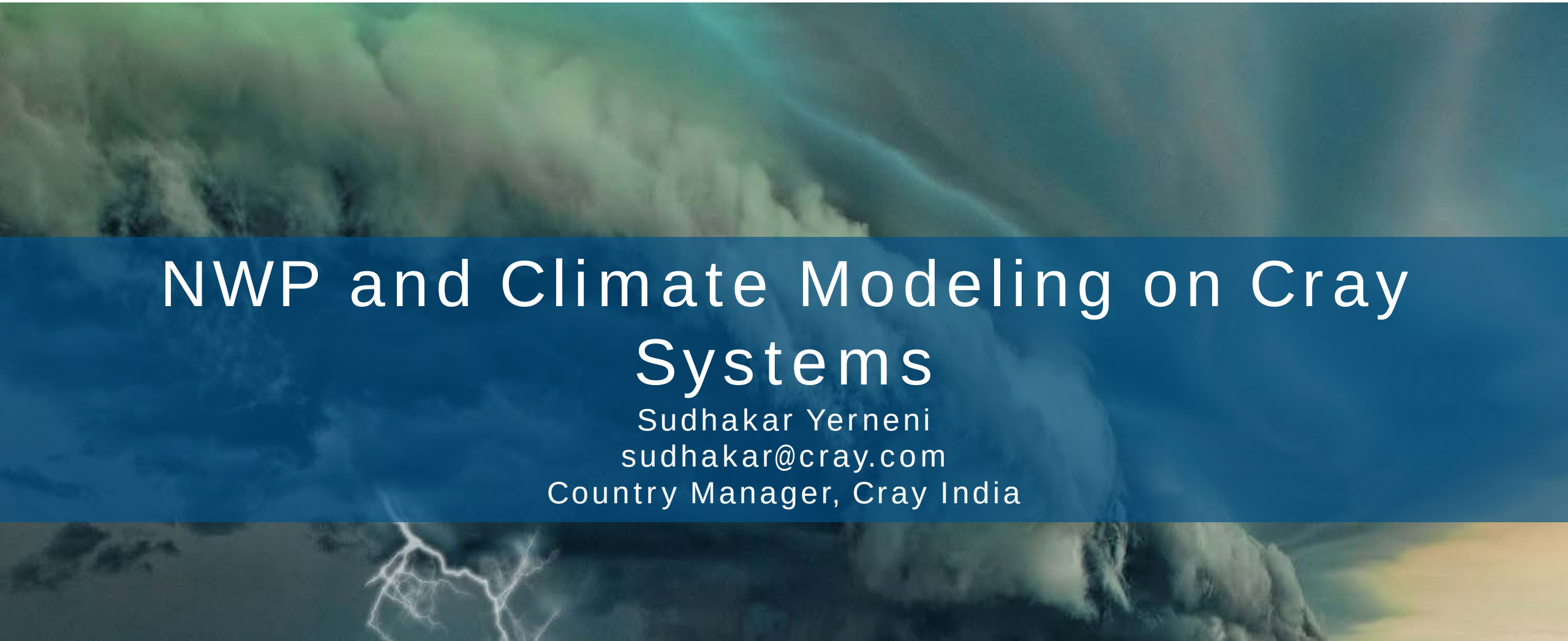

COMPUTE | STORE | ANALYZE

NWP and Climate Modeling on Cray Systems

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The Earth Sciences Community

Use-case and Technology Drivers

- Increasing emphasis on maximizing the benefits of improved predictability across society and economy:
  - Application of meteorological data to a broad range of services and stakeholders
- High-resolution numerical weather prediction and earth system climate modeling are grand challenge problems.
- The ability to perform weather and climate simulations at a range of spatial and temporal scales is critical:
  - Results in exponential increases in computational and storage and data management needs
- As infrastructures grow in size and complexity maintaining both reliability and usability becomes more challenging.
- Emerging analytical approaches to enable predictive modeling and knowledge discovery.

Cray Solutions for the Earth Sciences

Why Cray ?

