ECMWF: software, services, products and model developments

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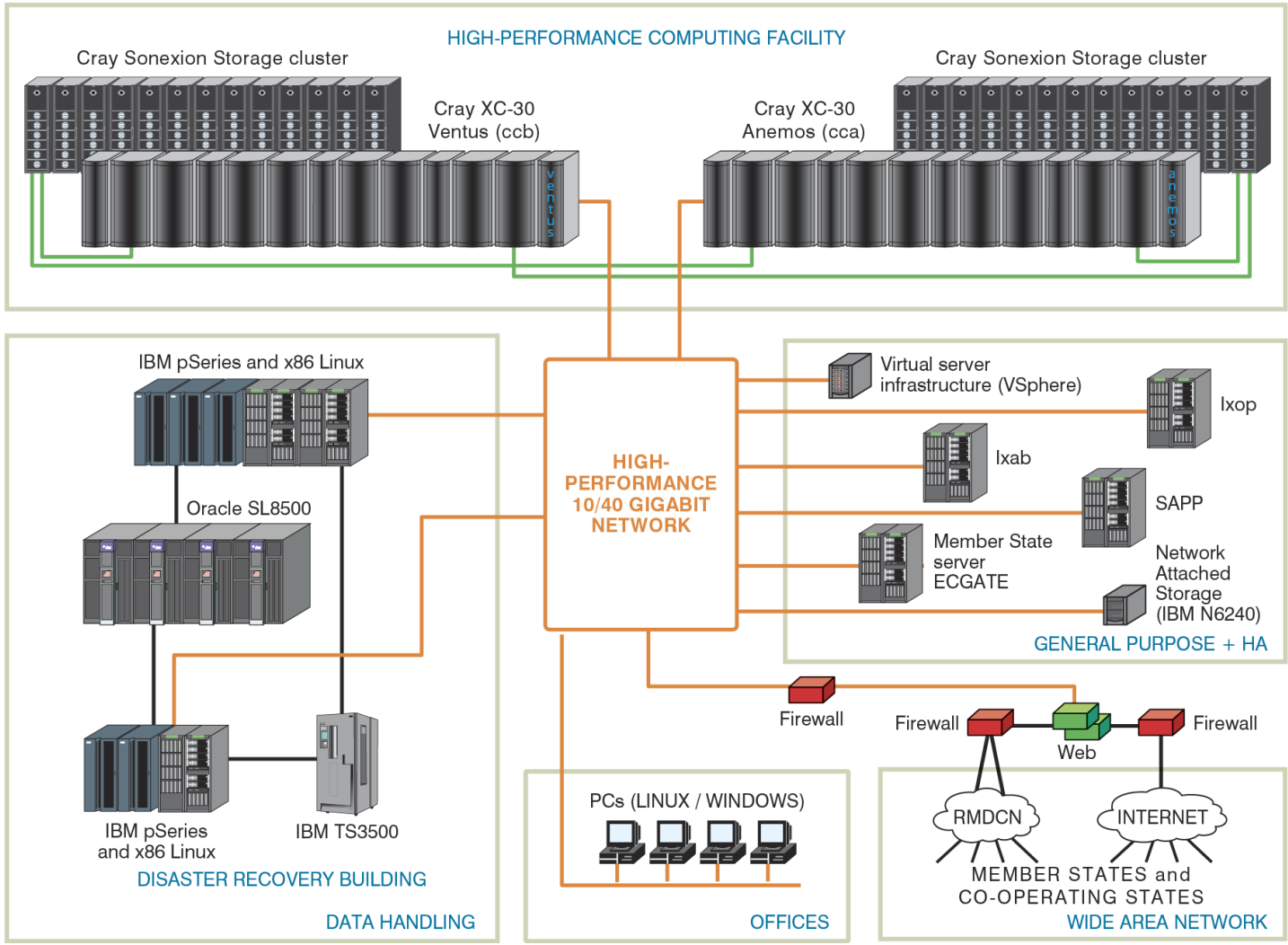
ECMWF

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

WEBINAR

"HPCF Cray phase 2 upgrade"

