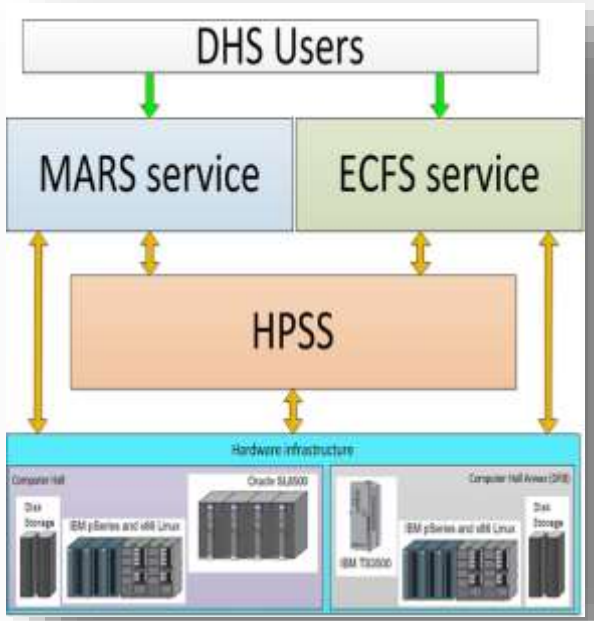
- Installation
- Acceptance
- Applications
- Scheduling
- I/O performance
- Service availability
- Support

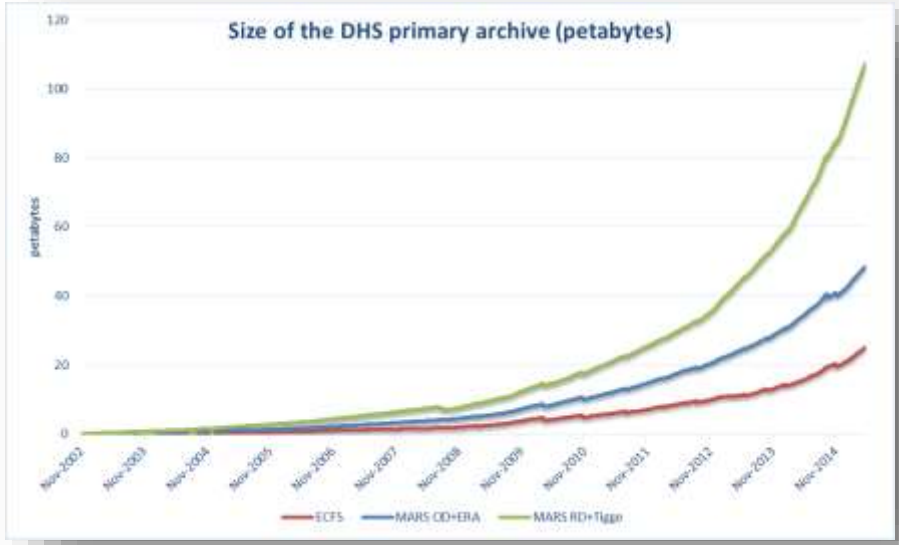




Data Archive

- Data archival and retrieval system for all ECMWF data
  - 123PB primary data (Sept 2015)
  - Adding ~135TB/day
- Large meteorological archive
  - Direct access from Member States
  - Available to research community worldwide
- User access via ECMWF developed applications
  - MARS – Meteorological Archival and Retrieval System
    - Access via “meteorological terms”, e.g. fields
  - ECFS – ECMWF Common File System
    - File based access for non-meteorological data





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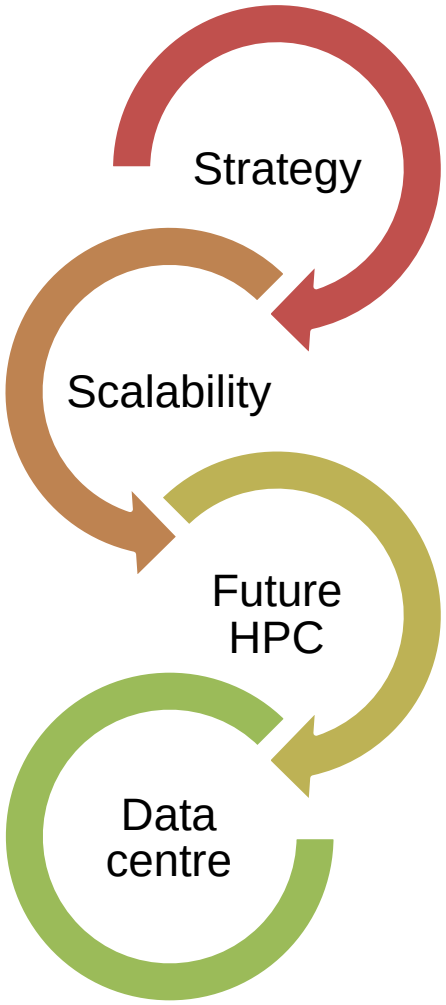
Challenges?



