

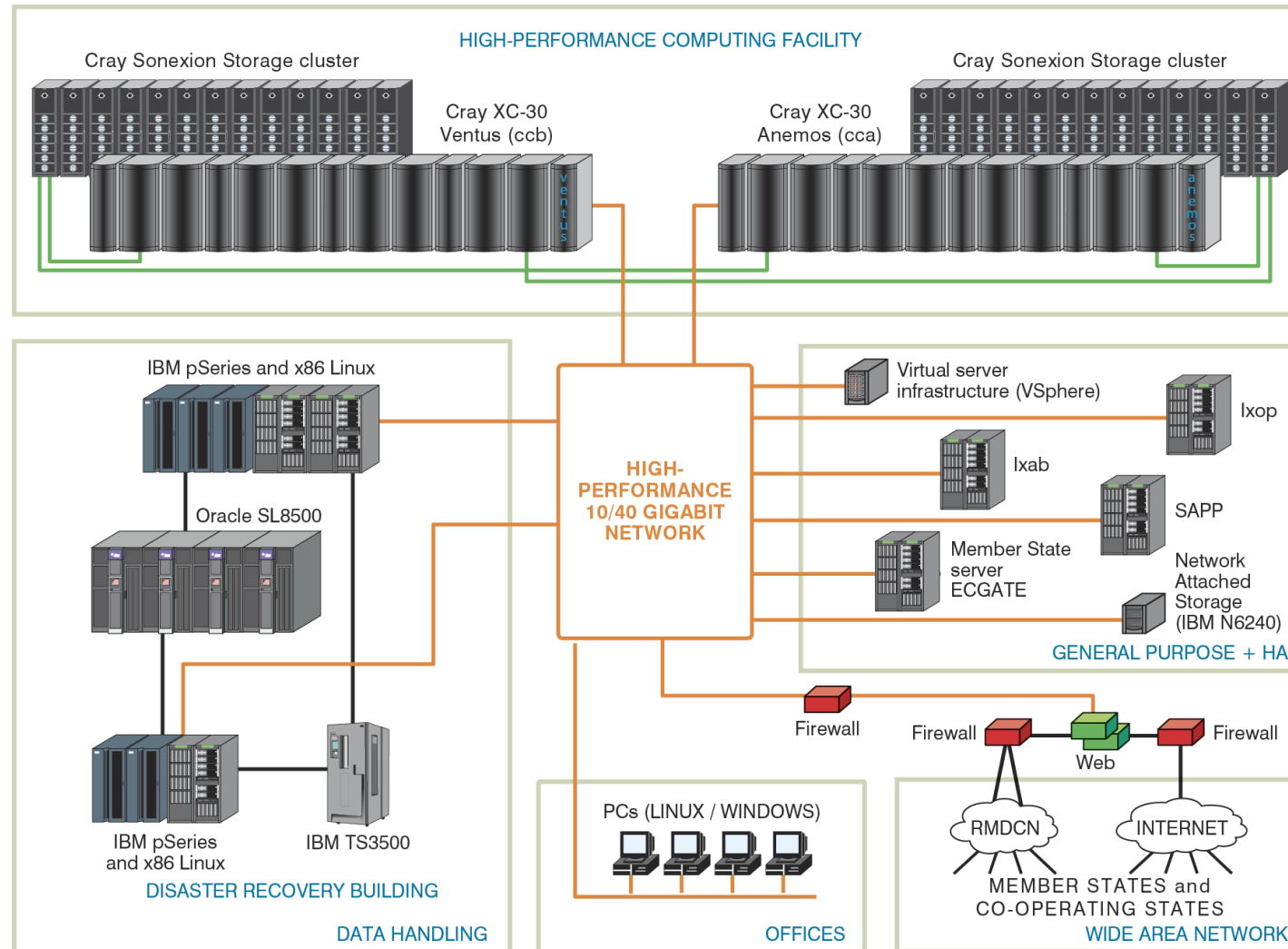
ECMWF: software, services, products and model developments

Enrico Fucile

ECMWF, Shinfield Park, RG2 9AX, Reading, UK



High Performance Computing Facility



High Performance Computing: Cray XC30

We had to say goodbye to the IBM and welcomed the Cray!



Operations moved to the Cray	17 September 2014
End of service of IBM	30 September 2014

CRAY configuration

	IBM Power7	Cray XC30
Sustained performance	~70 teraflops	~ 210 teraflops
Peak performance	~1500 teraflops	~3500 teraflops
Compute clusters	2	2
Each compute cluster		
Compute nodes	739	~3,500
Compute cores	23,648	~84,000
Cores per node/CPUs per node	32/64	24/48
Total memory (TiB)	46	~210
Pre-/post-processing nodes	20	~64
Operating System	AIX 7.1	SUSE Linux/CLE
Scheduler	IBM LoadLeveler	Altair PBSpro/ALPS
Interconnect	IBM HFI	Cray Aries
Each storage system		
High performance storage (petabytes)	1.5	Over 3
Filesystem technology	GPFS	Lustre
General purpose storage (terabytes)	N/A	38
Filesystem technology	GPFS	NFS via NetApp FAS6240 filer

HPC Phase 2 upgrade

<https://software.ecmwf.int/wiki/display/UDOC/HPC+Phase+2+system>

The new HPCs has increased number of physical cores per node, ie from 24 to 36. The logical cores (with hyperthreading on) will change from 48 to 72.

Users will have to check the geometry of their jobs and adapt the relevant PBS directives (EC_nodes, EC_tasks_per_nodes, etc ...) to the new nodes.

Schedule of the upgrade

April-May 2016	User testing period
16 th to 22 nd May 2016 (TBC)	Outage CCB (to upgrade remaining nodes)
June 2016	CCB final configuration (~3500 Intel Broadwell nodes)
13 th to 20 th June 2016 (TBC)	Outage CCA
July 2016	Reliability testing

WEBINAR

"HPCF Cray phase 2 upgrade"

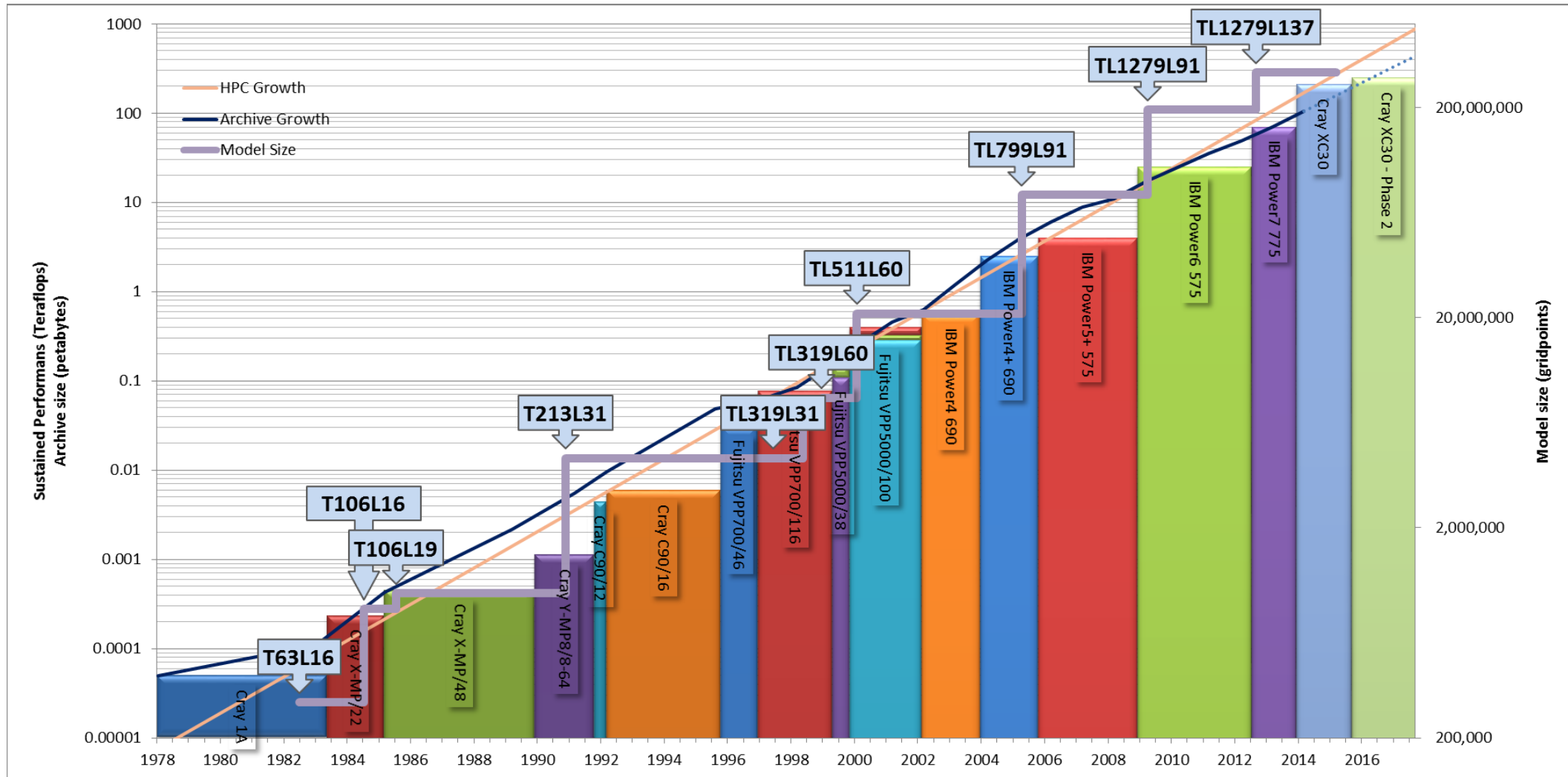
Tuesday, 12 April 2016, 8:00 UTC

If you are responsible for the migration of workload to the new system you are particularly invited to attend this webinar. Please register now at

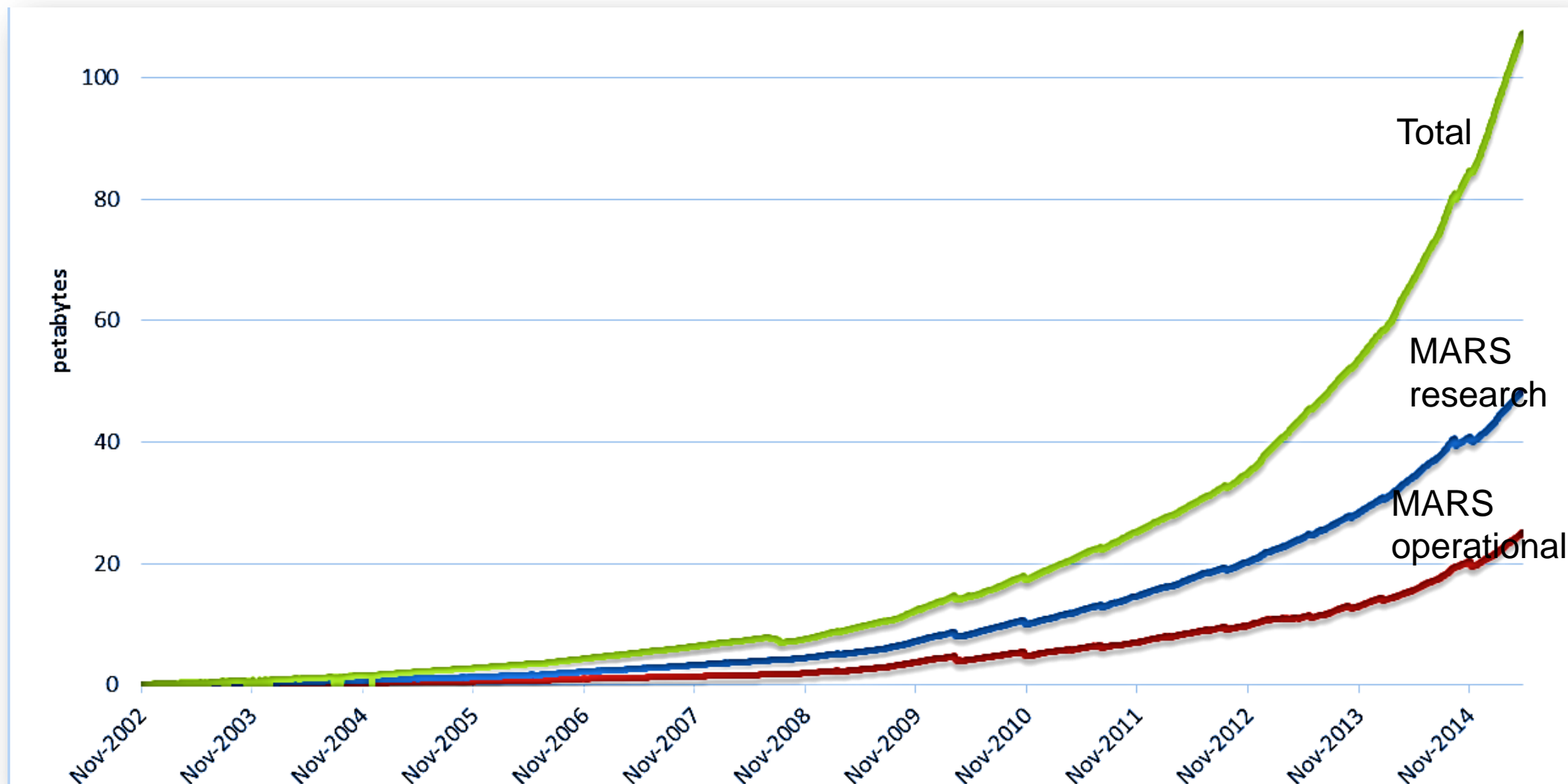
<https://ecmwf.webex.com/>

with the registration password "uscomp".

Growth of HPC sustained performance at ECMWF



Data archive exponential growth ...



ECMWF Services

The APPS

<http://apps.ecmwf.int/datasets/>

<http://apps.ecmwf.int/services/mars/catalogue/>

<http://eccharts.ecmwf.int/forecaster/>

<http://apps.ecmwf.int/codes/grib/param-db/>

<http://apps.ecmwf.int/codes/bufr/validator/>

COMPUTING:

HPC

ecgate

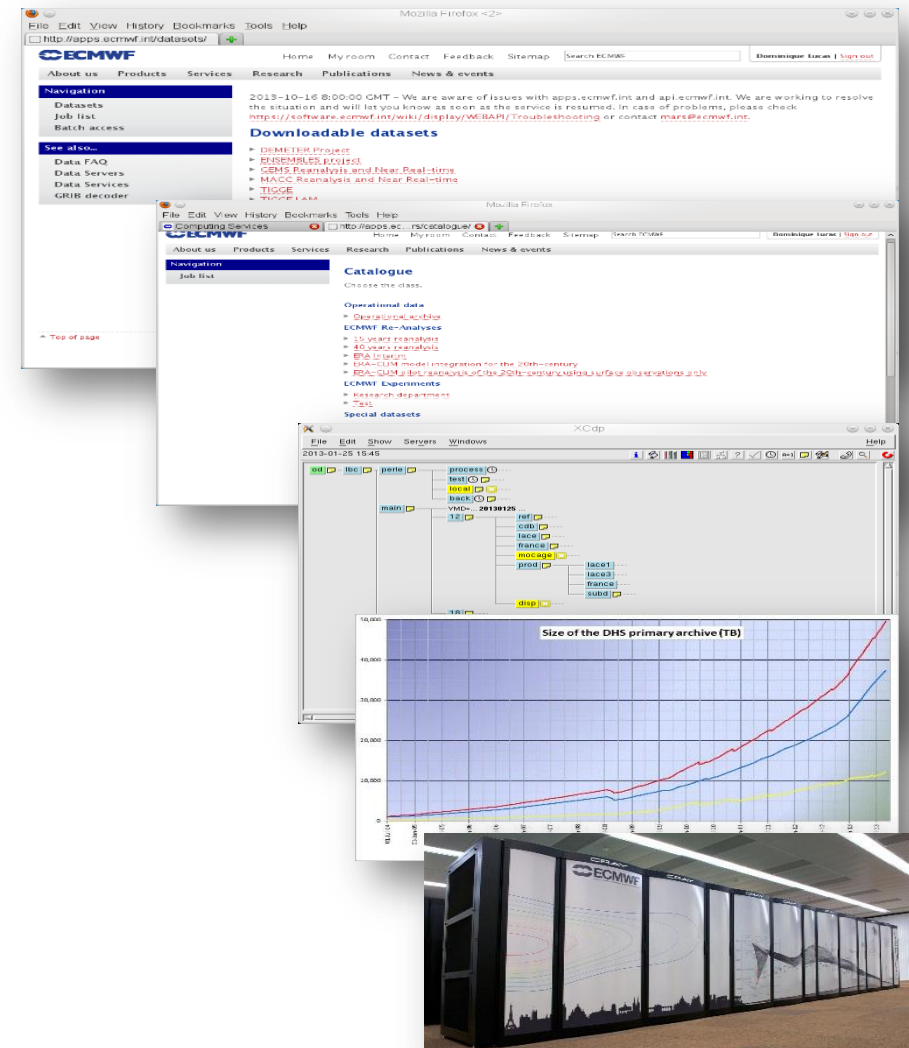
TIME-CRITICAL applications:

- ① Simple **job submission monitored** by ECMWF
- ② Member State **SMS suites monitored** by ECMWF
- ③ Member State **SMS suites managed** by ECMWF

DATA ARCHIVE (MARS)

Provision of BOUNDARY CONDITIONS

DISSEMINATION



Computing services: ecgate (Unix server)

- 12 compute nodes each with
 - 2 Intel Xeon processor (Sandy Bridge-EP):
 - 16 core at 2.7 GHz
 - 128 GB memory
 - 2 x 900 GB SAS HDD
- 6 I/O server nodes
 - ~172 TB raw disk space