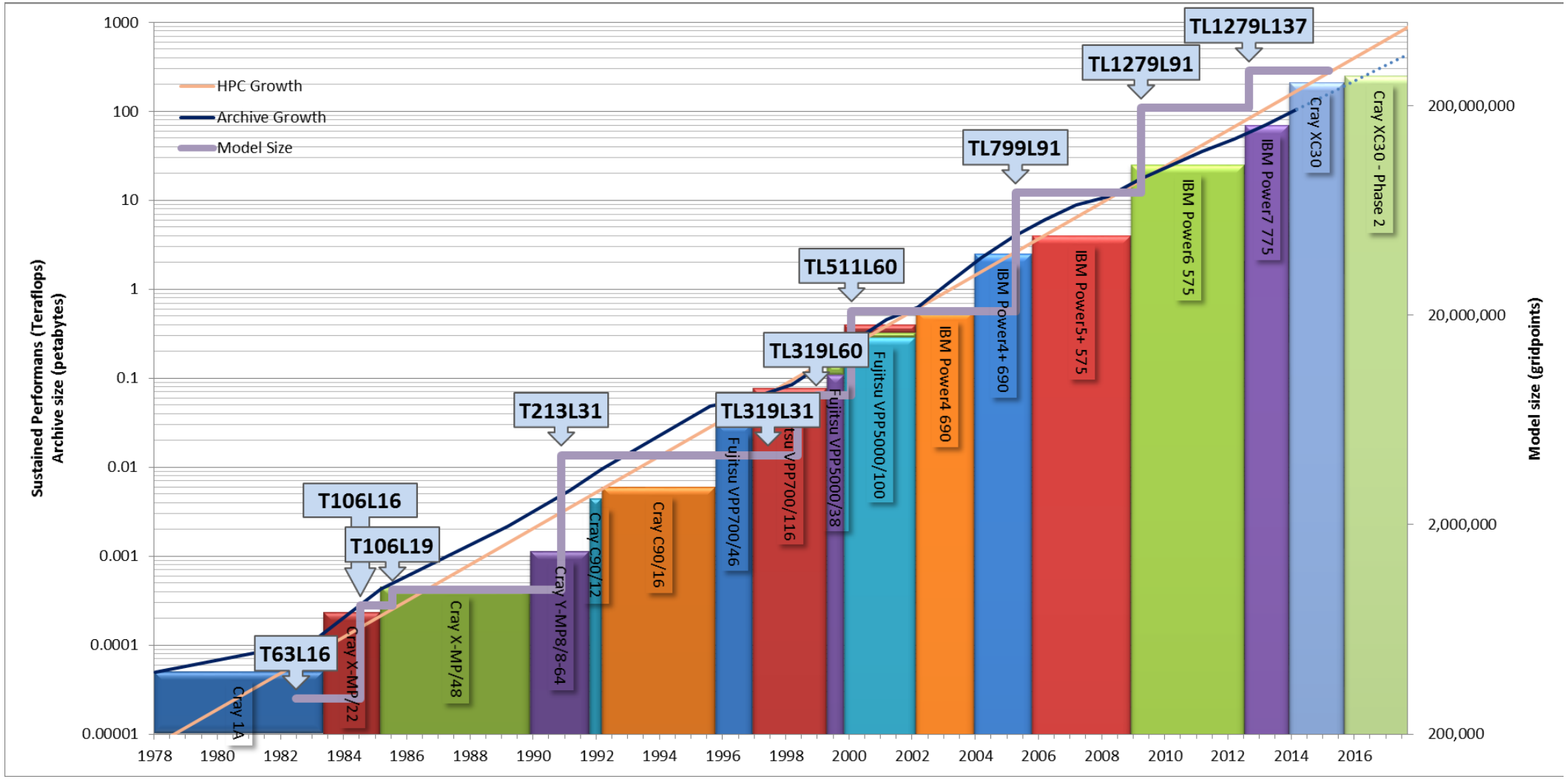
Tuesday, 12 April 2016, 8:00 UTC

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

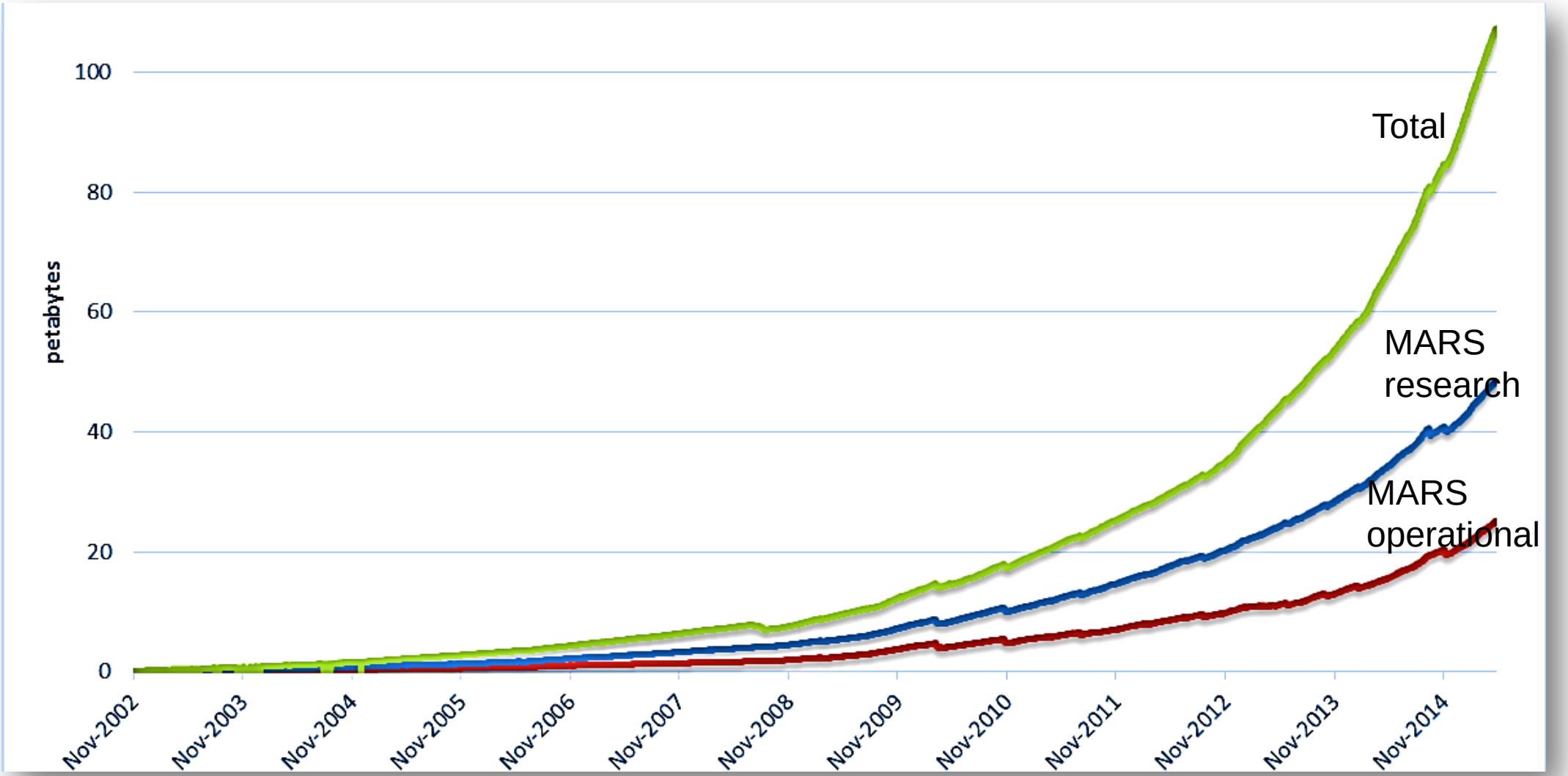
https://ecmwf.webex.com/