What is the challenge?

Today:

	Observations	Models
Volume	20 million = **2 x 10^7**	5 million grid points 100 levels 10 prognostic variables = **5 x 10^9**
Type	98% from 60 different satellite instruments	physical parameters of atmosphere, waves, ocean

Tomorrow:

	Observations	Models
Volume	200 million = **2 x 10^8**	500 million grid points 200 levels 100 prognostic variables = **1 x 10^{13}**
Type	98% from 80 different satellite instruments	physical and chemical parameters of atmosphere, waves, ocean, ice, vegetation

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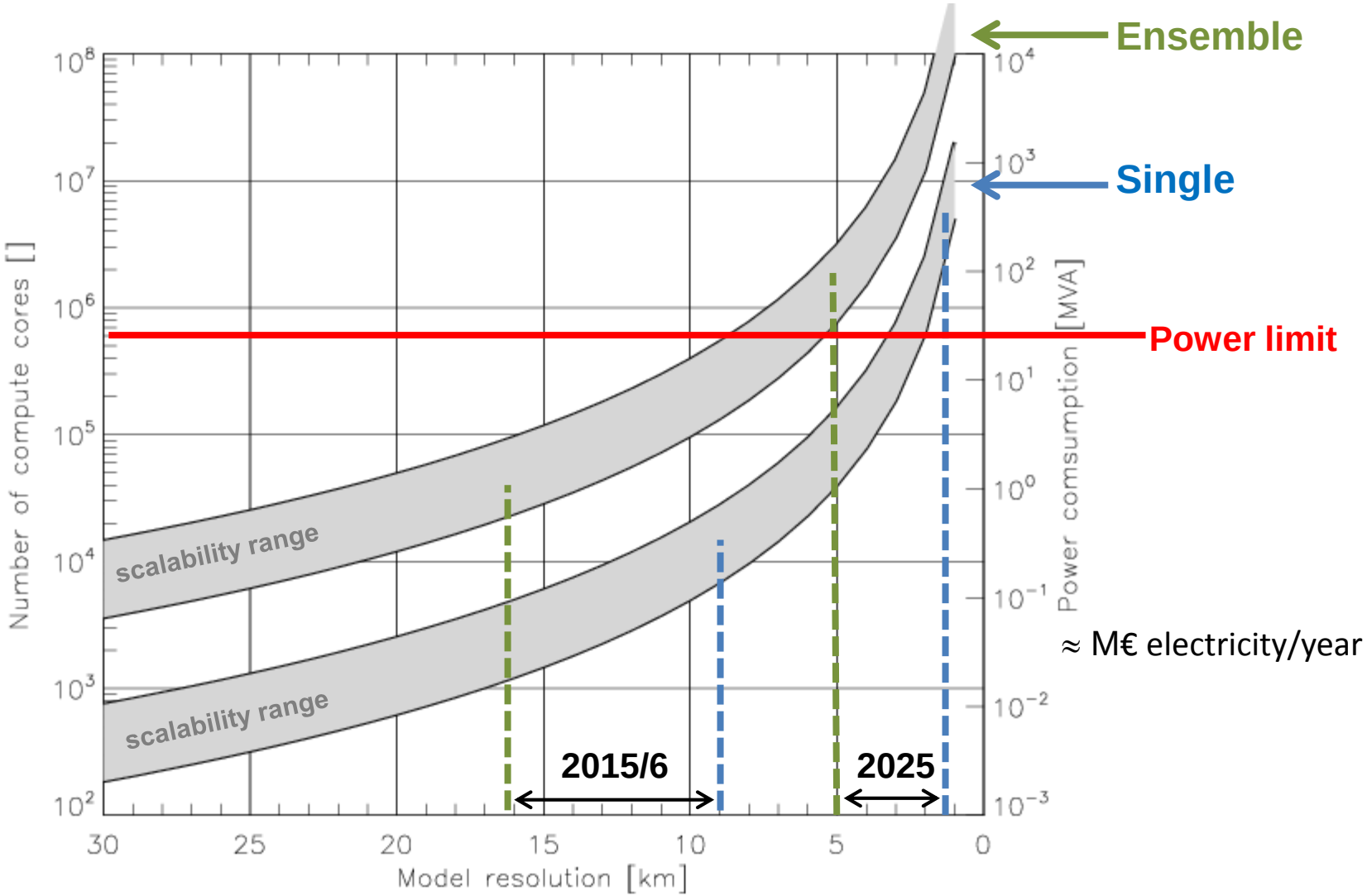
Factor 10 per day