Available to ~3000 users at more than 300 institutions

Operational status

Service status

Service Status

CCA		CCB		DISSEMINATION		ECACCESS	
ECFS		ECGATE		EFAS		EMAIL	
INTERNET		MARS		MSACCESS		preplFS	
RMDCN		TELEPHONY		WEB-SERVICES			

Notifications

<input type="text" value="Search"/>		date range: last 24h last 7 days last 30 days all		
Date Created	Service	Notification Type	Title	User Action Required
Wed 07/Jan/2015 14:37:27 UTC	ECFS	End	System Session complete - UPDATE: ECFS HPSS CORE server process restart	✓
Wed 07/Jan/2015 14:36:20 UTC	ECFS	In Progress	Clone of System Session - UPDATE: ECFS HPSS CORE server process	✓

<http://www.ecmwf.int/en/service-status>

Performance of services

To assess the performance of the services, ECMWF has a set of KPIs (Key Performance Indicator). They focus on:

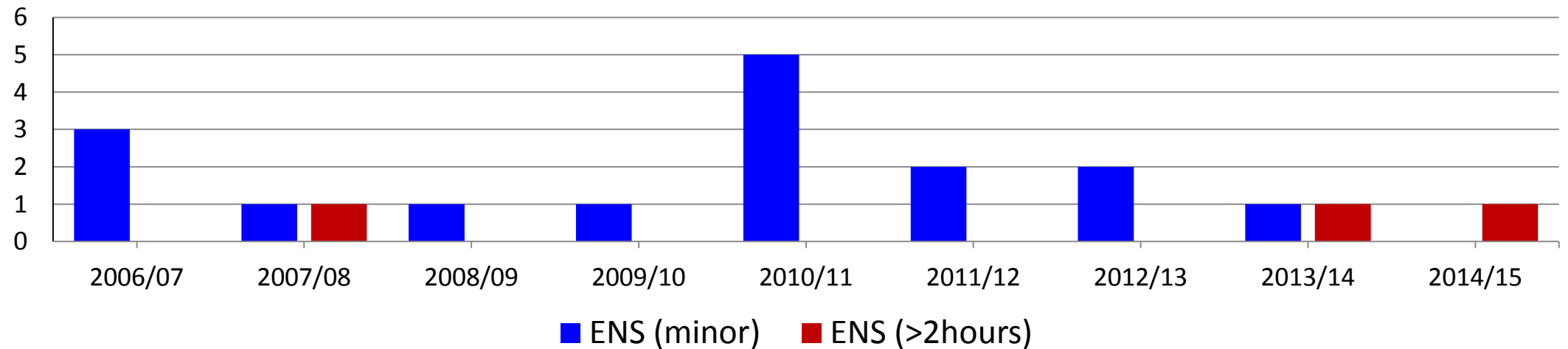
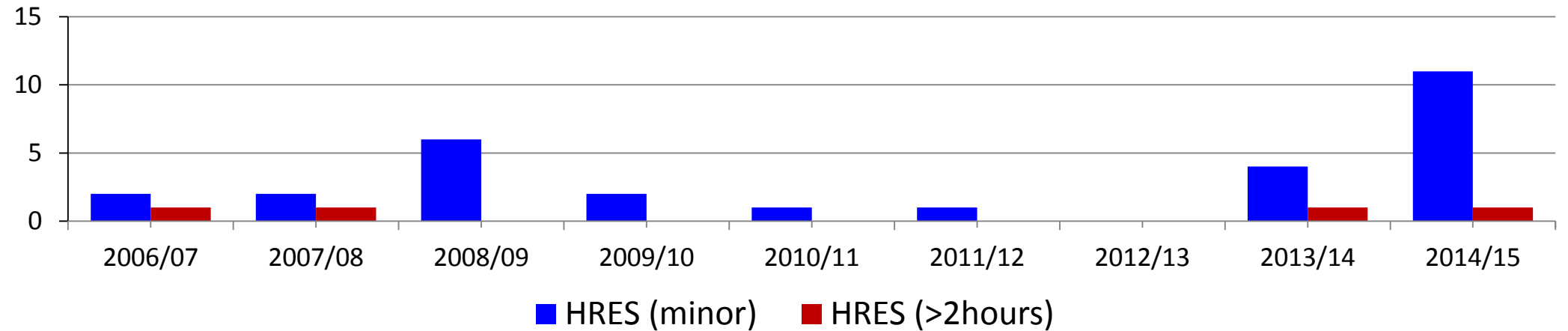
- Timeliness of forecast delivery

- Availability targets for HPCF and ecgate service

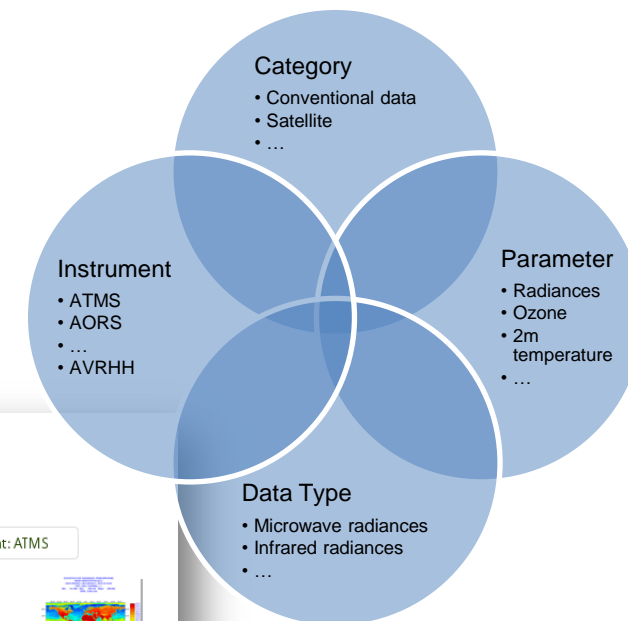
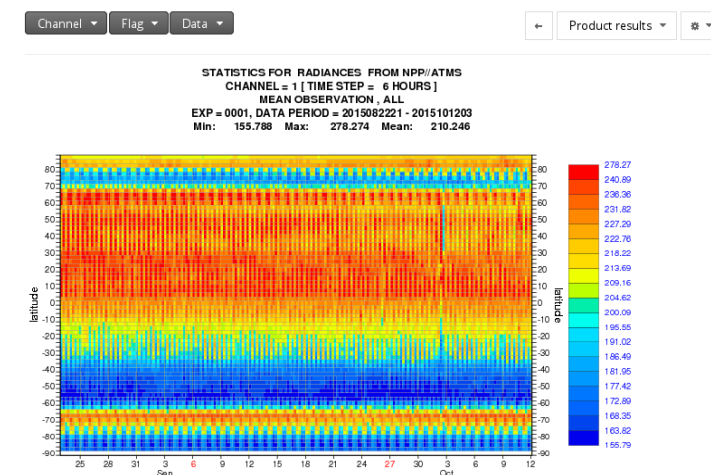
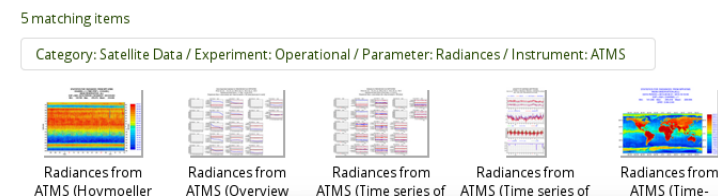
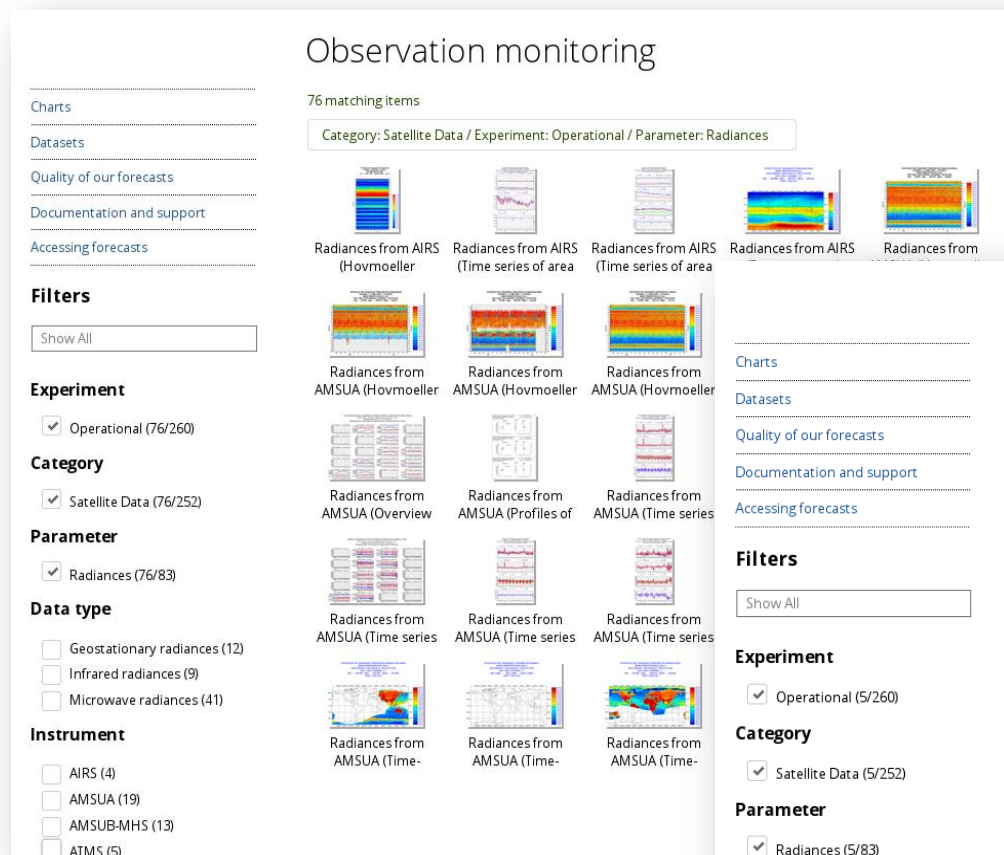
- Response time targets for Web service

- Service Levels for RMDCN service (network availability,..)

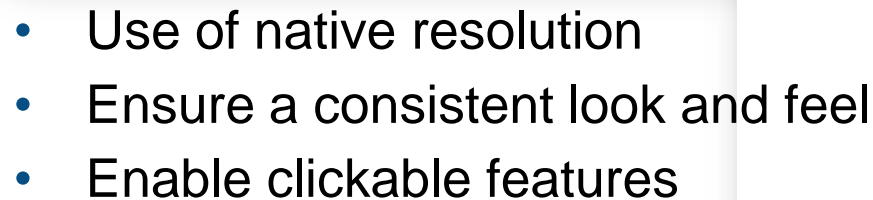
Timeliness of forecast delivery



Web services: faceted search



- Simplify the production of charts
- Ease the creation of new products
- Use ecCharts facilities



The chart navigator

Charts

Datasets

Quality of our forecasts

Documentation and support

Accessing forecasts

Filters

Show All

Product group

☐ Climagrams (5)

☐ Nino plumes (3)

☐ Spatial maps (10)

☐ Tropical storms (5)

Model

☒ ECMWF (23)

Type

☐ Forecasts (18)

☐ Forecasts (Public) (5)

Parameters

☐ 2m temperature (2)

☐ 500 hPa geopotential (1)

☐ 850 hPa temperature (1)

☐ MSLP (2)

☐ Precipitation (5)

☐ SST (2)

☐ Temperature (5)

Long range forecast

23 matching items

Model: ECMWF

ECMWF 2m temperature Public

ECMWF mean sea level pressure Public

Monsoon Indices

Nino plumes

Teleconnection Indices

Temperature area averages

ECMWF sea surface temperature

ECMWF 850 hPa temperature

Hurricanes Typhoon frequency

Tropical storm density anomaly

Quality of our forecasts

Documentation and support

Accessing forecasts

Filters

Show All

Product group

☐ Climagrams (5)

☐ Nino plumes (3)

☐ Spatial maps (10)

☐ Tropical storms (5)

Model

☒ ECMWF (23)

Type

☐ Forecasts (18)

☐ Forecasts (Public) (5)

Prob(most likely category of MSLP)

Forecast start reference is 01/07/15

Ensemble size = 51, climate size = 450

<---- below lower tercile

above upper

70..100%

60..70%

50..60%

40..50%

other

40..50%



ASO 2015

ECMWF 2m temperature Public

ECMWF 2m temperature (Public)

ECMWF mean sea level pressure Publ

ECMWF mean sea level pressure (Pub

ECMWF rain Public

ECMWF rain (Public)

ECMWF sea surface temperature Pub

ECMWF sea surface temperature (Put

ECMWF nino plumes (Public)

Forecast of Equatorial Pacific sea surf.

Monsoon Indices

monsoon.html

Nino plumes

Forecast of Equatorial Pacific sea surf.

Nino plumes (Annual range)

Forecast of Equatorial Pacific sea surf.

Precipitation area averages

temp_index.html

Sea Surface Temperature area averag

temp_index.html

Teleconnection Indices

< > VT: |

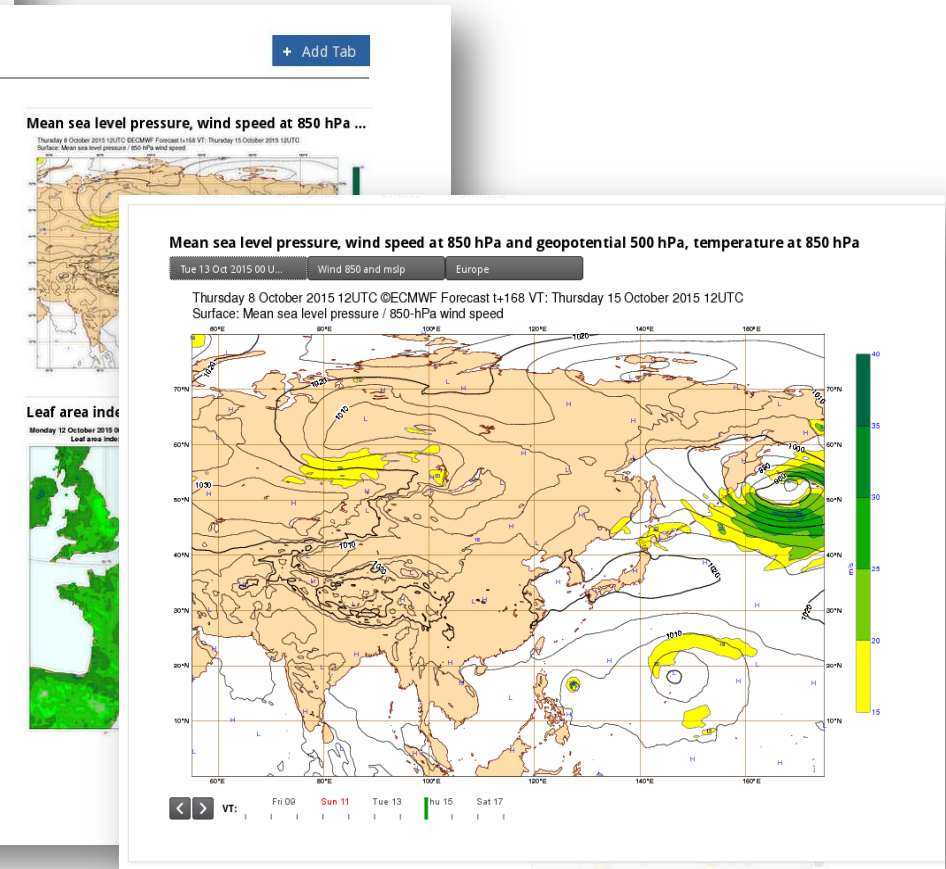
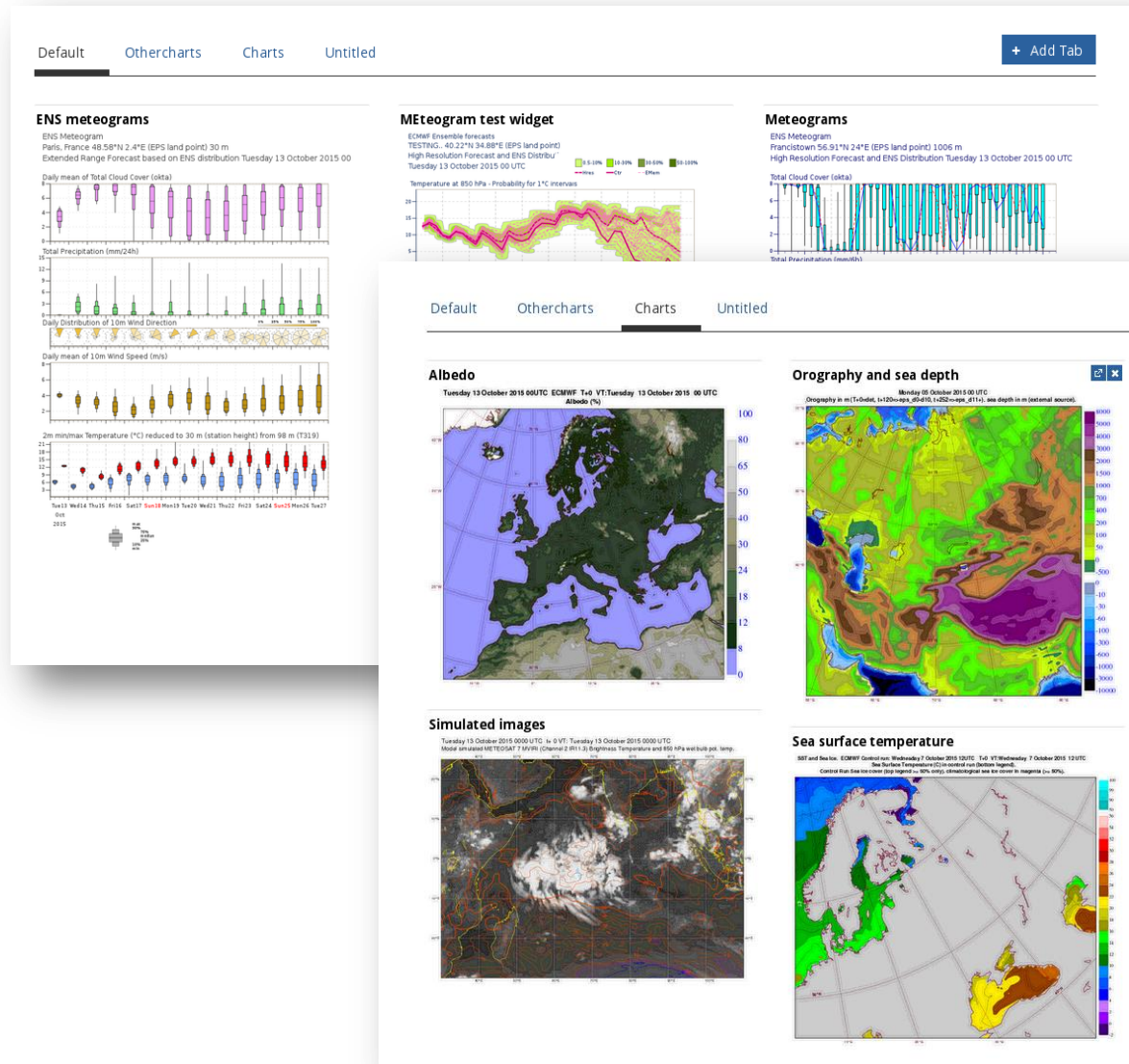
Nov/2015