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

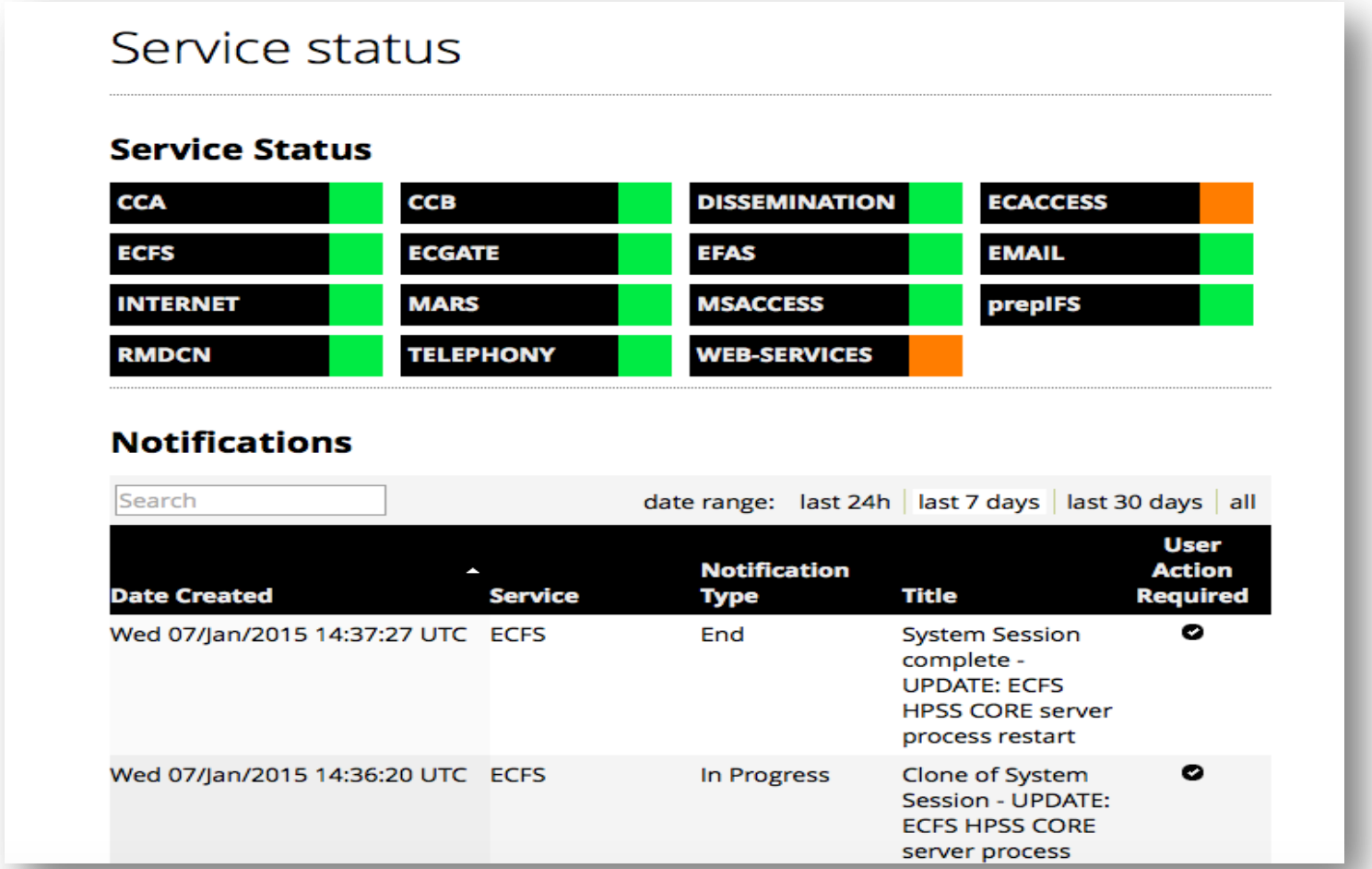
- 2 Intel Xeon processor (Sandy Bridge-EP):
- 16 core at 2.7 GHz
- 128 GB memory
- 2 x 900 GB SAS HDD