Factor 2000 per time step

Future HPC requirements and Scalability



≈ M€ electricity/year

Source: Peter Bauer

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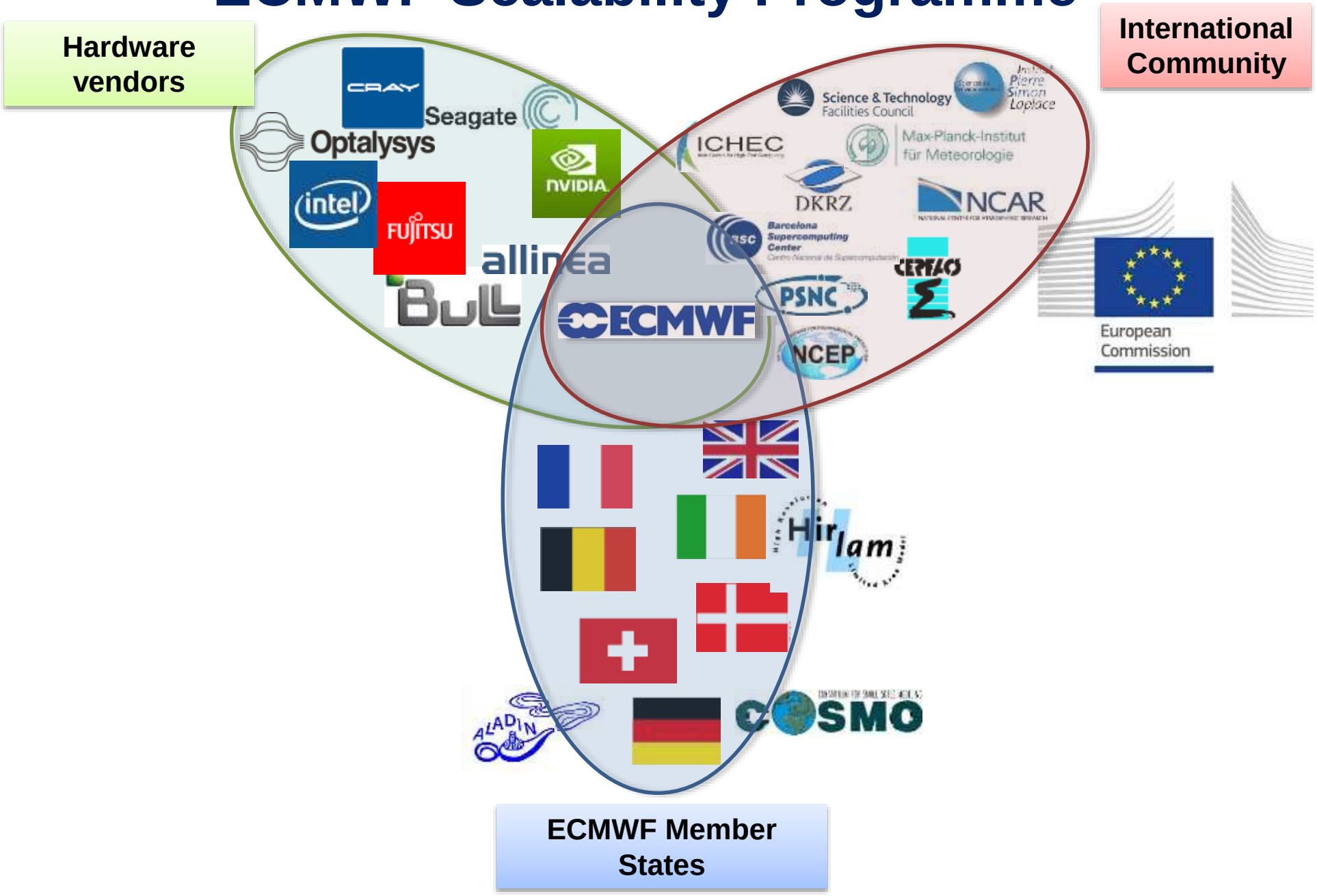
ECMWF Scalability Programme



ECMWF Scalability Programme

Board:

ECMWF, NHMS's, Regional consortia

Projects:

Observation processing (COPE)

Data assimilation (OOPS)

Numerical methods (Polymitos)

Model output Processing (Hermes)

IFS code adaptation (OAFS)

ESCAPE

ESiWACE

NextGO

Earth server2

Computer architecture support (CAS)

ECMWF

the science of weather prediction