▶

The dashboard

Allows forecasters to create their own working environment

Allows the caching of products



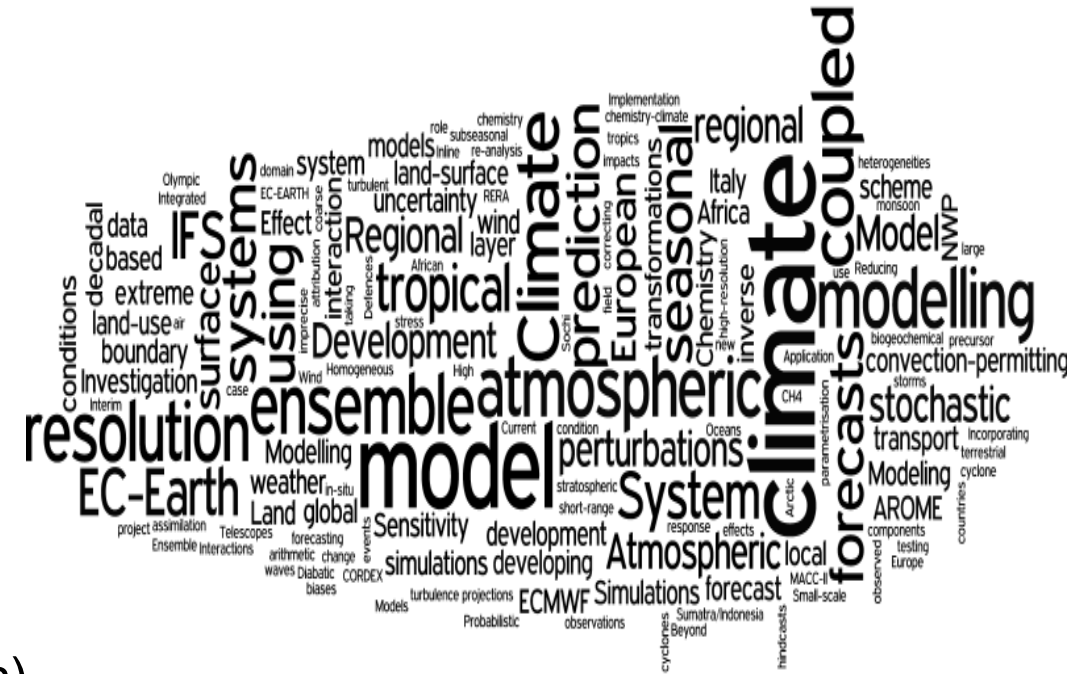
Special Projects

A maximum of 10% of the computing resources available to Member States may be allocated to Special Projects

For 2015:

HPCF: 545 million units (1 CPU hour = ~16 units)

Data Storage: 1440 terabytes



Applications from Co-operating States must be done via one of the ECMWF Member States

Forecast production

Operational cycles in May 2015 (Cy41r1) and March 2016 (Cy41r2)

ENS BC runs at 6 and 18UTC from July 2015

Cy41r2

- High resolution
 - HRES 9km
 - ENS 18km
 - Monthly forecast 18/36km
 - HRES-WAM 14km
 - ENS-WAM 28km
- ENS at same resolution up to day 15
- E-suite data on ecCharts

				anomaly correlation	RMS error	SEEPS
Europe	against analysis	Geopotential	100hPa			
			500hPa			
			850hPa			
			1000hPa			
		MSL pressure				
		Temperature	100hPa			
			500hPa			
			850hPa			
			1000hPa			
		Wind	200hPa			
			850hPa			
	against observations	Relative humidity	300hPa			
			700hPa			
		Temperature	100hPa			
			200hPa			
			850hPa			
		2m temperature				
		Wind	100hPa			
			200hPa			
			850hPa			
		10m wind				
		2m dew-point				
		Total cloud cover				
		24h precipitation				

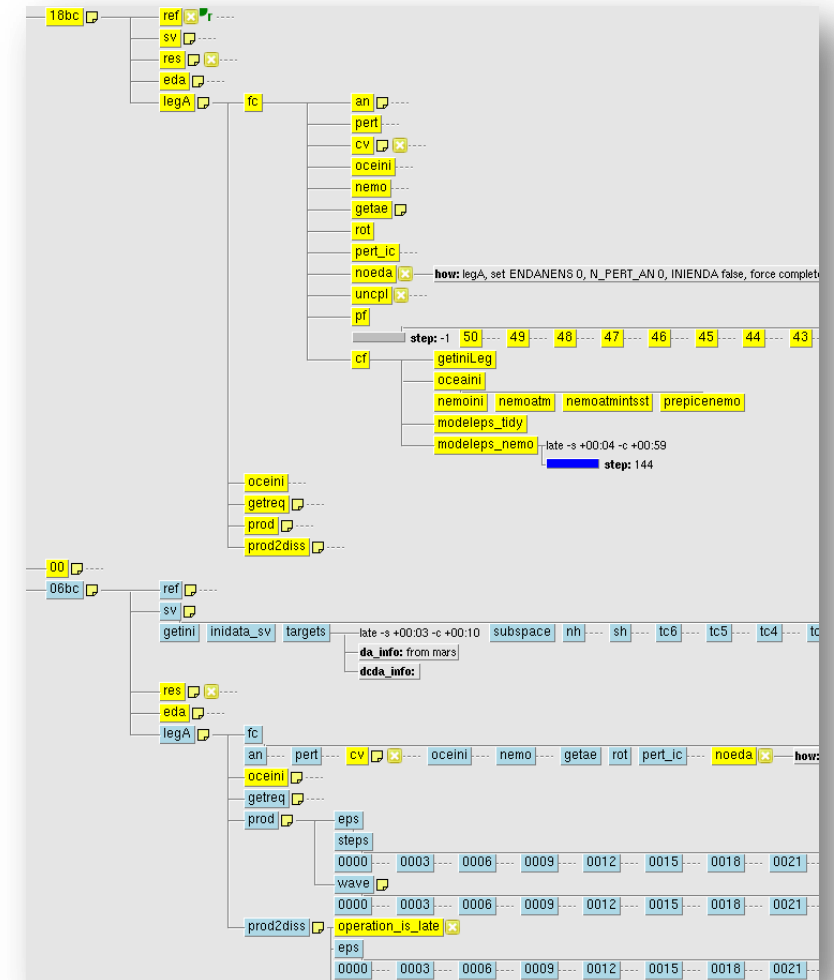
Boundary Condition optional programme

Ensemble products from the 00, 06, 12 and 18 UTC are available up to step 144 (3 hourly)

Products from the 4 cycles can be requested in Dissemination or retrieved from MARS

BC programme members can request the products via the standard channel:

<https://msaccess.ecmwf.int:9443/do/product/requirements>



ecFlowUI : modern and reliable interface

The image displays three overlapping screenshots of the ecFlowUI (4.1.0) interface, illustrating its modern and reliable design.

Left Screenshot: Shows the 'Tree' view of the workflow. The 'ecflow-metab' project is expanded, showing the 'ecflow' directory. The 'lxop_dev' directory is selected, displaying a list of tasks including 'module_sync', 'wipe_build', 'cct', 'ecgb', 'opensuse131', 'lxc', 'lxab', 'cca', 'ccb', 'eckit', and 'fdb'. The 'fdb' task is expanded, showing its sub-tasks: 'regenerate', 'lxop_dev', 'var_summary', 'git_srcs', 'make_build_dir', 'config', 'build', 'test', 'install', 'install_log', 'remove_write_perm', and 'module_sync'.

Middle Screenshot: Shows the 'Table' view of the workflow. The 'ecflow-metab' project is expanded, showing the 'libemos' directory. The 'opensuse113' task is selected, displaying a list of tasks including 'module_sync', 'wipe_build', 'cct', 'ecgb', 'opensuse131', 'lxc', 'lxab', 'cca', 'ccb', 'eckit', and 'fdb'. The 'fdb' task is expanded, showing its sub-tasks: 'regenerate', 'lxop_dev', 'var_summary', 'git_srcs', 'make_build_dir', 'config', 'build', 'test', 'install', 'install_log', 'remove_write_perm', and 'module_sync'.

Right Screenshot: Shows the 'Info panel' for the 'ecflow-metab' project. The 'ecflow' directory is selected, displaying the 'var_summary' task. The 'Info panel' shows the task's details, including its name, version, and a list of sub-tasks. The 'Script' tab is active, displaying the task's script content:

```
1 #include <head.h>
2
3 banner var_summary.start || true
4
5 the_date=`date`
6 ecflow_client --label=date "${the_date}"
7
8
9 if [ -d %ECF_HOME% ] ; then
10     python_file=%ECF_HOME%\%ECF_NAME%.py
11 else
12     # we can't use ECF_OUT since that is not always specified
13     python_file=var_summary_tmp.py
14 fi
15
16
17 #####
18 cat << EOF > $python_file
19 import ecflow
20
21 ci = ecflow.Client()
22 ci.sync_local()
23 defs = ci.get_defs()
24 if defs == None :
```

Software support infrastructure

Available at

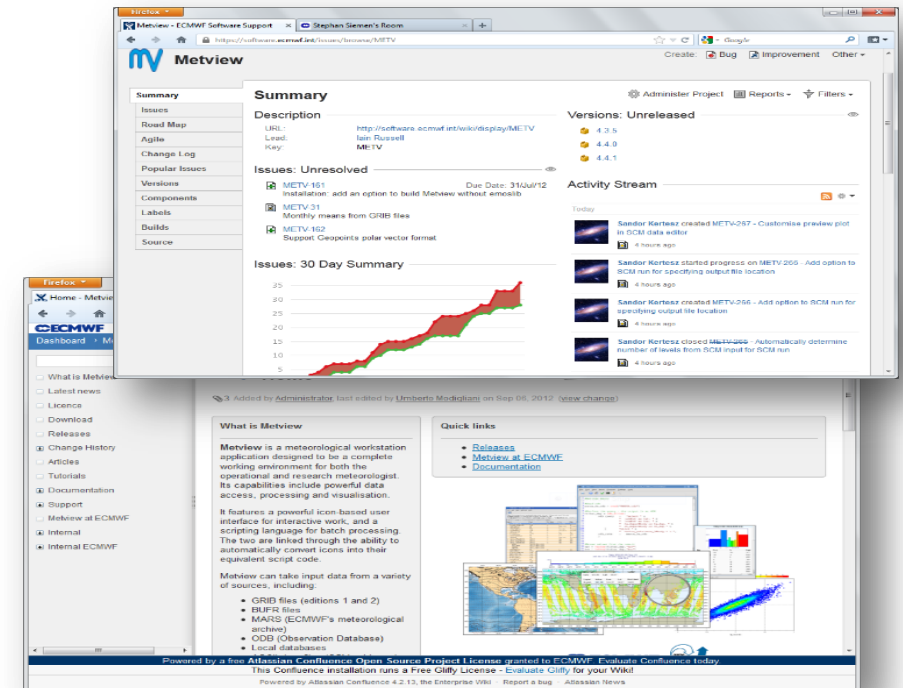
<http://software.ecmwf.int/>

Aims to improve support for external users by:

- keeping track of issues in a central place
- spreading knowledge throughout the Centre

Based on Atlassian Suite

- JIRA (issues)
- Confluence (documentation wiki)
- Bamboo (Builds)



MIR New Interpolation package

Flexible and maintainable design

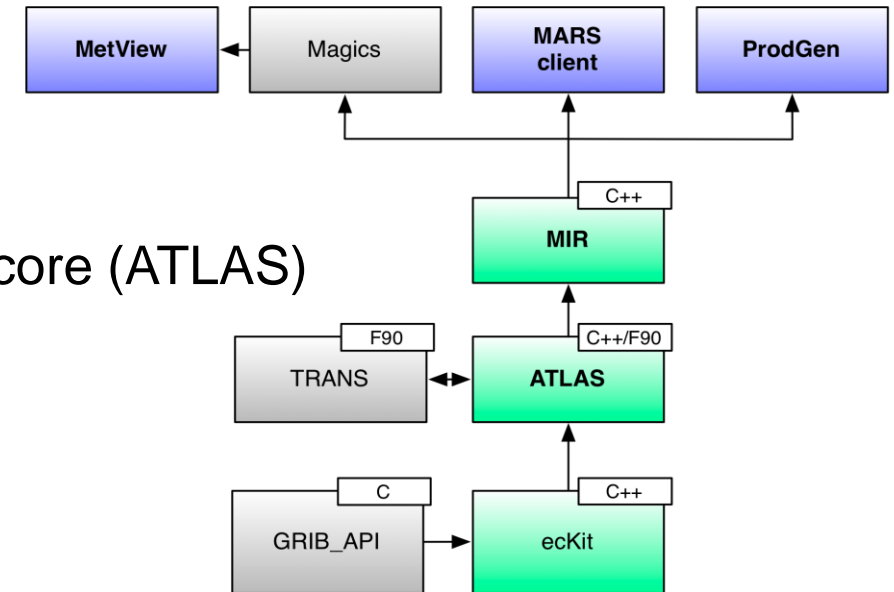
- Configuration driven
- Plugin based (users can extend)
- Share **data-structures** with future IFS dynamical core (ATLAS)

Any-to-Any Grid algorithm

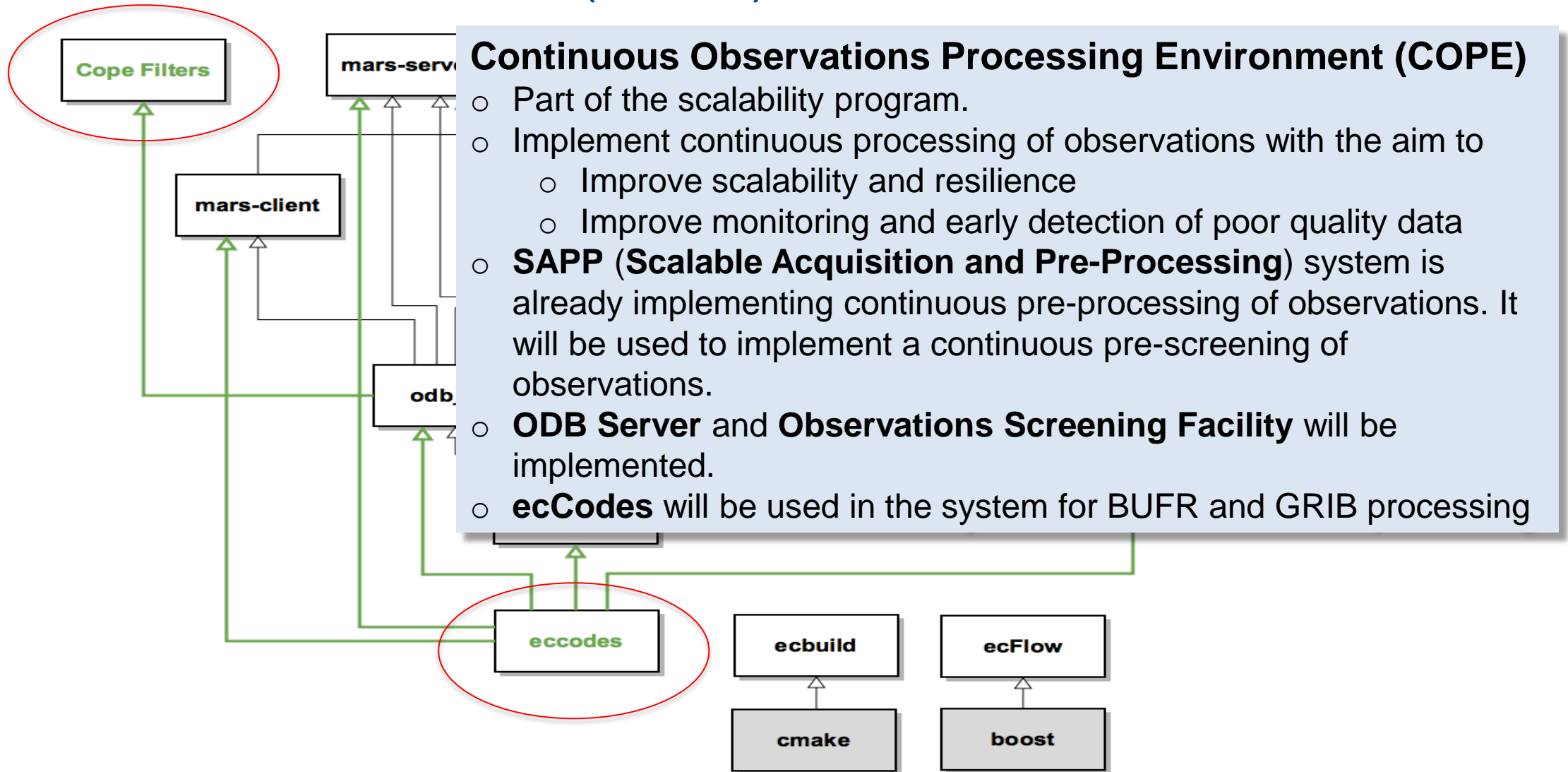
- There is **always** a default algorithm

Kernel based on linear **Interpolation Operators**

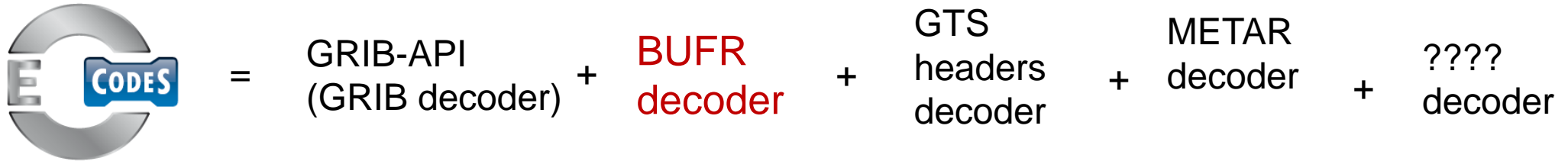
- Enabling caching of operators
- **Linear Algebra backend** support for GPU's & Accelerator cards (Intel Phi)



Software framework (future)



ecCodes



- A Beta release was made available in 2015
- Release with full BUFR encoding/decoding was made available in February 2016
- Training course at ECMWF in March 2016
- Testing of ecCodes in the new model cycle (CY43r1, summer 2016) will be followed by a new full release of ecCodes software.
- ecCodes will replace GRIB-API and migration plan will be announced during the year.
- ecCodes home <https://software.ecmwf.int/wiki/display/ECC/ecCodes+Home>
- ECMWF newsletter <http://www.ecmwf.int/sites/default/files/elibrary/2016/15041-newsletter-no-146-winter-201516.pdf>

Data visualization: Metview



Metview / ... / Visualisation - an Overview
3D visualisation with VAPOR
Created by Sandor Kertesz, last modified on Apr 02, 2014

What is VAPOR?