- Cray's solutions enable a broader and more detailed range of meteorological services and products
  - Advanced modeling capabilities
  - Shortened research to operations
- Experience delivering and operating world's largest and most complex systems
- Emphasis on total cost of ownership – power, upgradability and efficiency
- Commitment to long-term partnerships delivering significant ongoing value to our customers.

Market Presence

- Broad presence across NWP and climate communities:
  - From Terascale to Petascale
  - Research and operational environments
  - Model development platforms for extreme scale architectures

Met Office

Model Configuration

Global Model: UM N768 (~17km) L70
- 6 day twice daily, 2 day twice daily
- Data Assimilation: 4D-VAR

Global Ensembles: N400 (~33km) L70 12 mem.
- 7 day, 4 daily
- Data Assimilation: 4D-EnVAR

Other models (subset)
- UK HighRes: 1.5km, 36h 8x daily
- UK Ensembles: 2.2km, 12m, 36h, 4/day

Outlook:
- Further upgrades as Phase 1b Cray systems enter operations

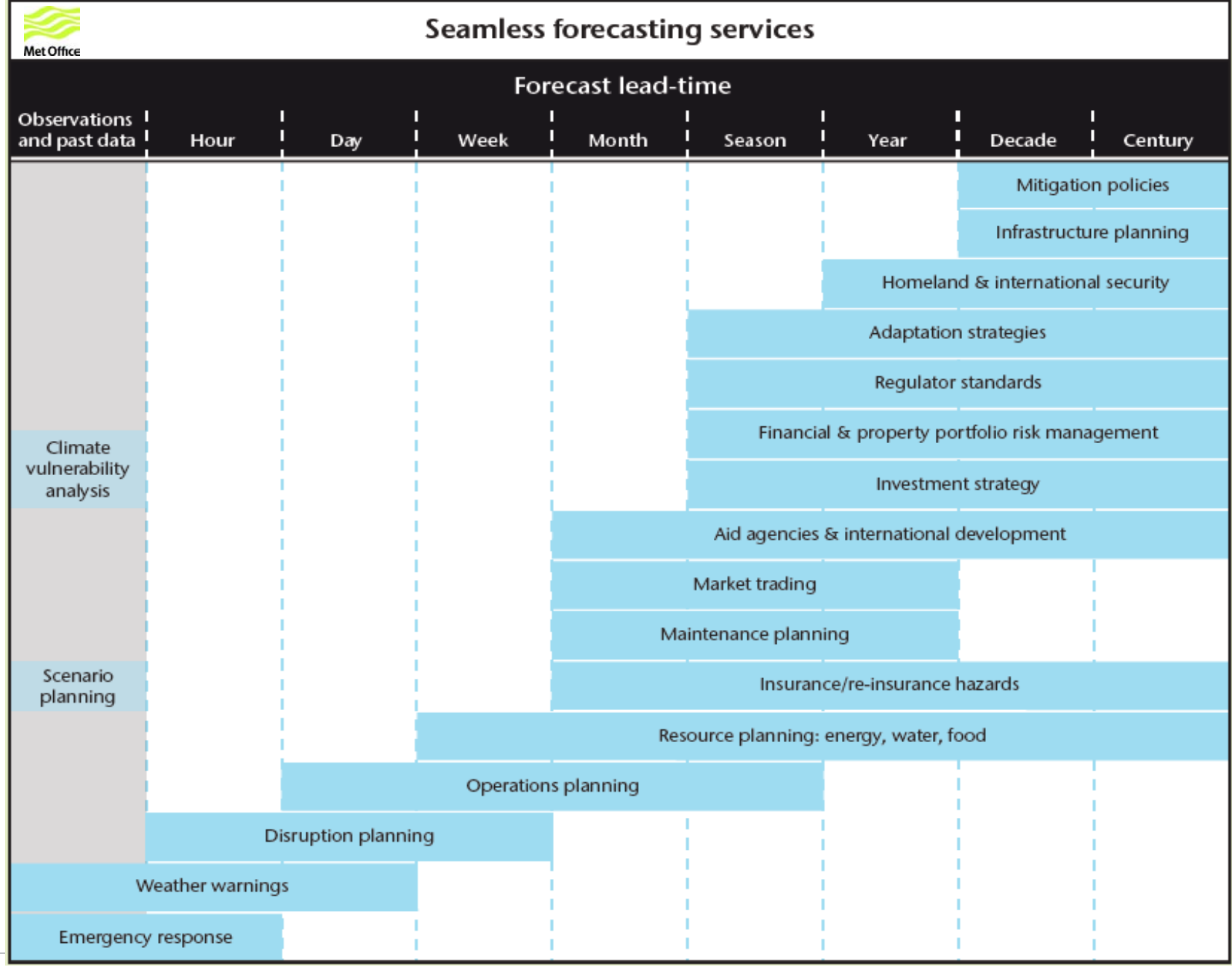
System Overview

- Dual Cray XC – Phase 1a
  - Details not public yet, Haswell