6 I/O server nodes

- ~172 TB raw disk space

Available to ~3000 users at more than 300 institutions

Operational status



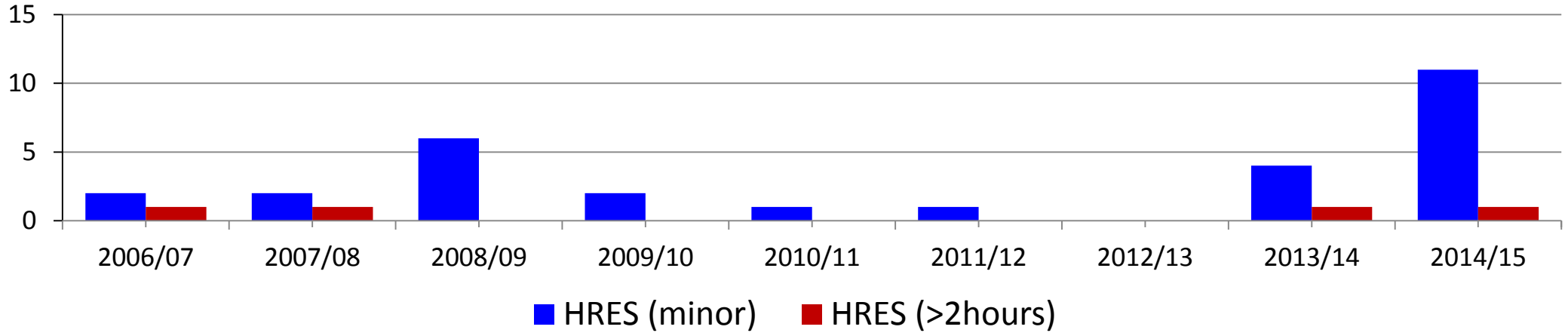
http://www.ecmwf.int/en/service-status

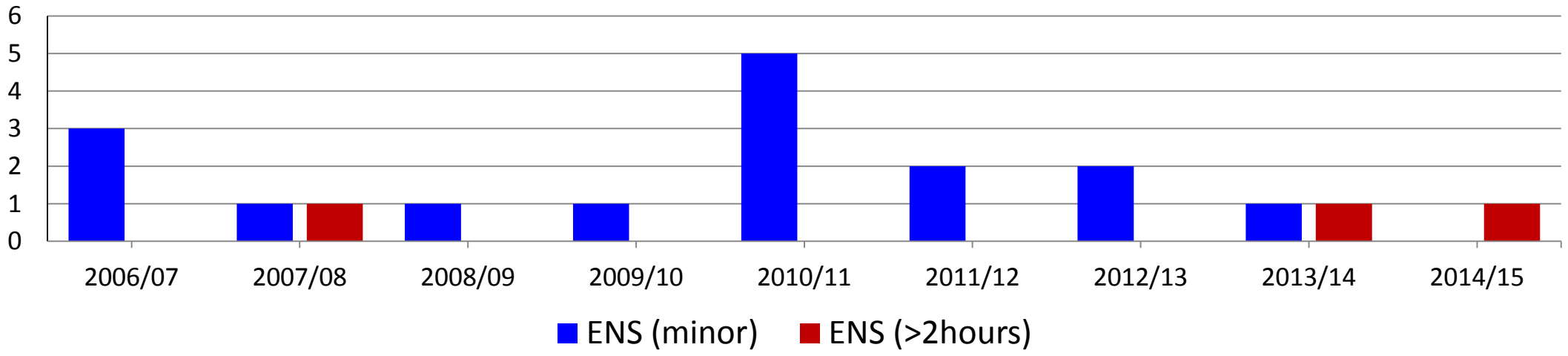
Performance of services

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

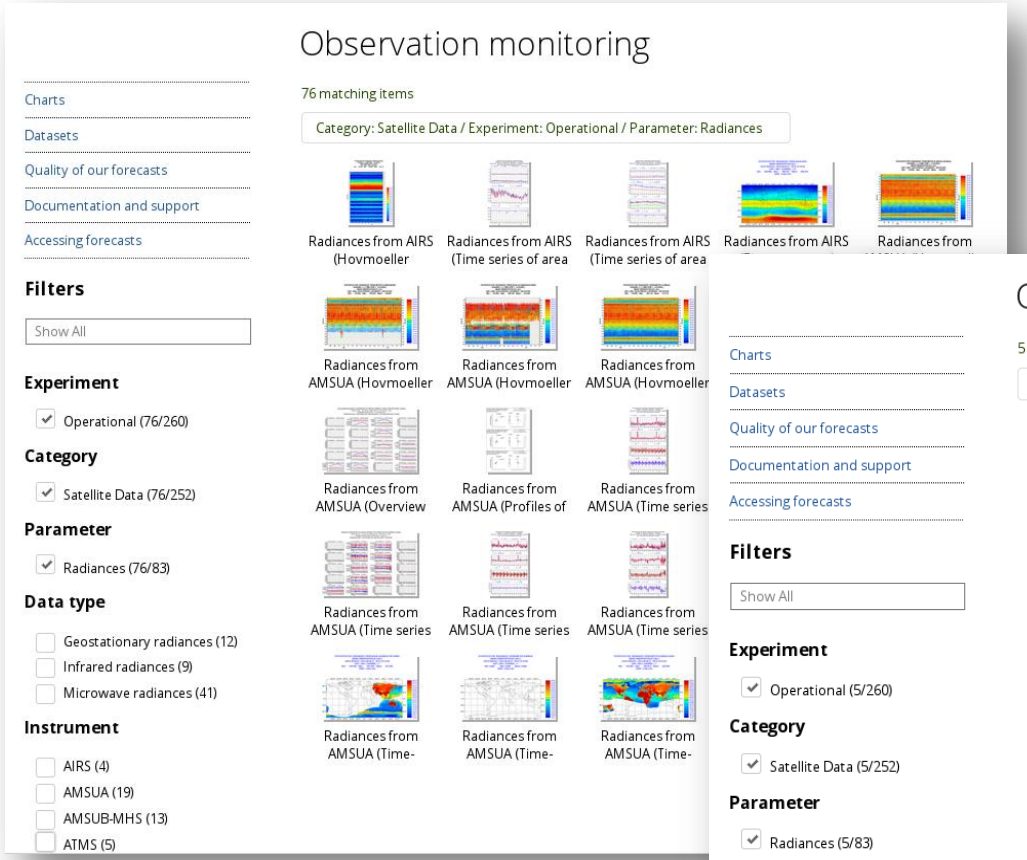
- Timeliness of forecast delivery
- Availability targets for HPCF and ecgate service
- Response time targets for Web service
- Service Levels for RMDCN service (network availability,..)