VAPOR stands for **Visualization and Analysis Platform** for UNIX, Windows and Mac systems equipped with modern graphics cards.

The home of the software is <https://www.vapor.ucar.edu>.

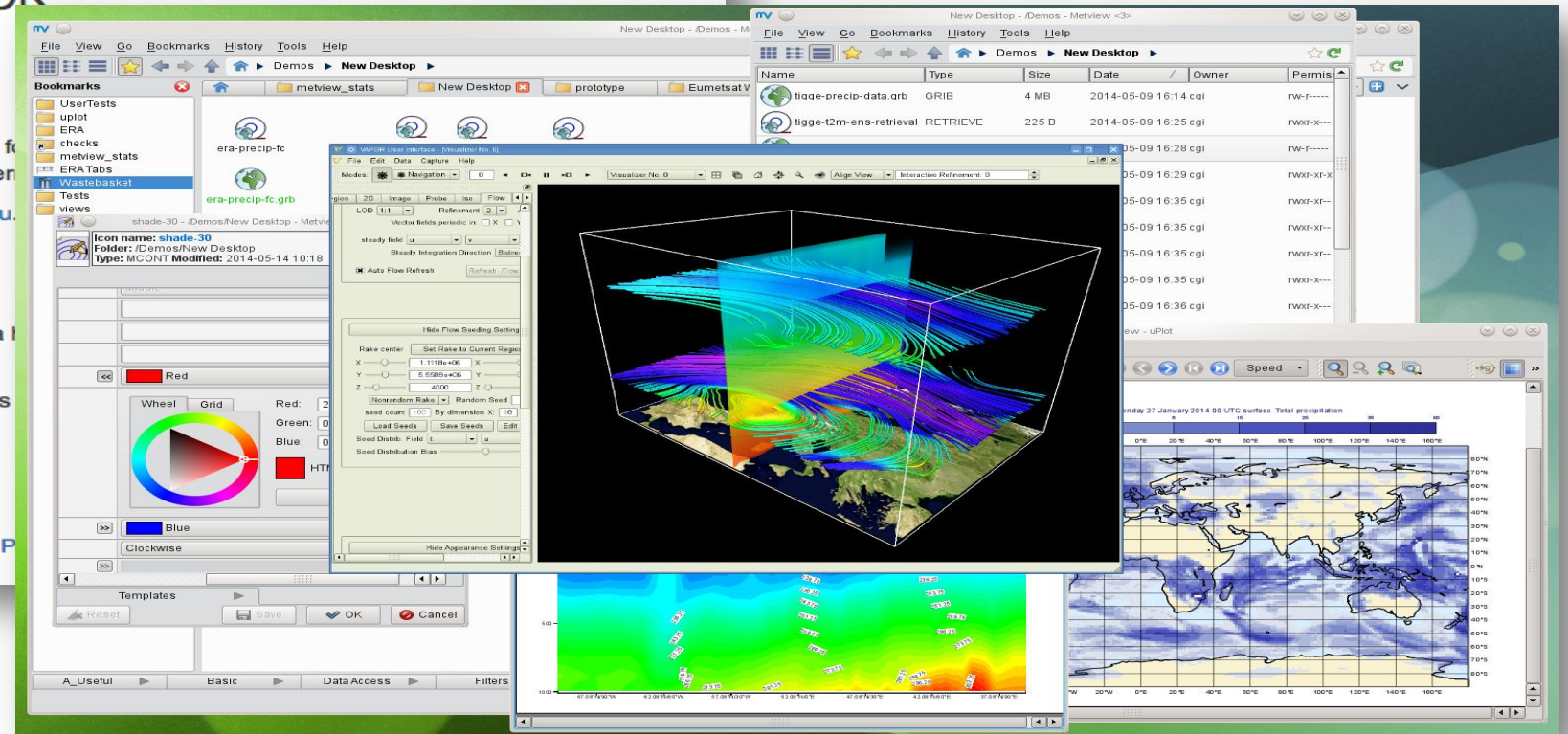
How to use VAPOR with Metview?

VAPOR has its own internal data model and NWP data but there is no such tool available for GRIB.

Metview's **VAPOR Prepare** icon helps to overcome this.



Once the conversion has been completed the VAPOR Prepare icon is actually displayed in VAPOR.



<http://software.ecmwf.int/metview>

Partnership

S2S (WWRP/THORPEX/ WCRP joint research project)

<http://www.s2sprediction.net>

Bridging the gap between weather and climate

MISSION: to improve forecast skill and understanding on the subseasonal to seasonal timescale, and promote its uptake by operational centres and exploitation by the applications community.

Specific attention will be paid to the risk of extreme weather, including tropical cyclones, droughts, floods, heat waves and the waxing and waning of monsoon precipitation.

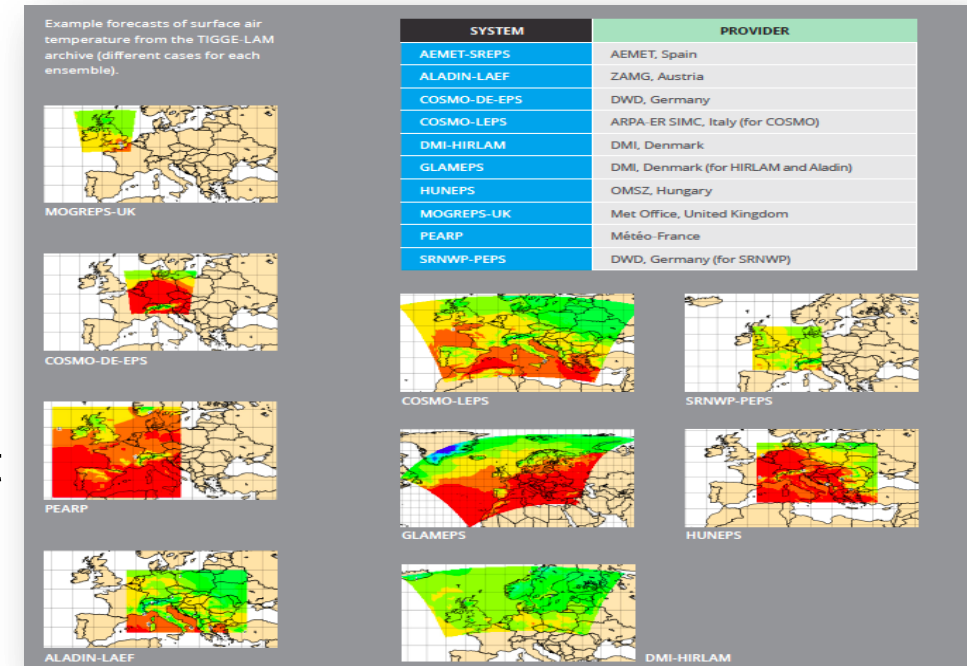


Partnership

TIGGE-LAM

<http://www.smr.arpa.emr.it/tiggelam/>

TIGGE-LAM is an extension of the THORPEX interactive Grand Global Ensemble (TIGGE) to include weather forecasts from limited area model (LAM) ensembles. These forecasts are produced at high resolution (12 and 2 Km grid spacing) and Provide detailed information for the short range, up to few days ahead.



Knowledge exchange: the Portals

The image displays three overlapping screenshots of ECMWF web portals. The top-left screenshot shows the 'Forecast User Home' page, which includes a welcome message and links to 'Severe Event Catalogue', 'Forecasting issues', and 'Forecast evaluation (main ECMWF)'. The top-right screenshot shows the 'Computing Representatives Portal', featuring a search bar and a list of representatives including Carsten, Daniel, Dominique, Paul, Xavier, and Umberto. The bottom-right screenshot shows the 'Catalogue Contact Points Portal', which includes a search bar and sections for 'Standard templates' and 'Calculate the price of ECMWF's products'.

Forecast User Home

Computing Representatives

Catalogue contact points

<https://software.ecmwf.int/wiki/display/FCST/Forecast+User+Home>

<https://software.ecmwf.int/wiki/display/CCP/Catalogue+Contact+Points+Portal>

<https://software.ecmwf.int/wiki/display/CR/Computing+Representatives+Portal>

Severe event catalogue

[Severe Event Catalogue](#)

Created by Florian Pappenberger, last modified by Linus Magnusson on Sep 22, 2014

On this space we collect material for evaluation of severe/extreme weather events. The focus is on the meteorological conditions and the forecast performance. The amount of material differs from case to case, and we are not claiming to give the full picture of the cases here. Users are welcome to contribute with material for the cases by using the comment function in the bottom of each page. To suggest a new case to evaluate, please contact us [here](mailto:forecast_user@ecmwf.int) (forecast_user@ecmwf.int). If you have any initial comments and material, please include them in the mail.

(Please note that some of the links on the pages are only accessible from ECMWF.)

Featured

201409 - Floods - Pakistan

Heavy monsoon rain during the first week of September led to flooding in north-eastern Pakistan, and has killed about 280 people.

[Read more ...](#)

201408 - Rainfall - Sweden, Denmark

Significant flooding, due to a relatively short-lived burst of convective activity,

201406 - Rainfall - Bulgaria

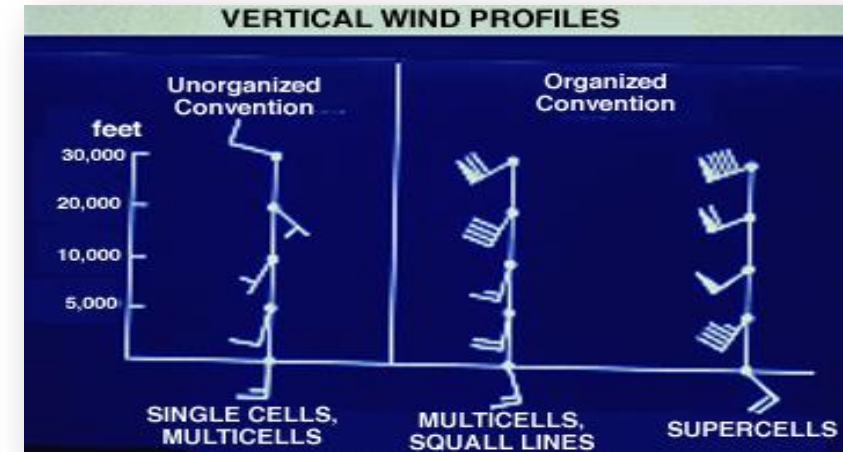
An unstable air mass triggered a lot of convection accompanied by heavy thunderstorms, hail and torrential rain across Bulgaria from 15 to 19 June 2014. Climatologically June is one of the wettest months over most parts of the country. Nevertheless rainfall accumulations exceeded

[illegible]

<https://software.ecmwf.int/wiki/display/FCST/Severe+Event+Catalogue>

Severe convection: CAPESHEAR

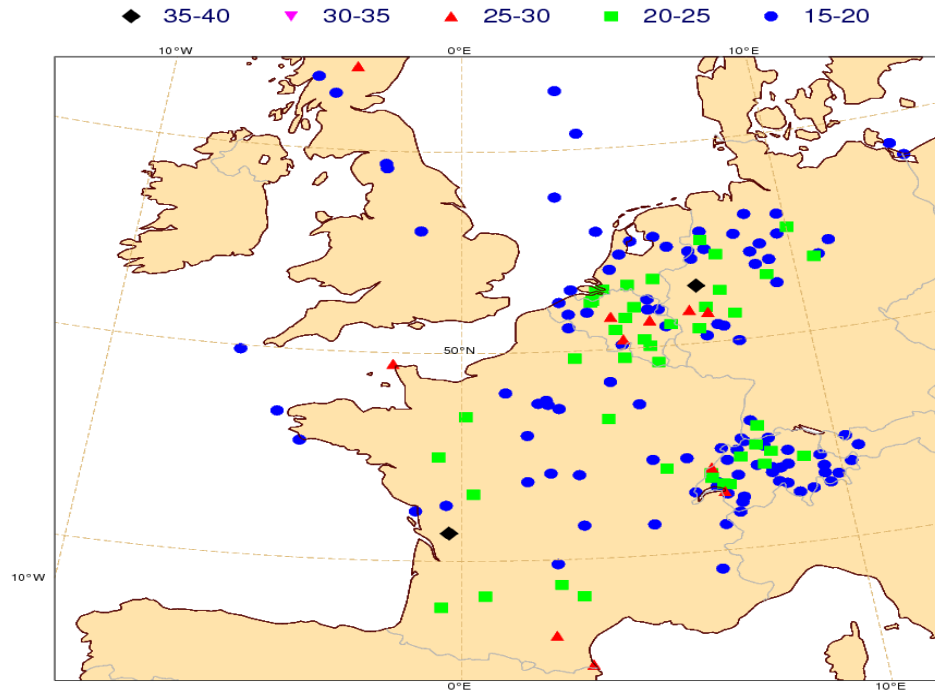
$$CAPESHEAR = [WindShear]_{L1}^{L2} * \sqrt{CAPE}$$



- CAPE is a key ingredient of deep moist convection
- Large vertical wind shear favors organized convection
- Super cells occur where strong shear is combined with large instability
- CAPE values of less than 10 J/kg are filtered out to emphasize convection rather than anomalous but insignificant CAPESHEAR
- Limitations: CIN not taken into account

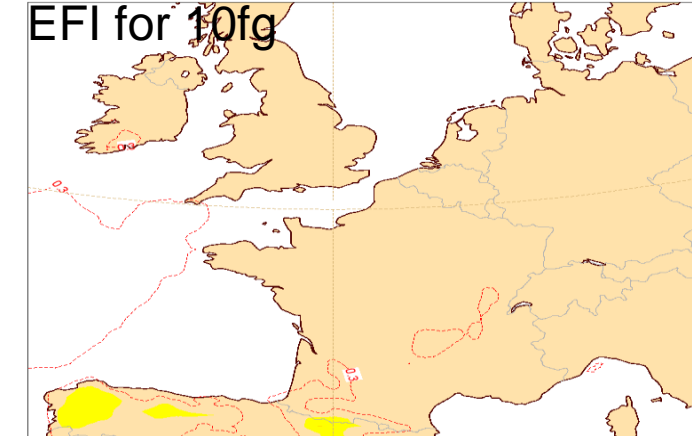
An example of severe convection (9/06/2014)

Observed maximum wind gusts on 09 June 2014

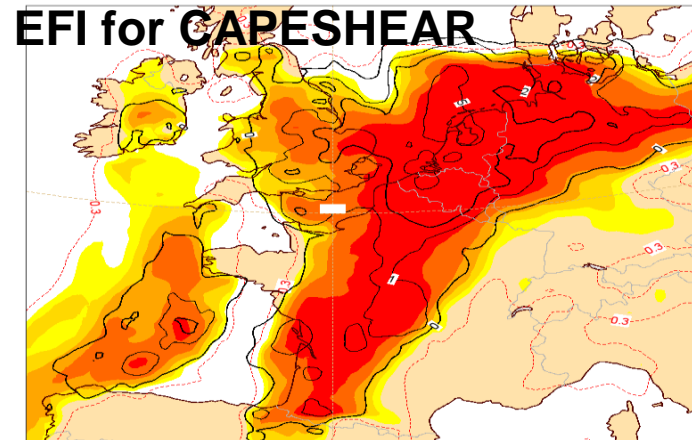


- Severe convection affected Western Europe from southern France to northern Germany on 9 Jun 2014.
- The maximum wind gust at Düsseldorf airport was 42 m/s.