- Equivalent performance to IBM P7
- Operational August 2015
- Approx 11PB of Cray Sonexion
- Phase 1b: 2016
  - Addition of Broadwell
  - Combined 1ab >6x sustained

Trend Towards Seamless Forecasting

- Across timescales and resolution
- Diverse set of audiences and stakeholders
- Driving use and capability of HPC resources

- Enabled By Cray Supercomputing Systems



European Centre for Medium-Range Weather Forecasting

"Ventus"

Anemos"

Model Configuration

Global Model: IFS T1279 (~16km) L137
- 10 day, twice daily
- Data Assimilation: 4D-VAR

Global Ensembles: T639 (~32km) L91 51 mem.
- 15 day, twice daily (64km beyond day 10)
- Data Assimilation: 4D-EnVAR

Other models
- Extended 46 day ensembles (weekly)
- Seasonal forecasts monthly/quarterly

Outlook:
- Mid-2016: Upgrade to 9km (global) 18km (ensembles)

System Overview

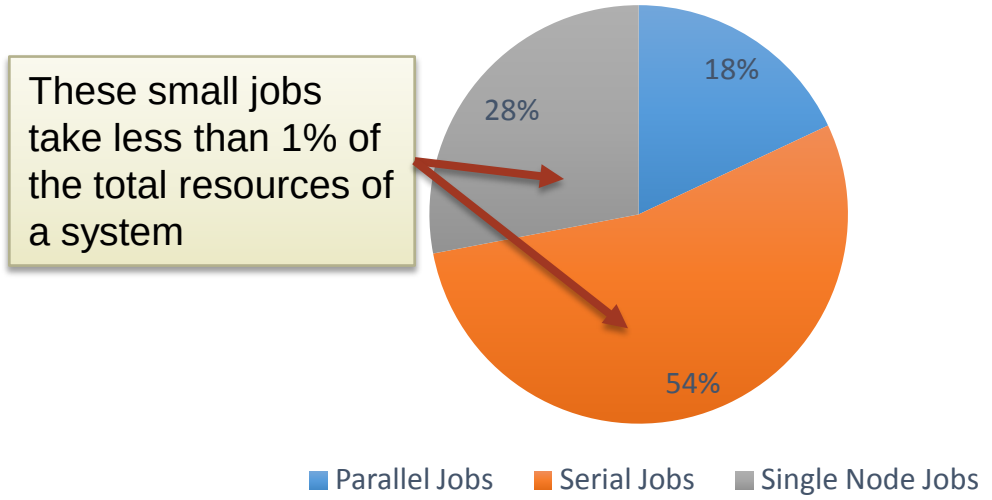
- Dual Cray XCs – "Ventus" & "Anemos":
  - Each 3505 nodes (Ivy Bridge)
  - 3.6 Petaflop peak
- Cray Sonexion Lustre Storage
  - ~12PB capacity
  - ~500GB/s bandwidth
- ~50PB archive (growing rapidly)
- Operational September 2014