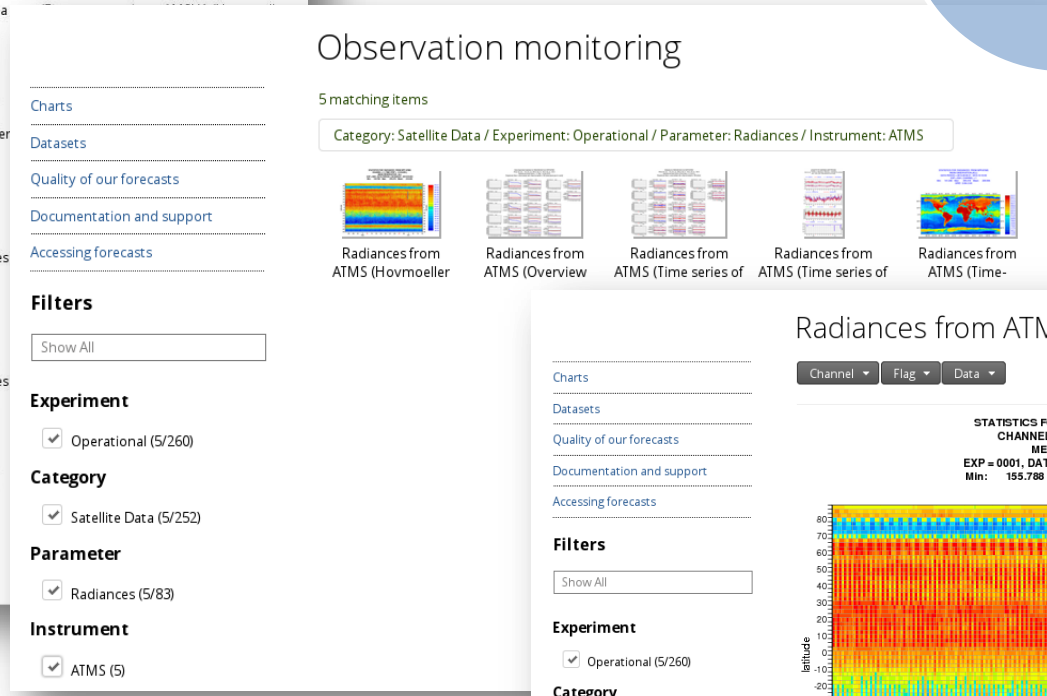
Timeliness of forecast delivery

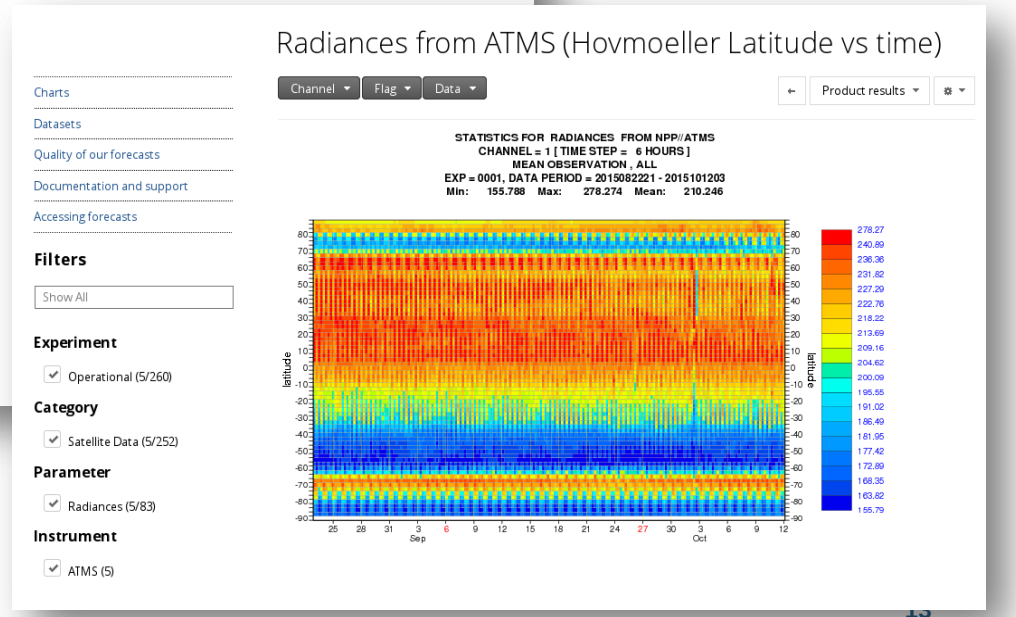




Web services: faceted search







Category
- Conventional data
- Satellite
- …