Mon 09 Jun 2014 00UTC @ECMWF expver = 1 VT: Mon 09 Jun 2014 00UTC - Tue 10 Jun 2014 00UTC 0-24h
Extreme forecast index and Shift of Tails (black contours 0,1,2,5,10,15) for: 10m wind gust



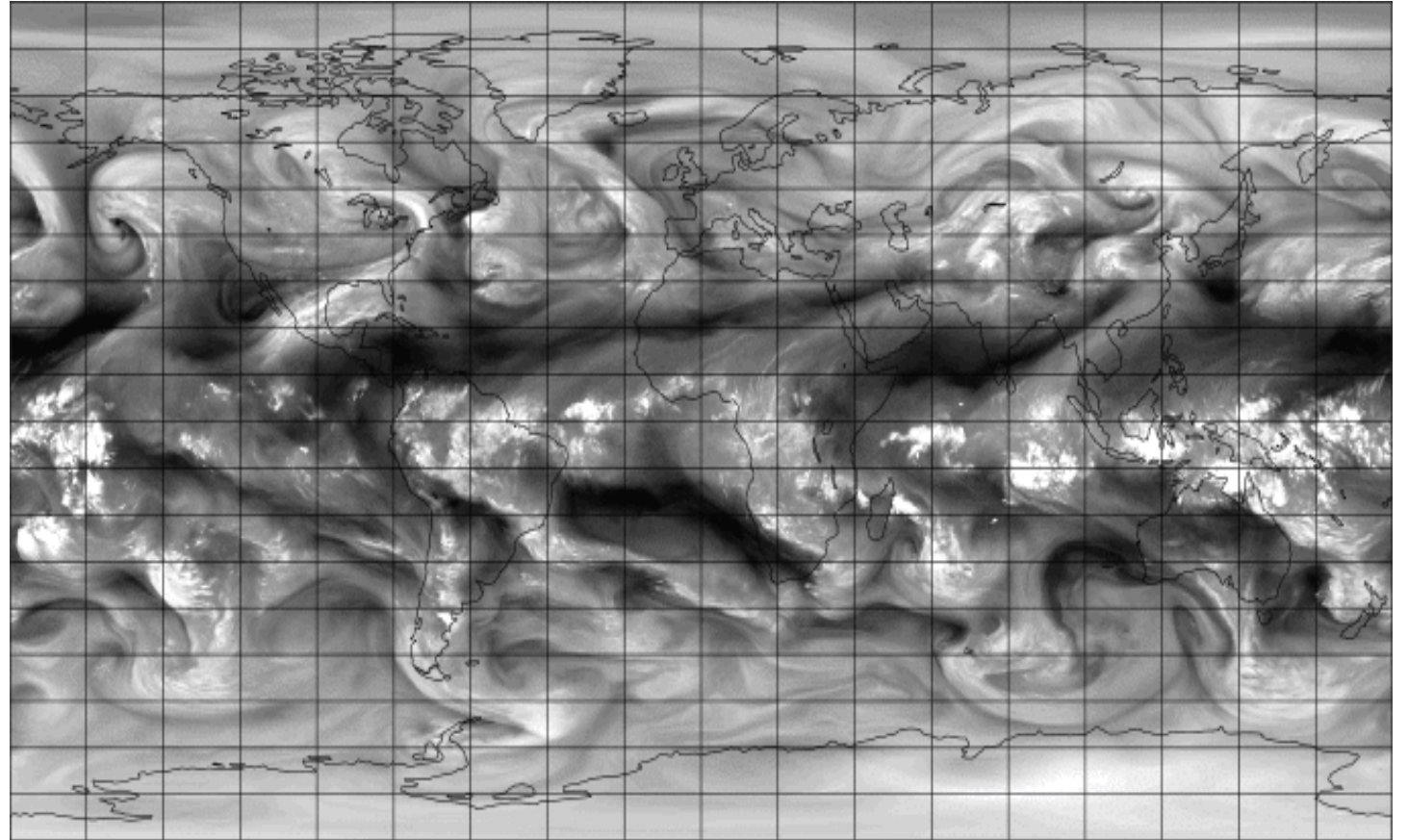
Mon 09 Jun 2014 00UTC @ECMWF VT: Mon 09 Jun 2014 00UTC - Tue 10 Jun 2014 00UTC 0-24h
Extreme forecast index and Shift of Tails (black contours 0,1,5,10,15) for: SCI
M-CLIMATE (5 members X 20 years every Thursday X 5 weeks)



Simulated Satellite Data

SSD, by capturing detailed cloud and/or humidity features, show the high-resolution ECMWF forecasts as a weather satellite would see it.

Central wavelength	Description
6.30 (μm)	Water vapour (~300hPa)
7.36 (μm)	Water vapour (~500hPa)
10.79 (μm)	Clouds (surface)



ECMWF is the operator of the Copernicus **CAMS** and **C3S** services under a Delegation Agreement signed with the EC on 11 of November 2014

The maximum amount of funds entrusted to ECMWF is:

- 76 M€ for the Atmosphere Monitoring Service
- 215 M€ for the Climate Change Service.

The Copernicus programme is set for the period up to end of 2020, with 2021 being a transition year to enable the Services to be brought to an end or to be continued or reinstated.

CAMS:

Transition from H2020 MACC-III and operations ramp-up

New Composition-IFS model version: **Daily analyses and D+5 forecasts with Composition-IFS and production of GFAS fire emissions** *(based on Cy41r1 and implemented on 3/09/2015 following successful e-suite validation (external)) It included new satellite data (MODIS Deep Blue and GOME-2 SO₂); improvement of wildfire emissions; improvement of the UV processor*

C3S:

Set-up of the “Proof of Concept” phase, workshops and consultations
Global reanalysis and seasonal forecasts (ECMWF internal contributions)

ERA-interim to be replaced by ERA5

Model version	August 2006 (IFS Cy31r2)	November 2015 (IFS Cy41r2)
Model boundary conditions	As in forecasting (inconsistent SST)	Appropriate for climate (CMIP5, HadISST.2)
Spatial resolution	79 km global 60 levels to 10 Pa	31 km global 137 levels to 1 Pa
Time period	1979 - present	1979–present (extension to ~1950?)
Dissemination	Monthly	Monthly for ERA5; daily for ERA5T
Observations	Mostly ERA-40, GTS	Various reprocessed CDRs
Radiative transfer	RTTOV7	RTTOV11
Analysis method	4D-Var 1D+4DVar rain	10-member EDA All-sky radiance assimilation
Variational bias corrections	Satellite radiances	Radiances, ozone, aircraft, surface pressure, radiosondes

European Flood Awareness System (EFAS)

A success story for continuous policy support

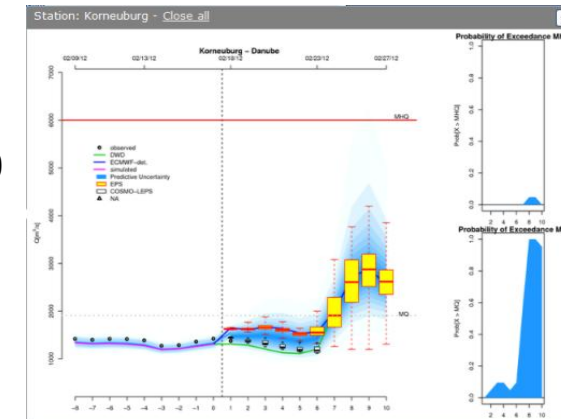
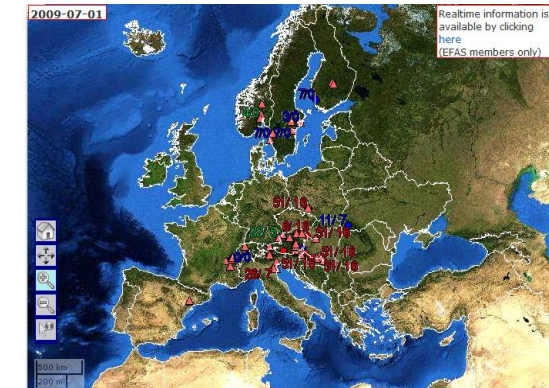
Need: lack of coherent flood information and coordination in Europe for trans-national flood events before EFAS, e.g. during Elbe and Danube floods in 2002

Added value of EFAS: better preparedness and improved disaster and crisis management in Europe with trans-national flood early warning information to EC civil protection (MIC) and Member State authorities

JRC : Since 2007 experimental daily flood forecasts to >30 Member States authorities and since 2010 daily to the MIC/ERCC

In 2012 operational 7/365 service with funding of DG ENTR-GMES Initial Operations and DG ECHO-MIC/ERC. New tender in 2015 with operational service is provided by consortia:

- EFAS computational centre (ECMWF)
- EFAS dissemination centre (SE, SK, NL)
- EFAS hydro data collection centres (ES)
- EFAS meteo data collection centres (DE)



Forecast performance: headline scores

2 primary scores

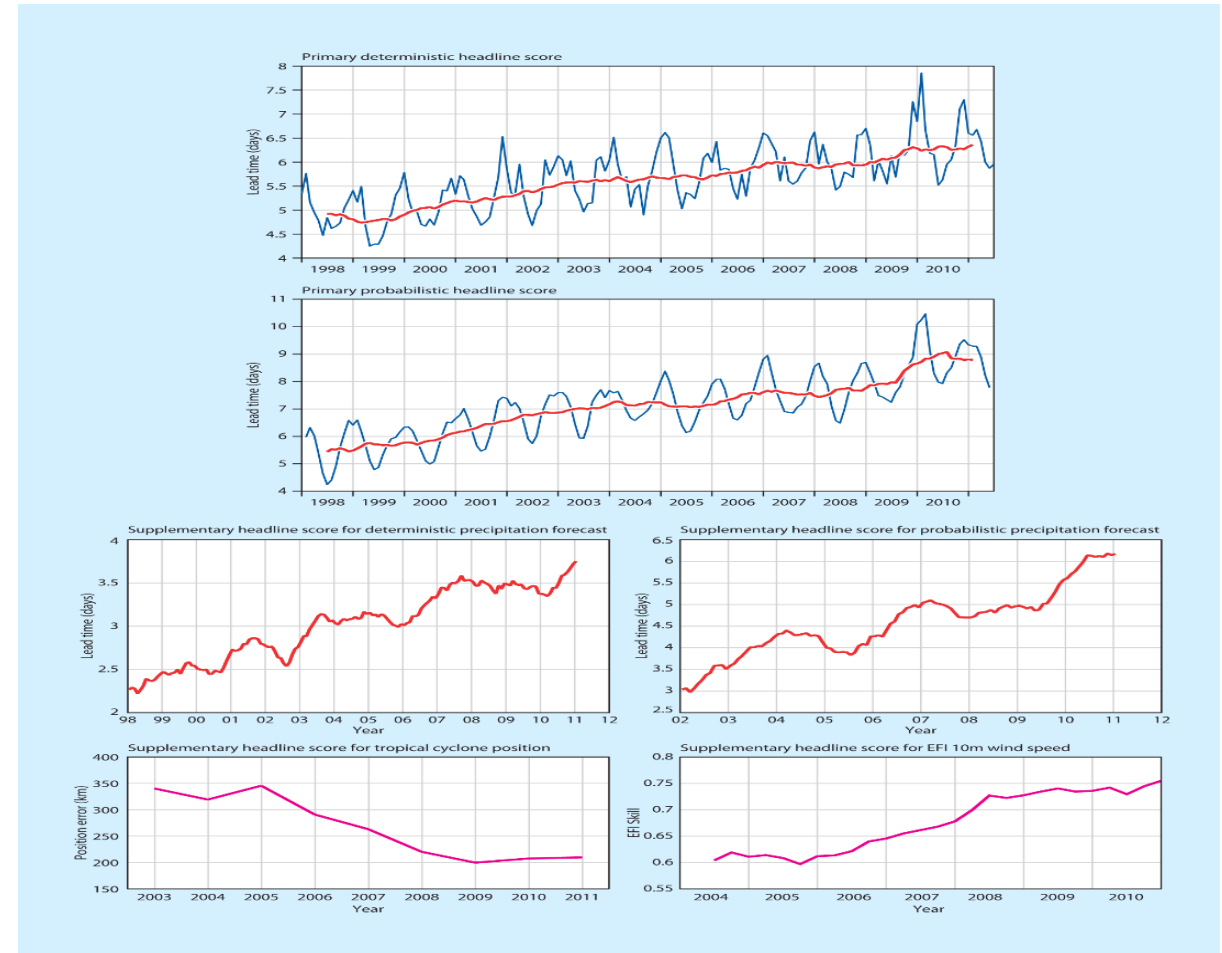
- HRES upper-air skill
- ENS upper-air skill

4 supplementary scores

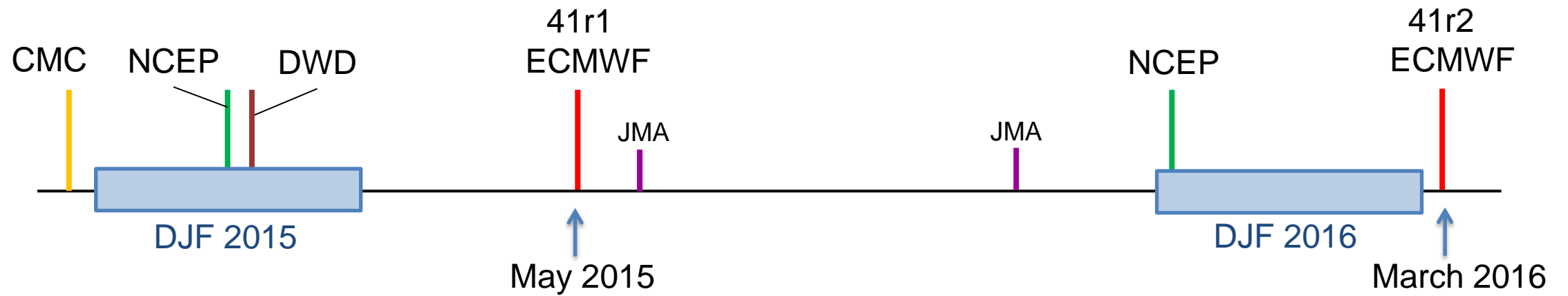
- Precipitation
- HRES skill
- ENS skill

Severe weather

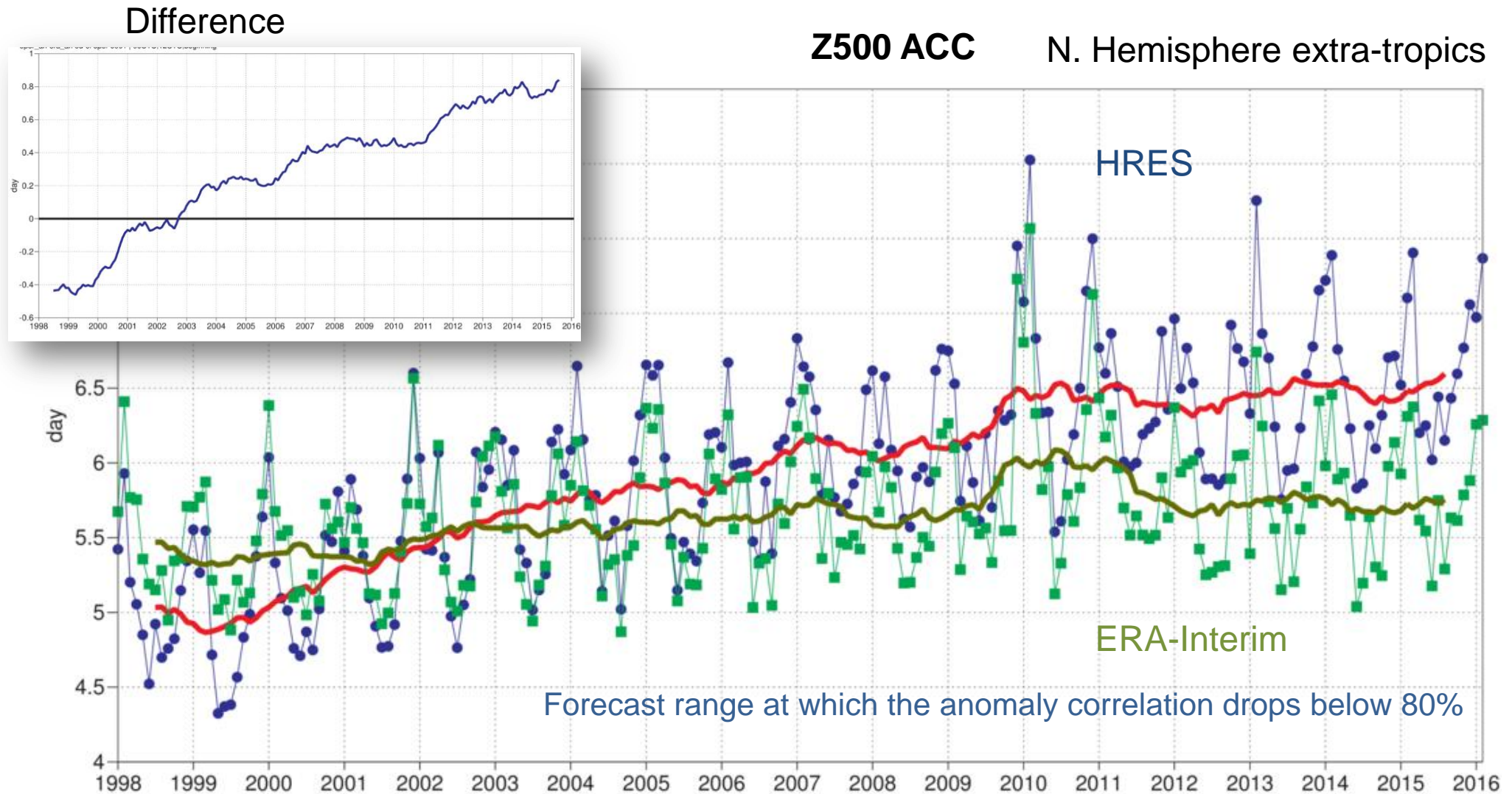
- Tropical cyclone track position error
- EFI skill