A Day In the Life of Anemos

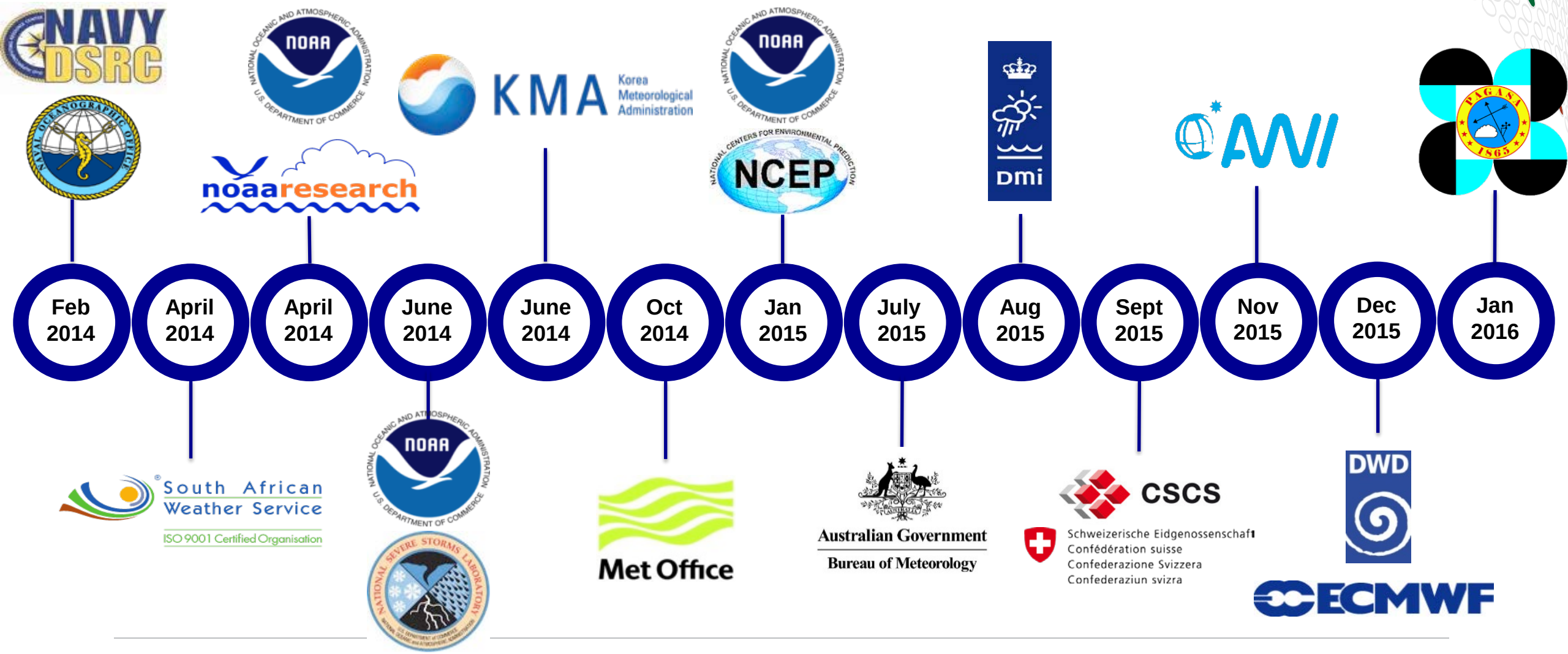
What ?	How Many?
Total Jobs	217,118 per day
Parallel Jobs	39,081
Single Node Jobs	60,793
Single Core Jobs	117,244

Source:
http://www.ecmwf.int/en/computing/our-facilities/supercomputer

ECMWF Daily Job Distribution



Cray Growth in Weather, Climate and Oceanography over the Last Two Years



Summary

- **Cray is platform of choice for leading weather, climate and ocean modeling centers:**
  - Delivering high performance, efficiency, & reliability
  - Enabling unprecedented simulations
  - Supporting the development of next generation modeling capabilities
  - Key community within Cray's customer base