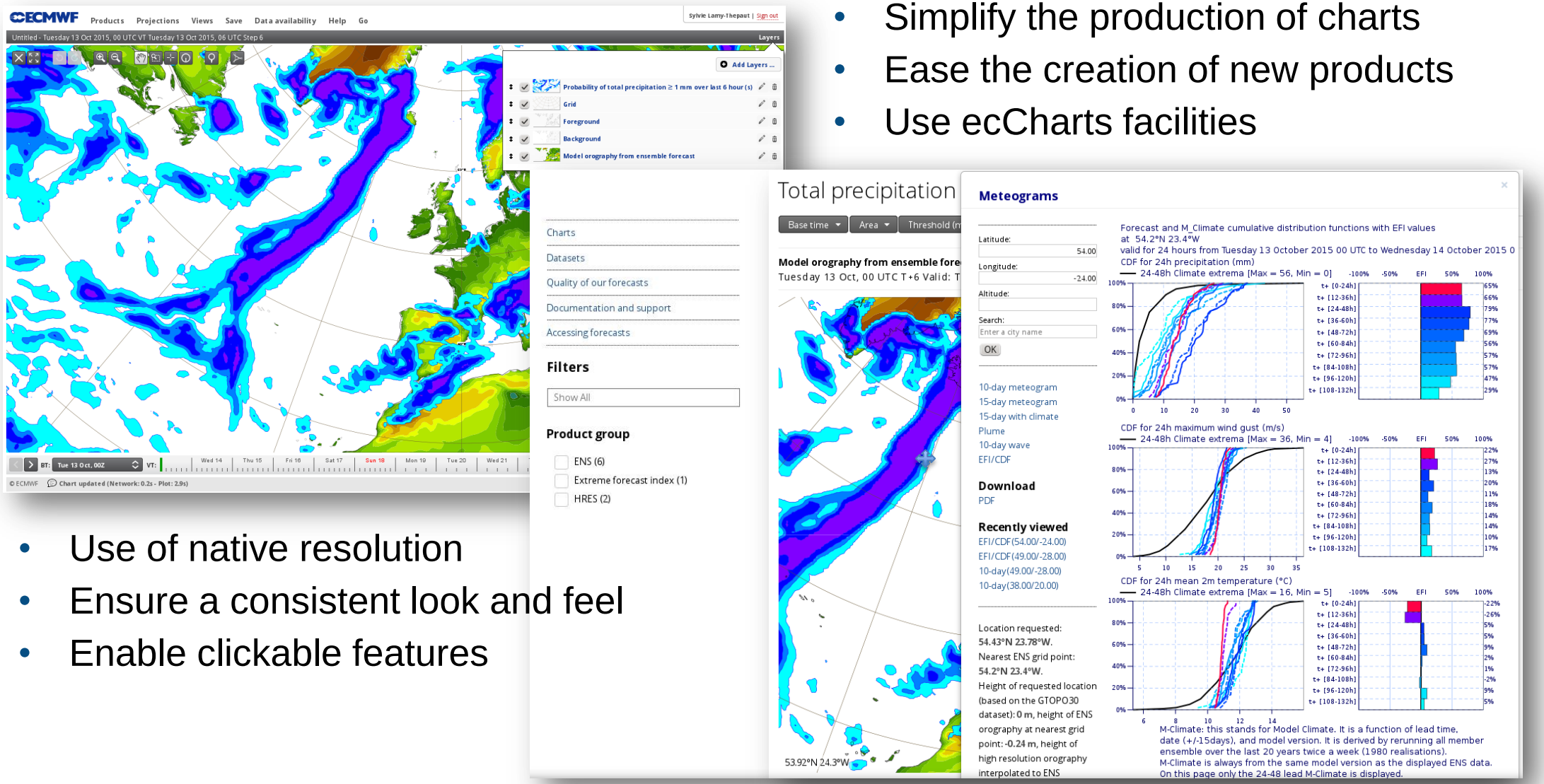
Instrument
- ATMS
- AORS
- …
- AVRHH

Parameter
- Radiances
- Ozone
- 2m temperature
- …

Data Type
- Microwave radiances
- Infrared radiances
- …

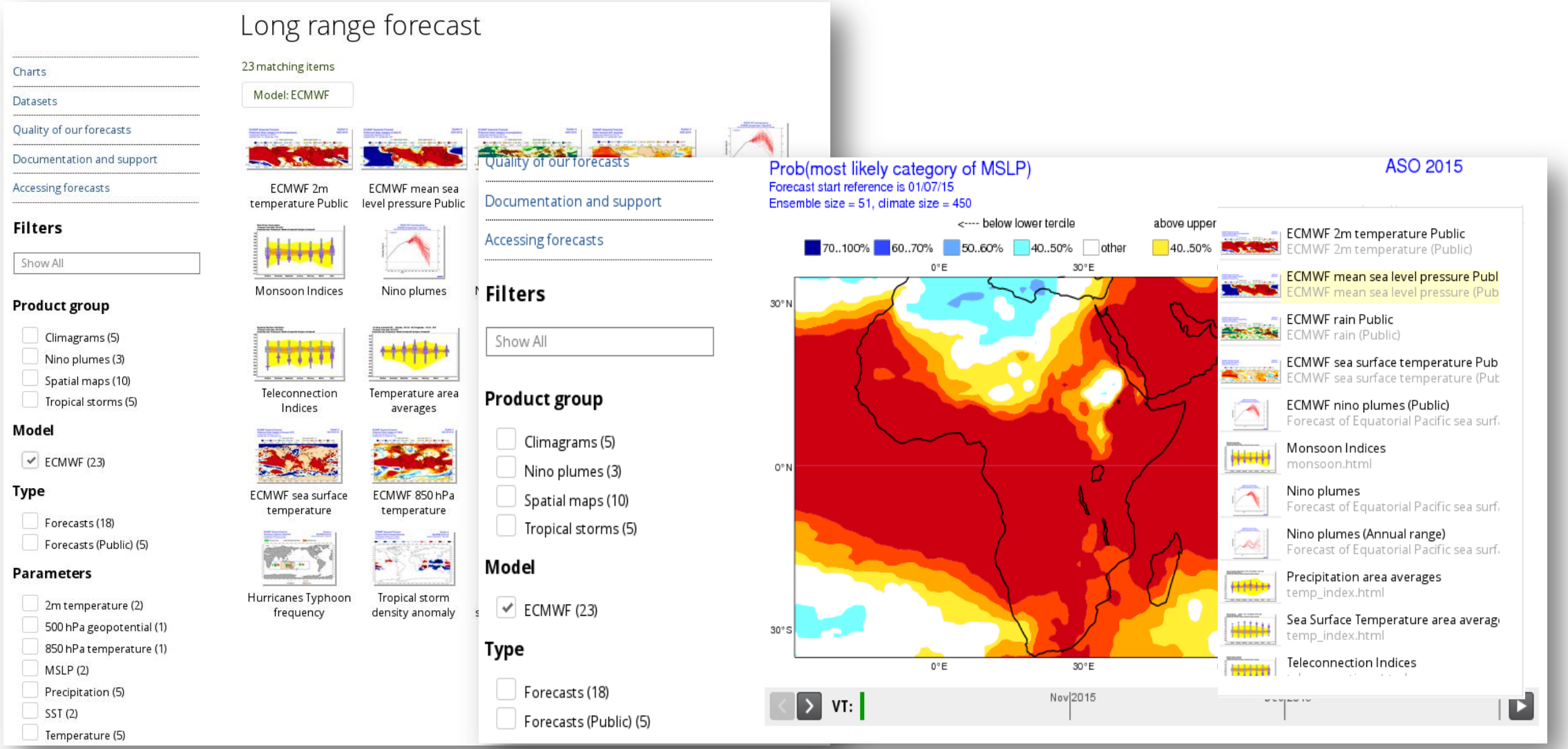