Global model upgrades

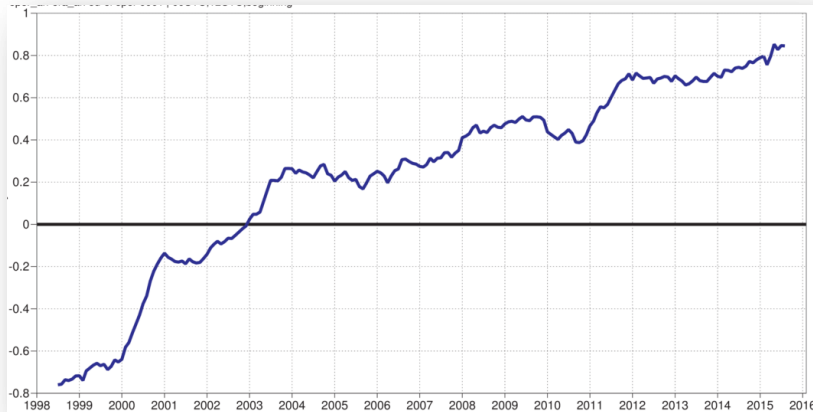


Model performance: HRES relative to ERA-I



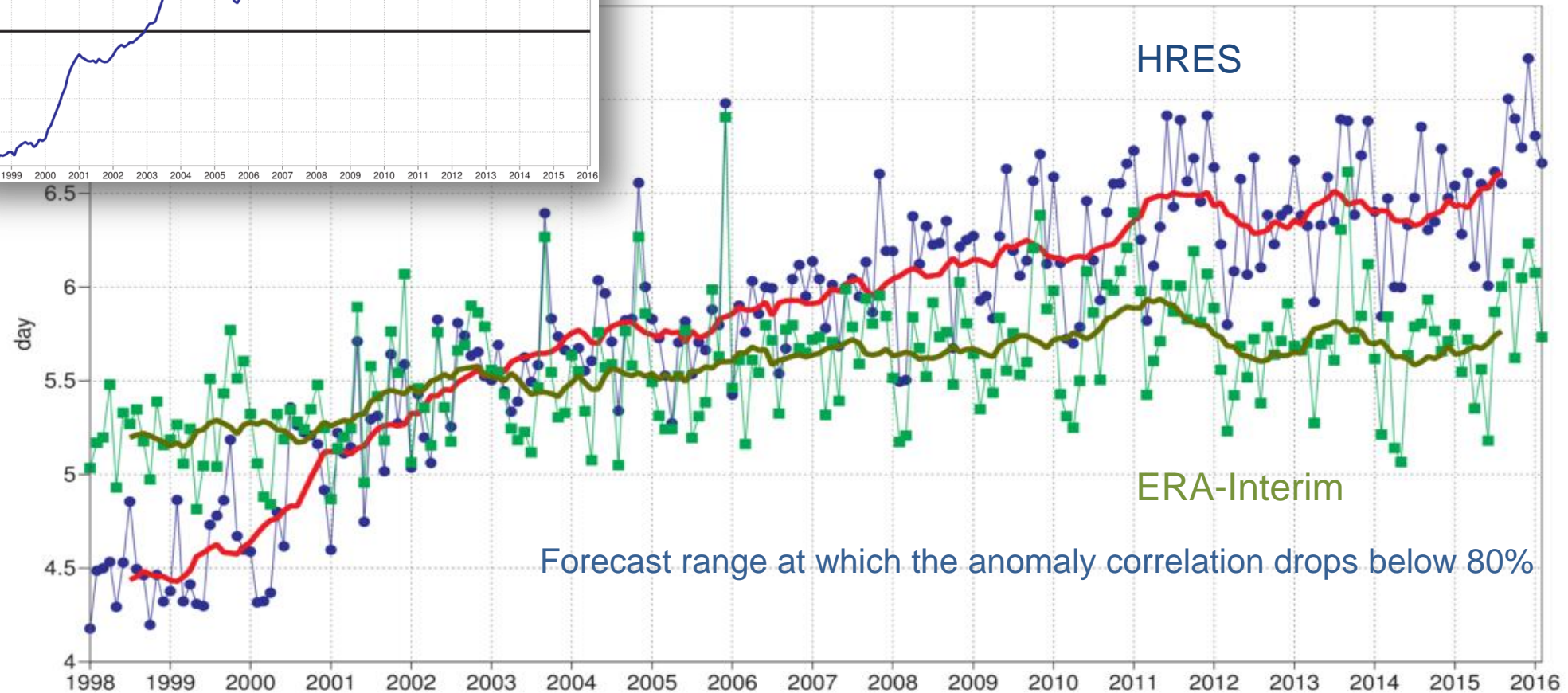
Model performance: HRES relative to ERA-I

Difference

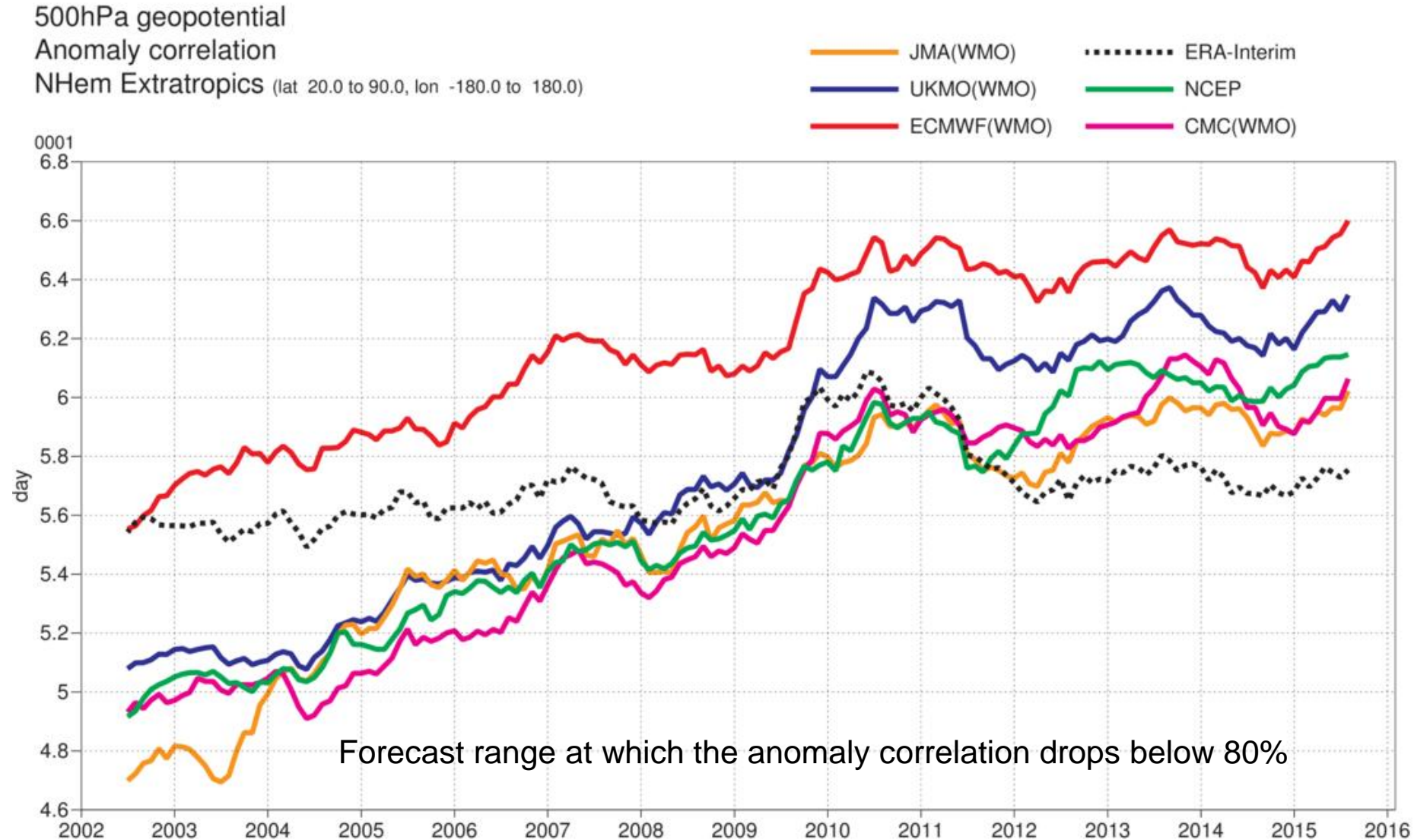


Z500 ACC

S. Hemisphere extra-tropics



Model performance: comparisons with other centres



Model performance: ENS

850hPa temperature
Continuous ranked probability skill score
NHem Extratropics (lat 20.0 to 90.0, lon -180.0 to 180.0)

T+192

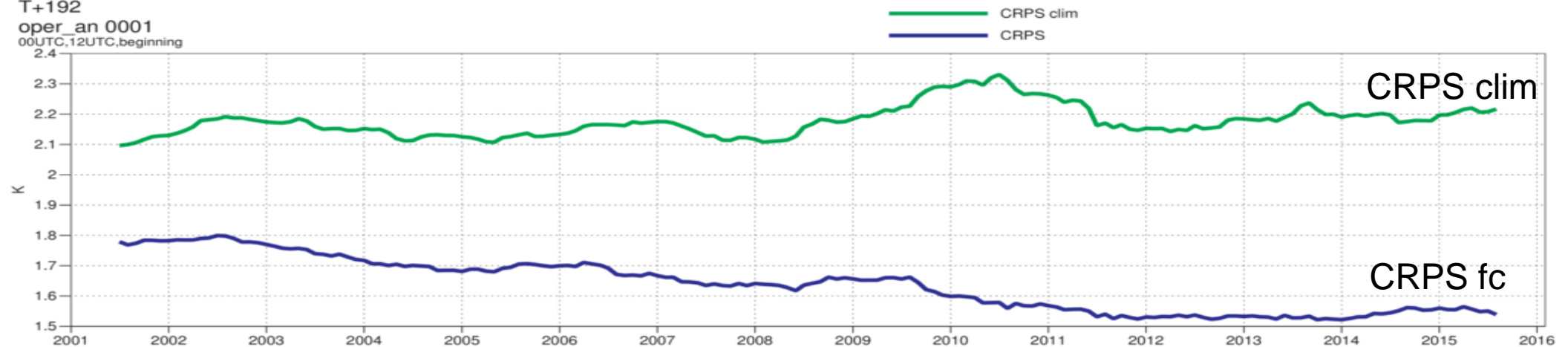
oper_an od enfo 0001 | 00UTC,12UTC,beginning



850hPa temperature
NHem Extratropics (lat 20.0 to 90.0, lon -180.0 to 180.0)
T+192

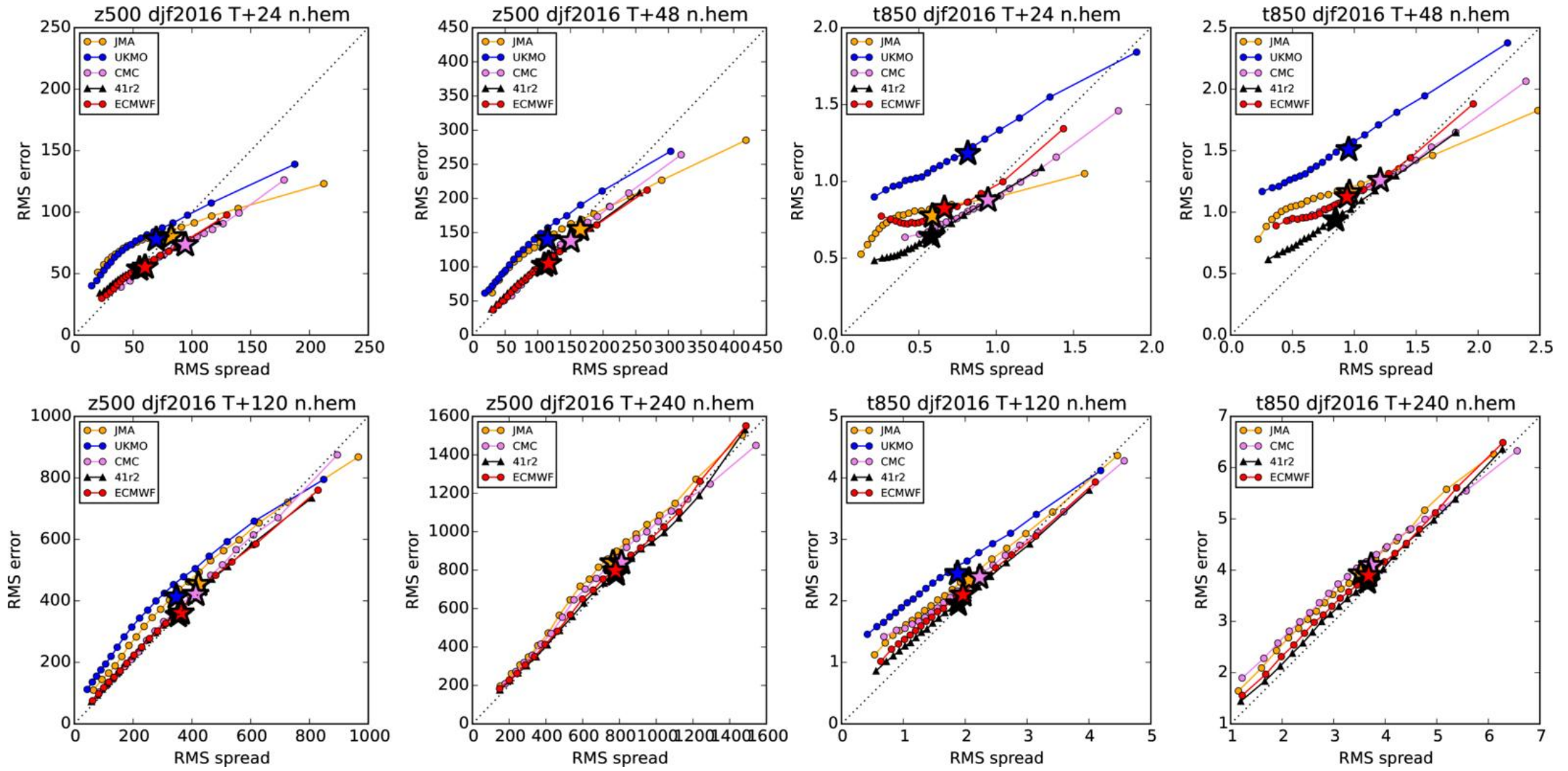
oper_an 0001

00UTC,12UTC,beginning



ENS spread reliability

Extra-tropics



Z500

T850

Precipitation skill – comparison with other centres

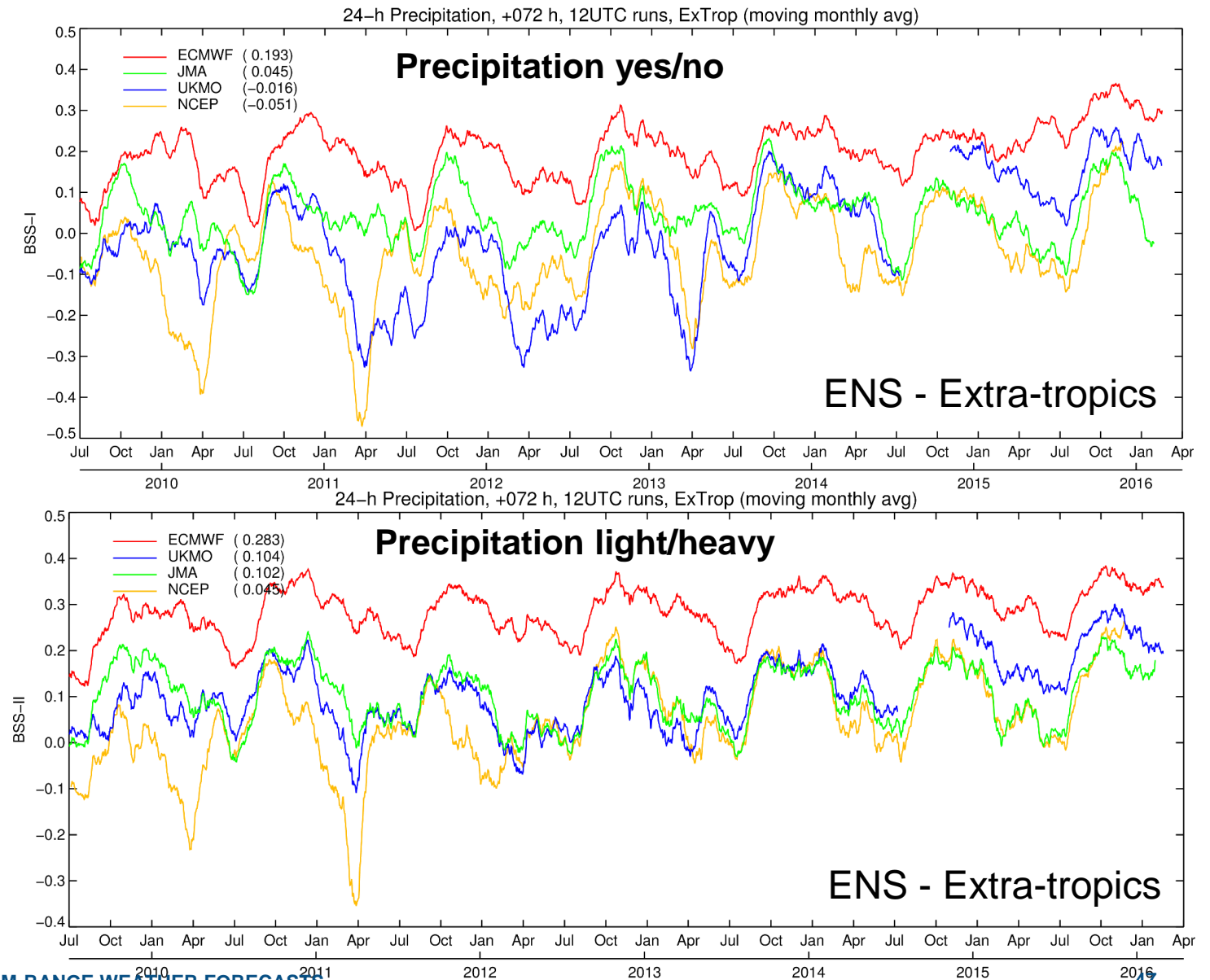
24-hour precipitation

Verification against
SYNOP observations

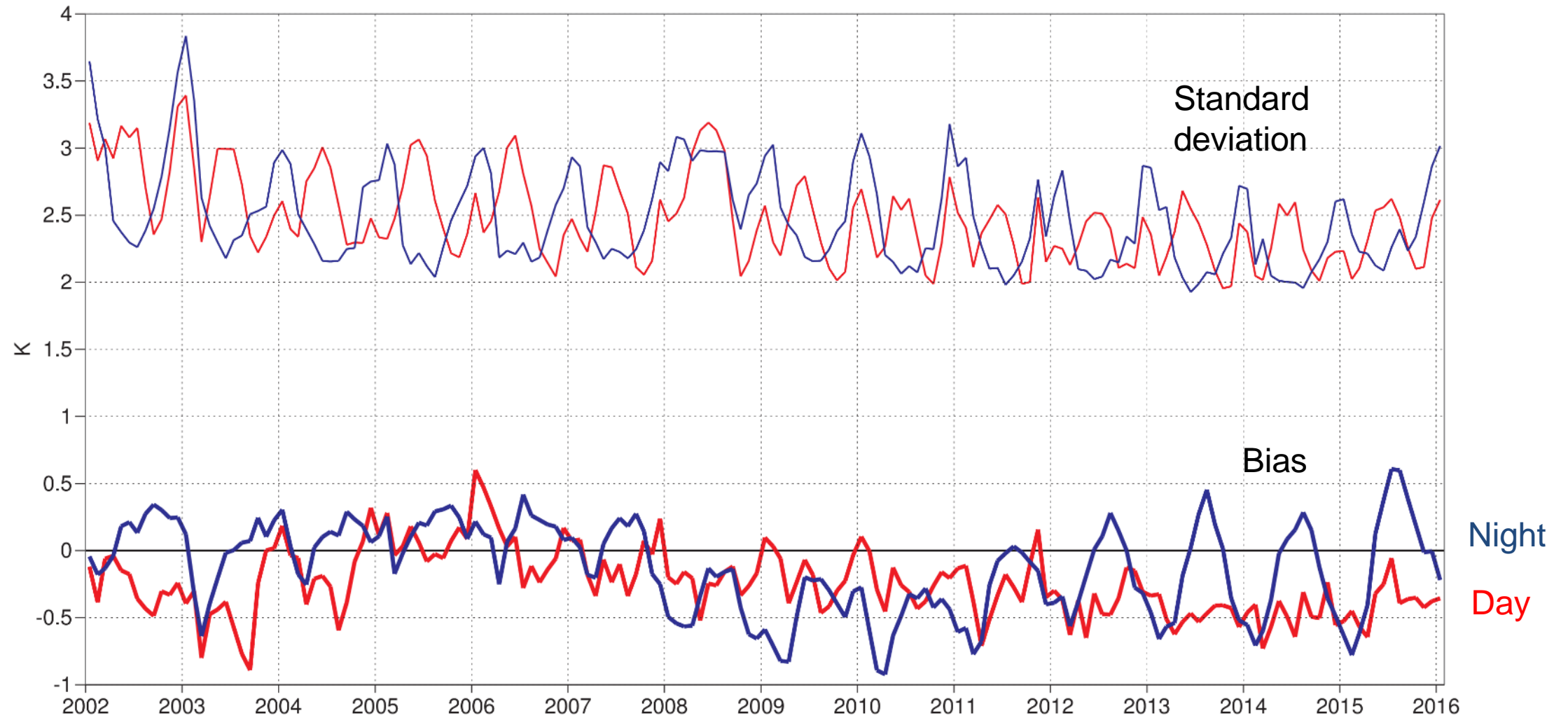


ECMWF Newsletter No. 144 –
Summer 2015

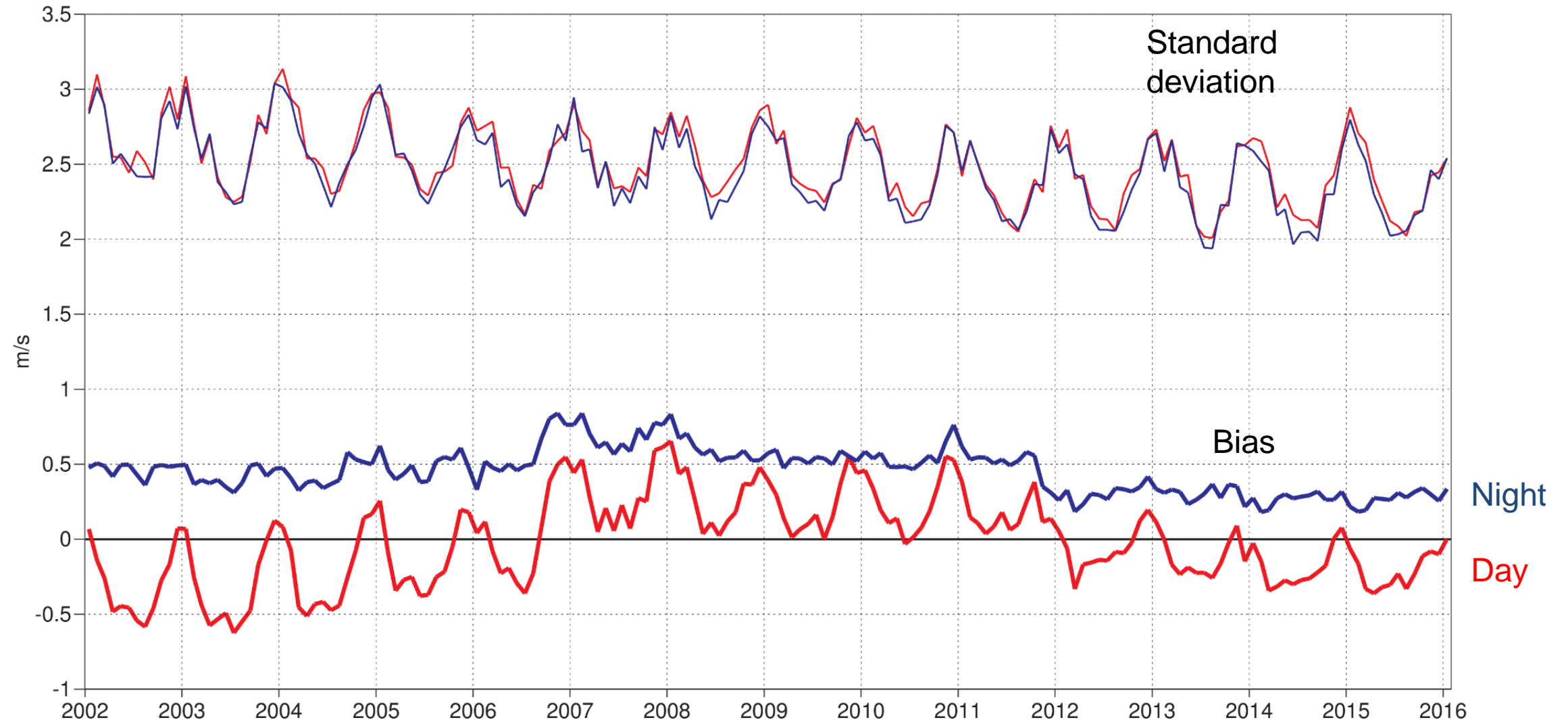
T+ 72



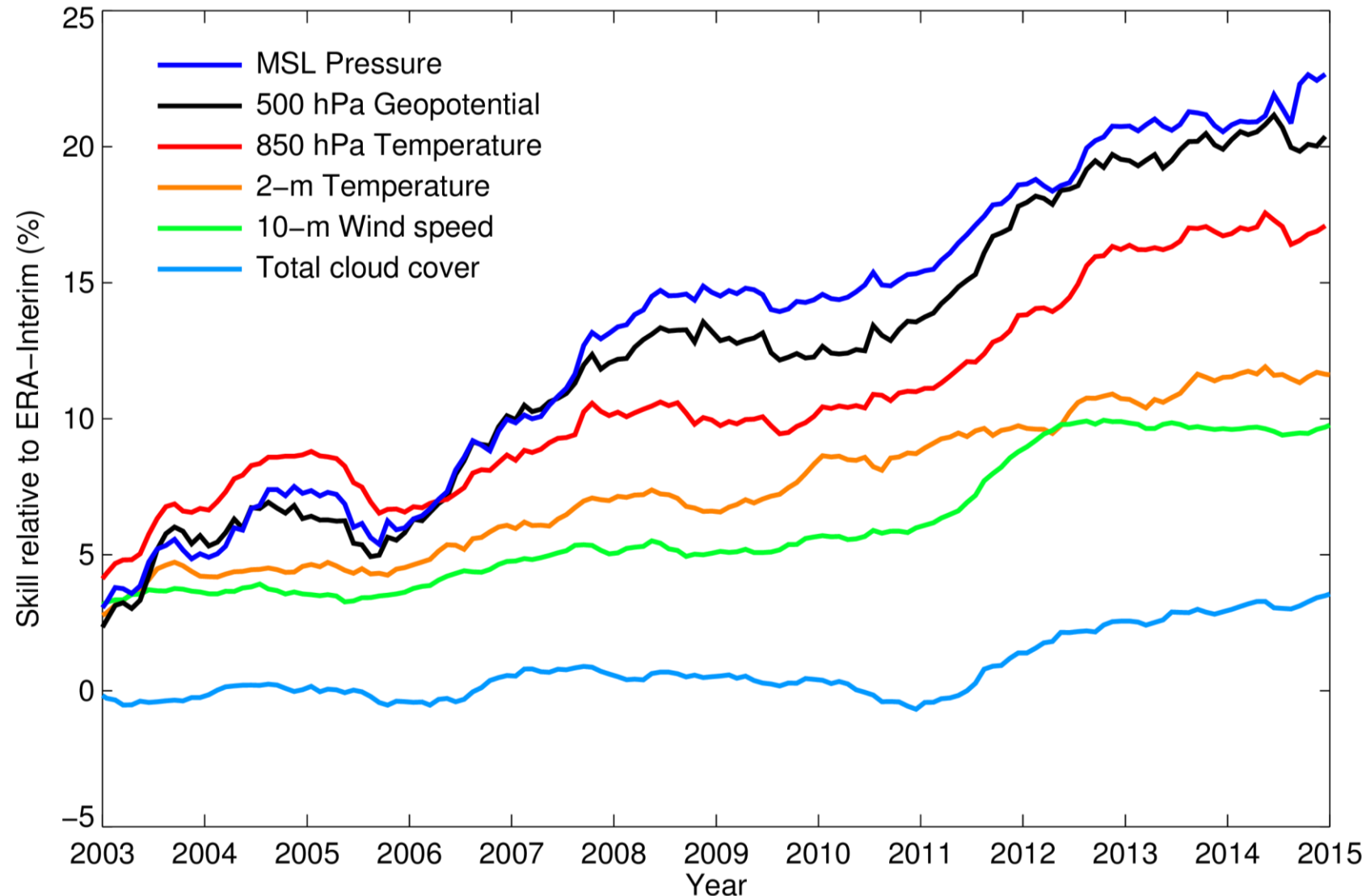
2m temperature Europe (verified against SYNOP)



10m wind Europe (verified against SYNOP)

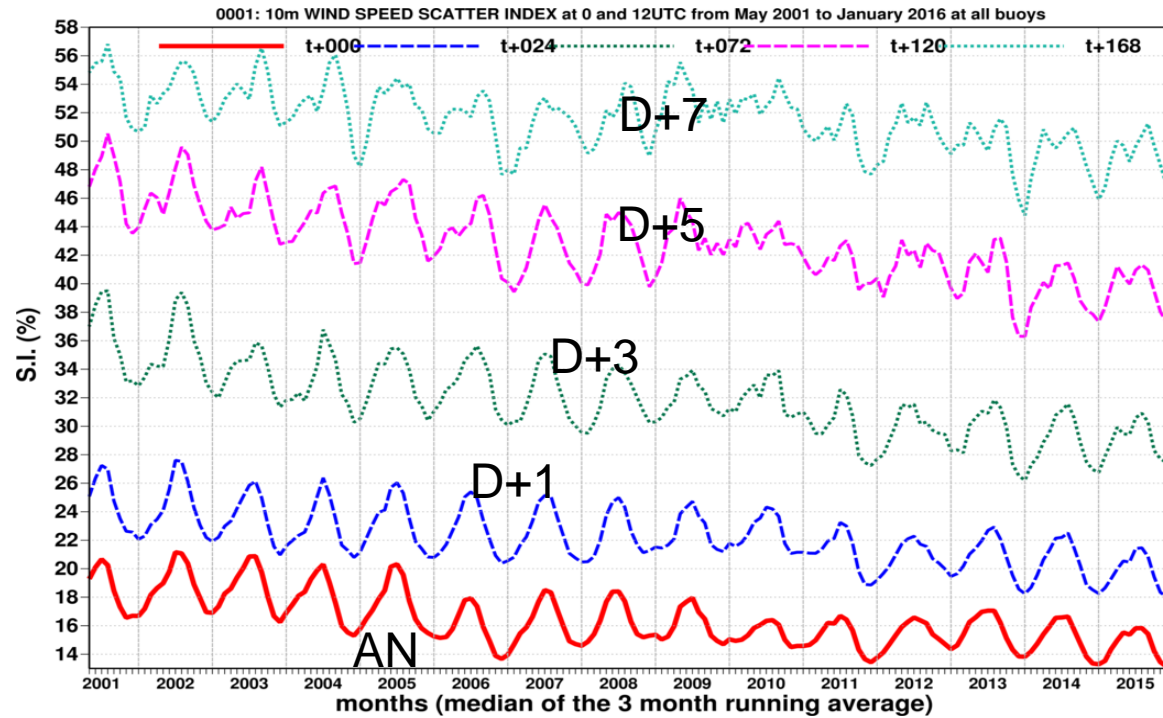


Model performance: skill gain relative to ERA-Interim

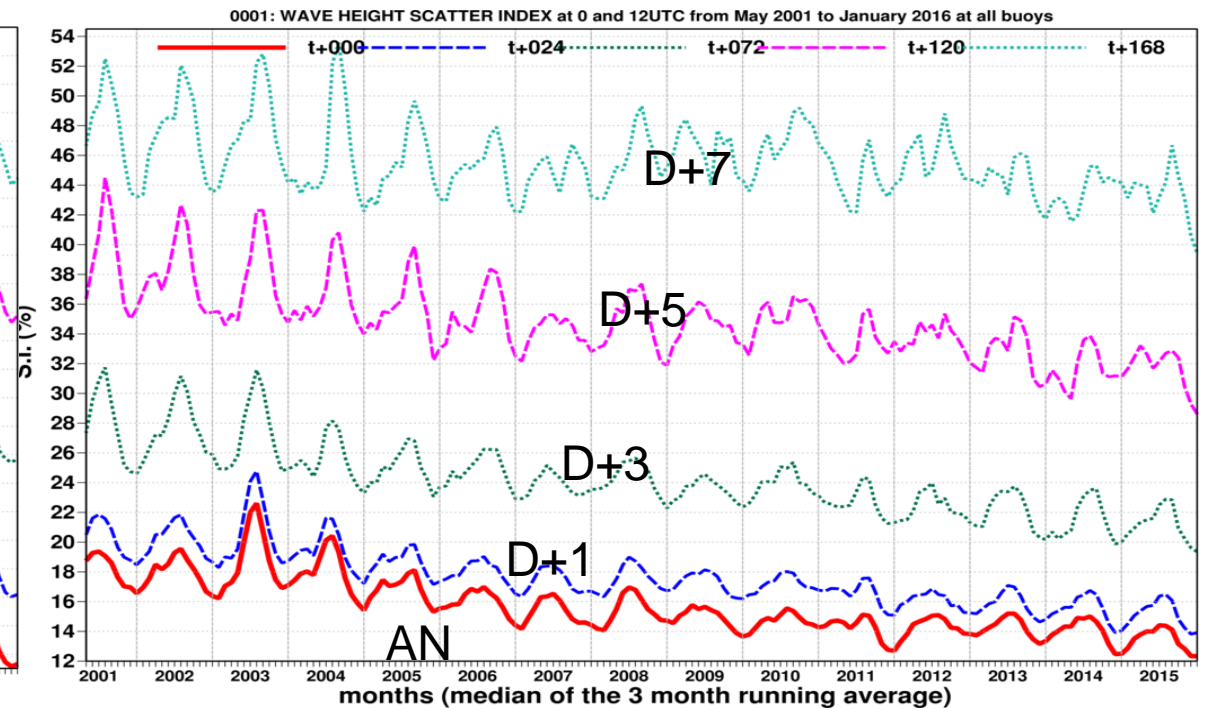


Forecast range: Day 5

Model performance: ocean waves



Wind speed

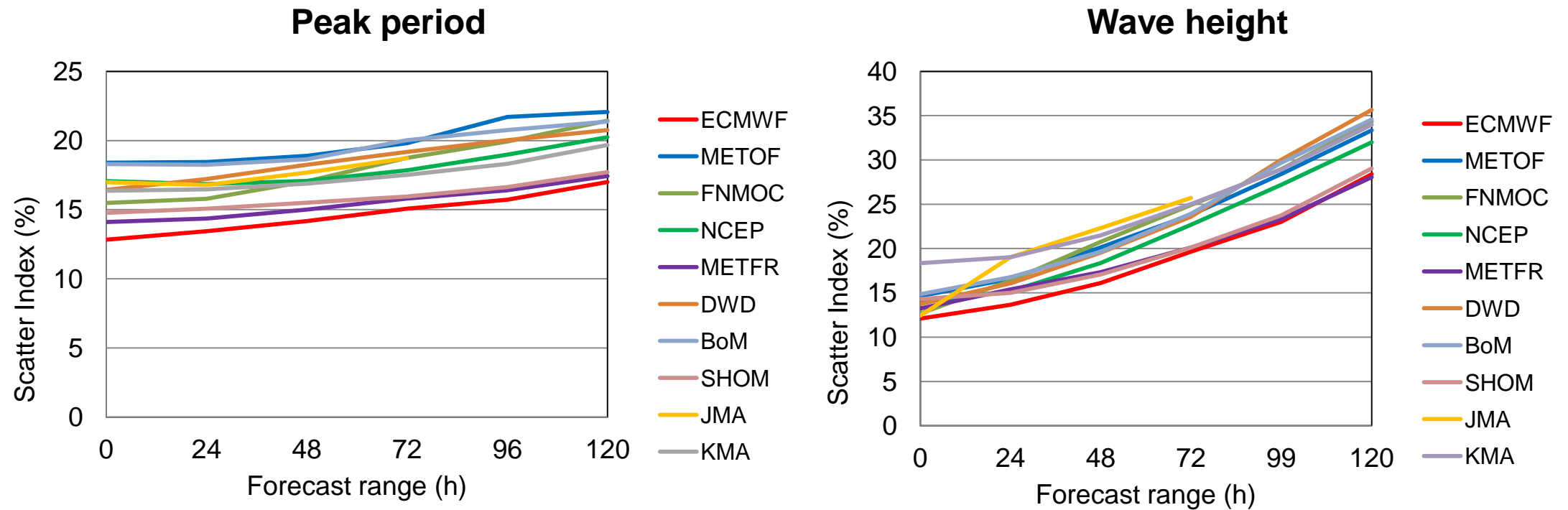


Wave height

Ocean waves – comparison to other centres

Verification against buoys

Scatter index (SI) is the standard deviation of error normalised by the mean observed value