The interactive maps …

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

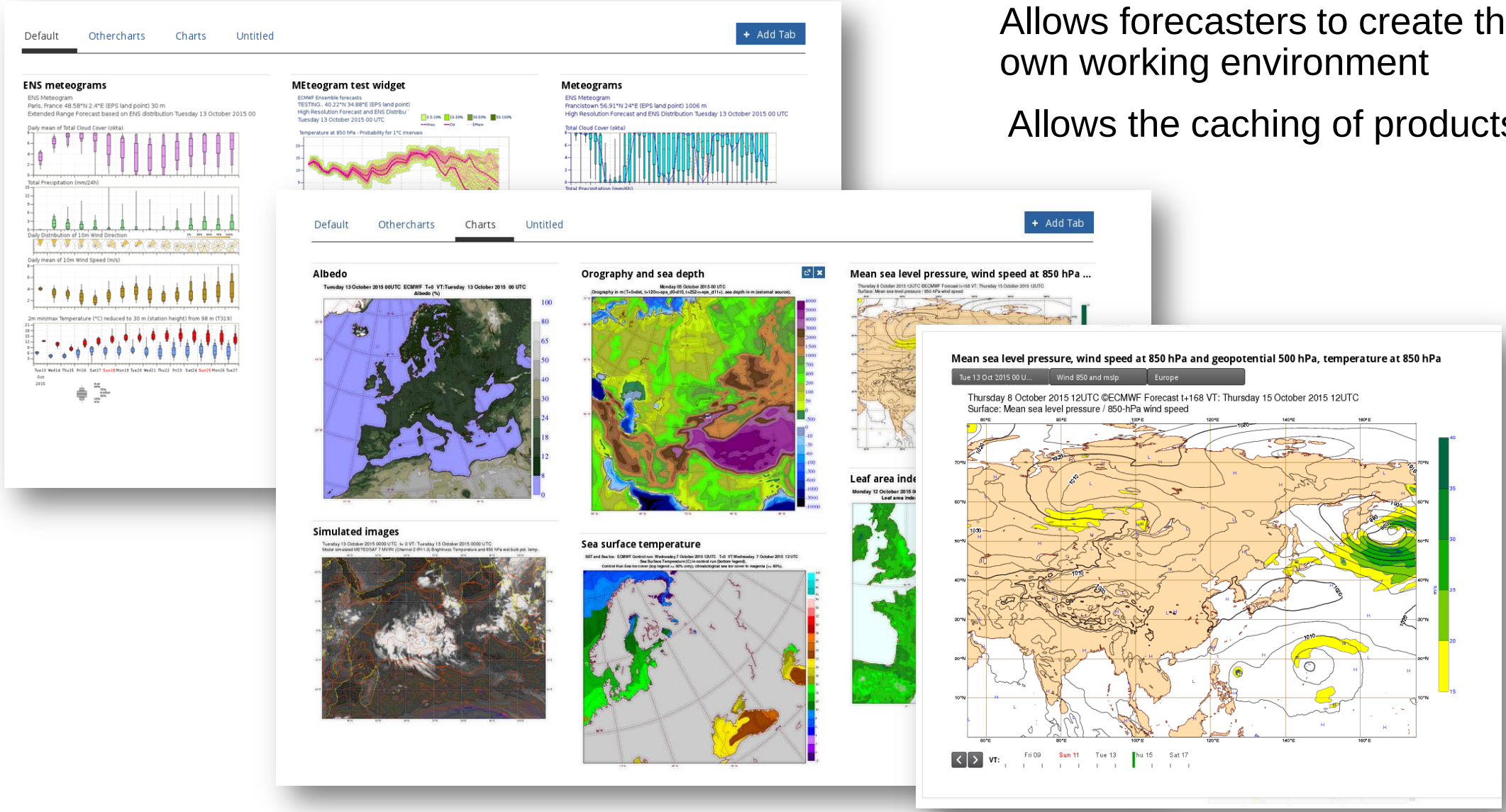


- Use of native resolution
- Ensure a consistent look and feel
- Enable clickable features