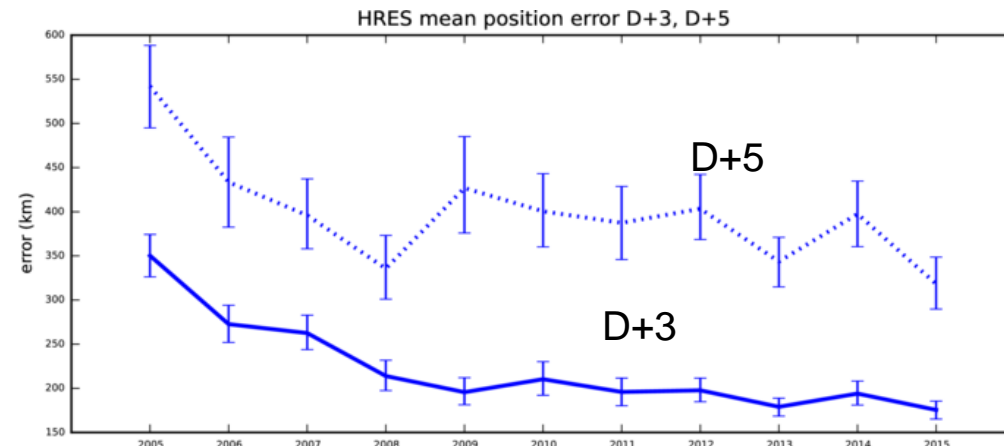
Tropical cyclones

Lowest position and speed errors so far

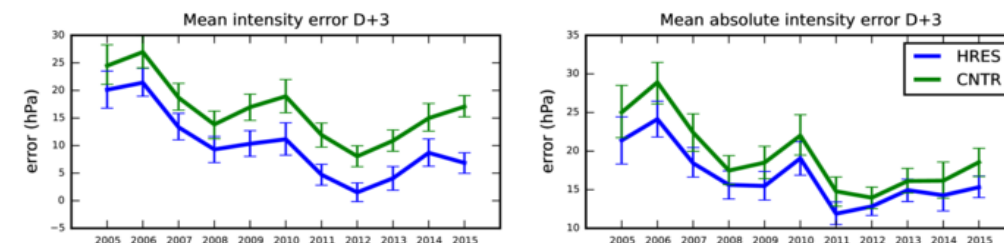
Intensity still a challenge

Good match position spread/error

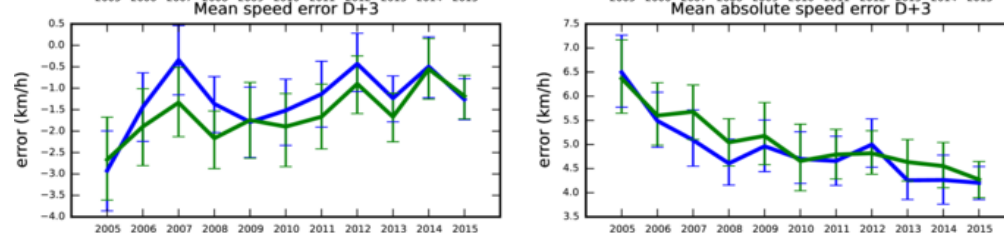
Position



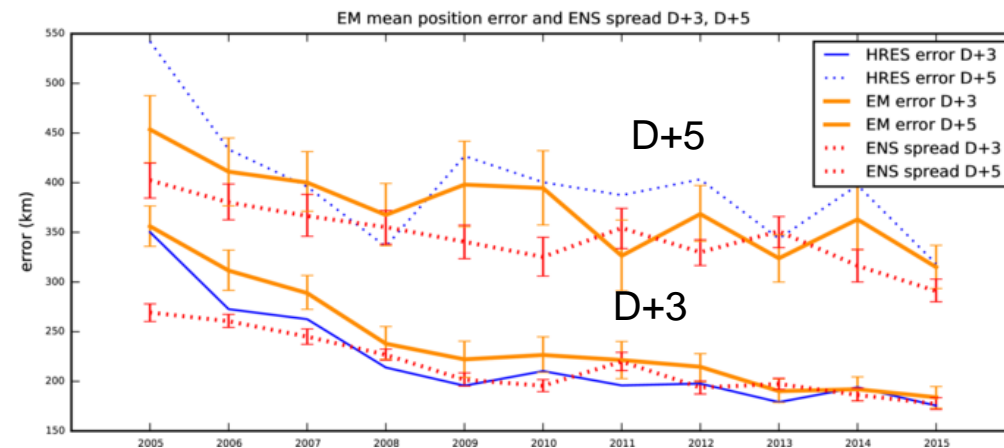
Intensity



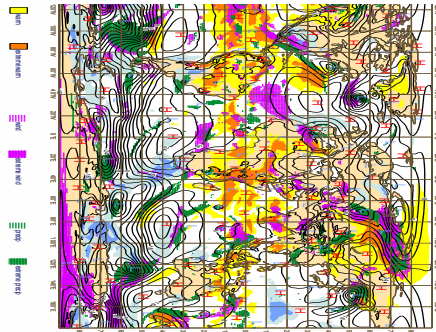
Speed



Position error/spread

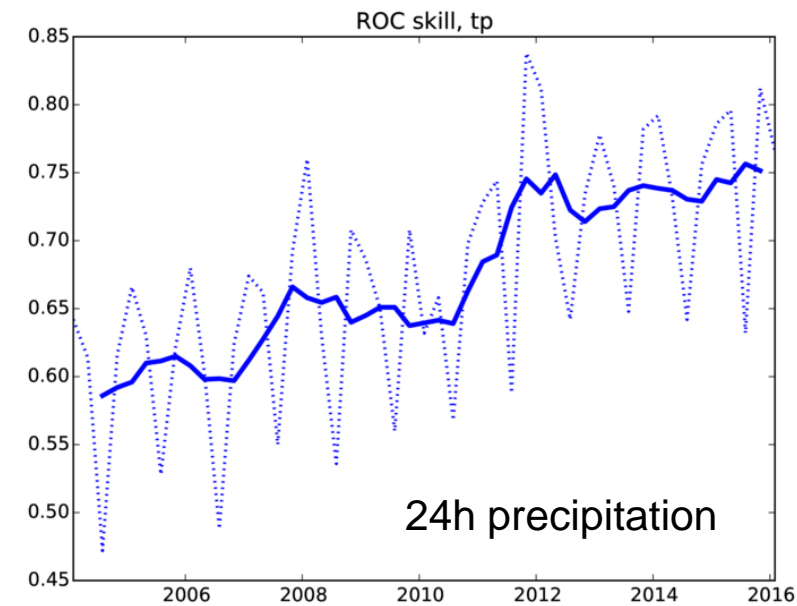
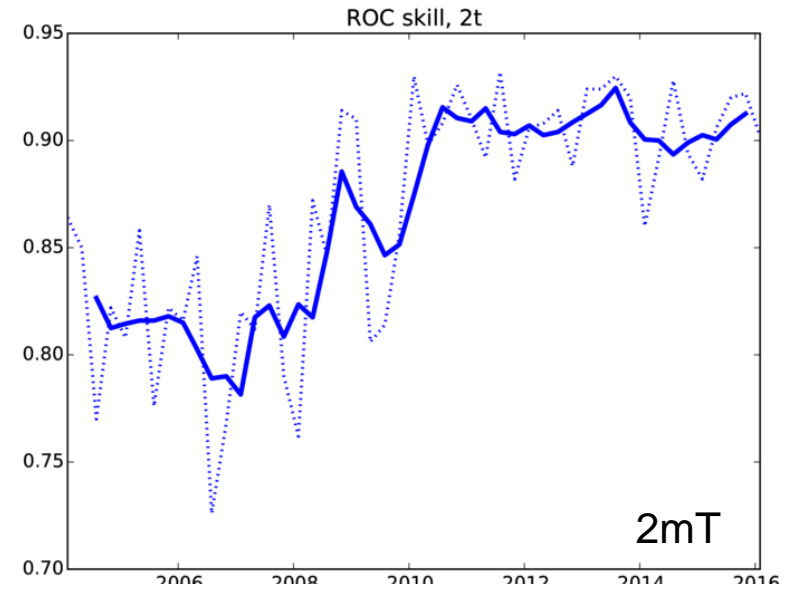
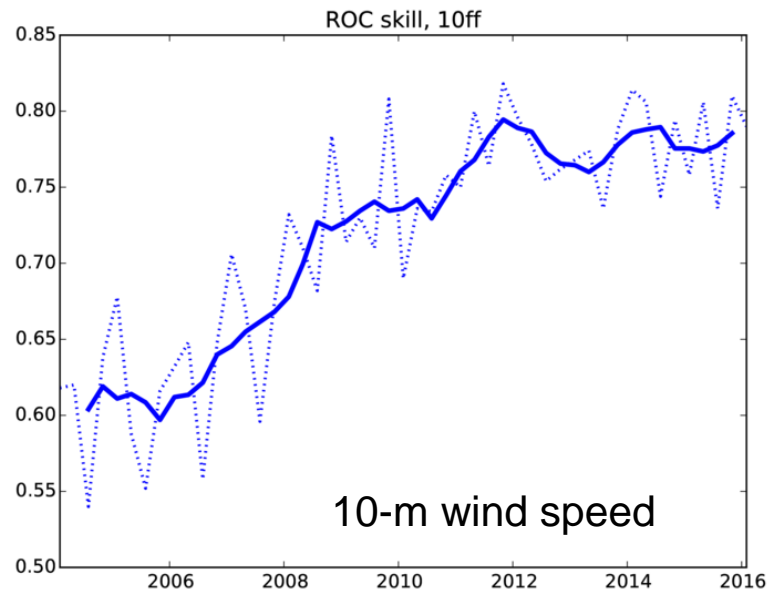


Model performance: EFI skill



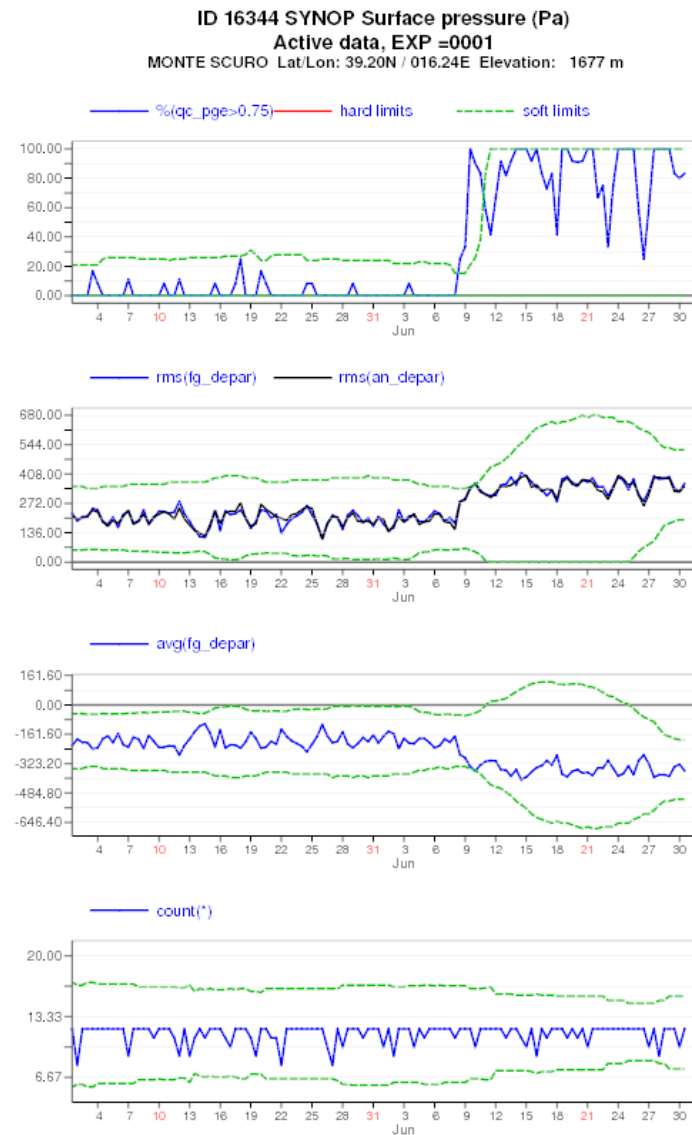
predicted by EPS March 21 March 2016 0000 UTC
e mean March 21 March 2016 0000 UTC
2d precipitation maximum 10m wind gust and mean 2m temperature at 2d
11 March 21 March 2016 0000 UTC 0 Tuesday 22 March 2016 0000 UTC

Forecast range: Day + 4



Observations statistics

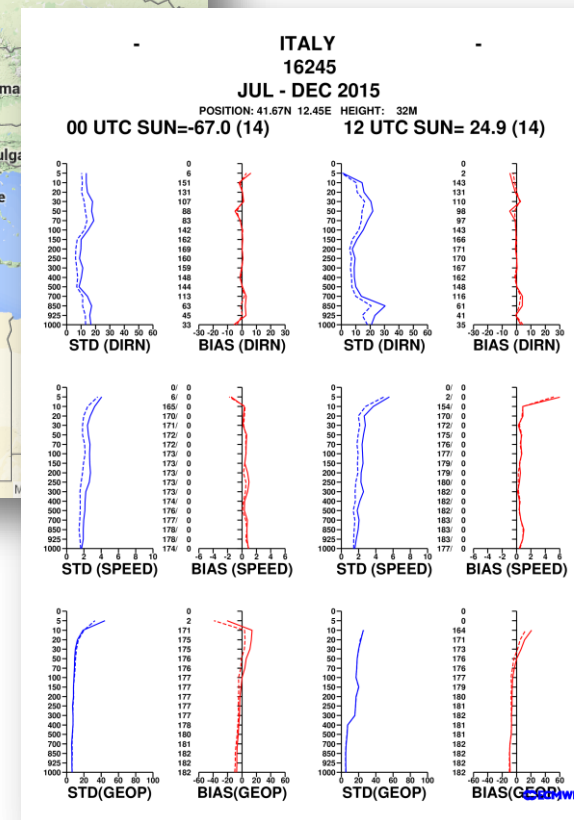
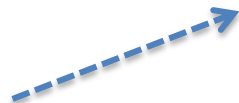
WMO Id	Valid Date (YMDH)	Station Name	Country	Position	Subtype Description	varr
16312	2015050200	Gioia Del Colle	Italy	See on Google Maps	1=>SYNOP(Manual Land SYNOP)	Sur pre (Pa)
16111	2015050412	Monte Settepani	Italy	See on Google Maps	3=>SYNOP(Automatic Land SYNOP)	Sur pre (Pa)
16060	2015072900	Torino Venaria Reale	Italy	See on Google Maps	3=>SYNOP(Automatic Land SYNOP)	Sur pre (Pa)
16344	2015063012	Monte Scuro	Italy	See on Google Maps	9=>SYNOP(Abbreviated SYNOP)	Sur pre (Pa)
16450	2015073100	Enna	Italy	See on Google Maps	9=>SYNOP(Abbreviated SYNOP)	Sur pre (Pa)



Observation statistics

WMO best TEMP stations (2015)

WMO code	Location
16044	Udine
16080	Milano
16113	Cuneo
16144	Bologna
16245	Pratica di Mare
16320	Brindisi
16429	Trapani
16546	Decimomannu



Thank you