The chart navigator



The dashboard

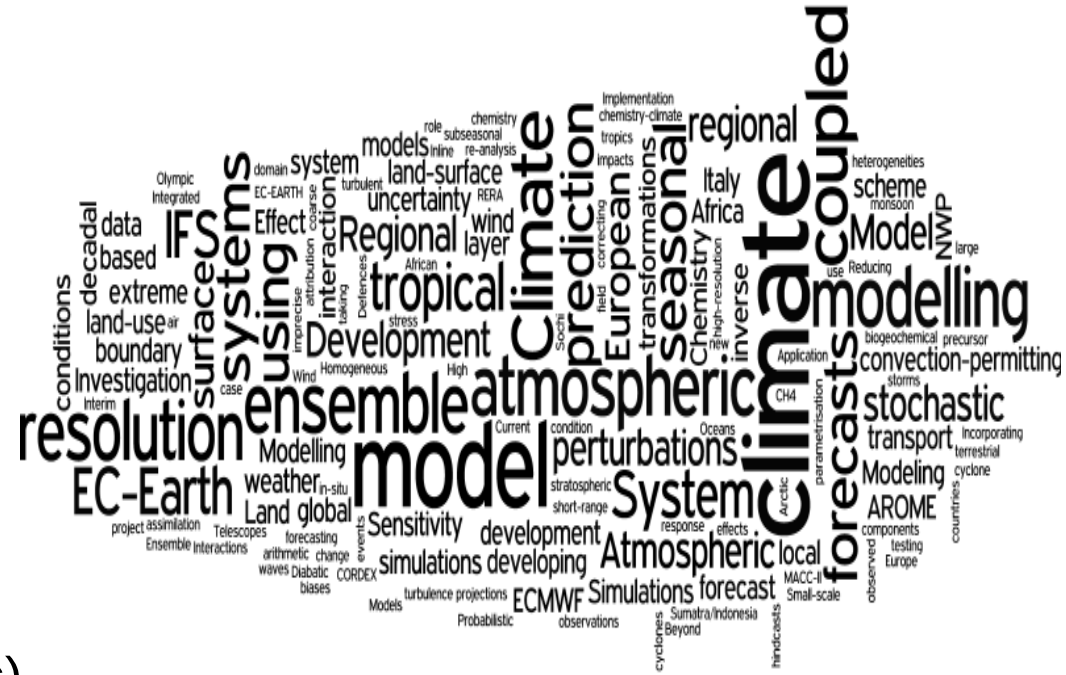


Allows forecasters to create their own working environment

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

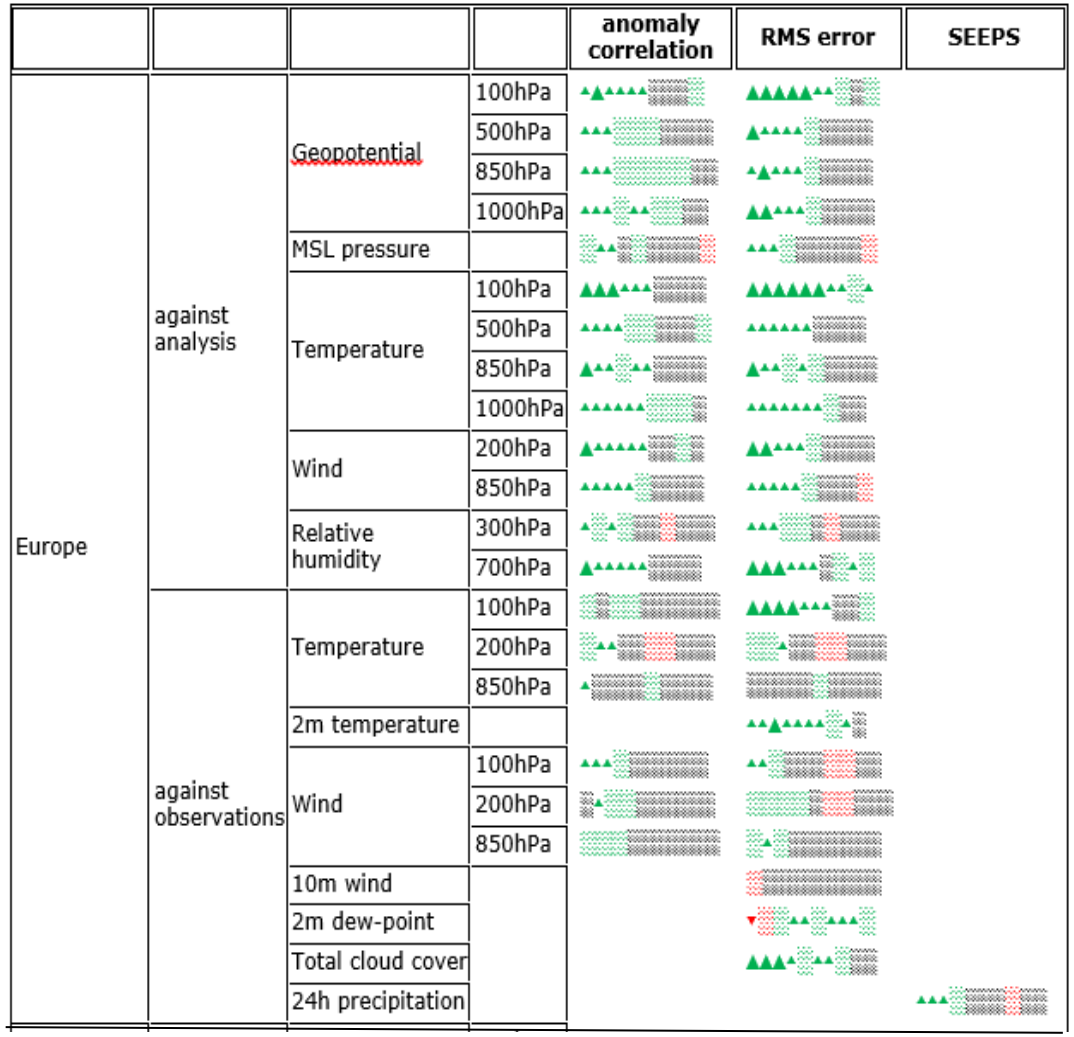
Forecast production

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



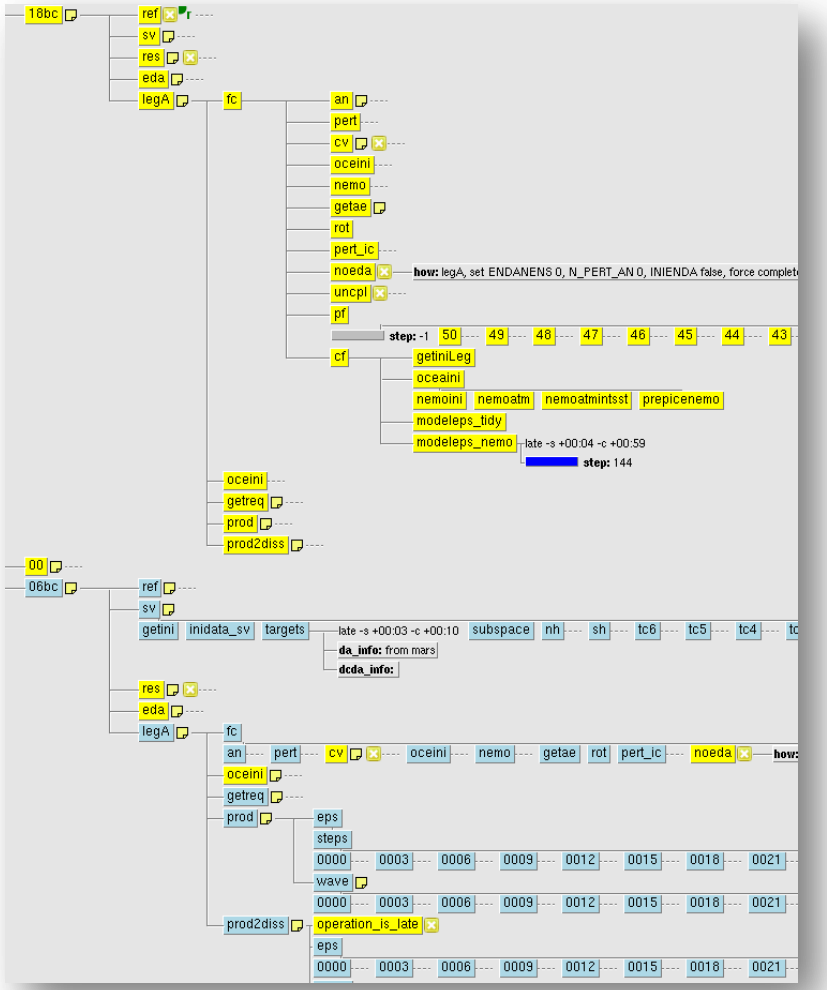
Boundary Condition optional programme

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

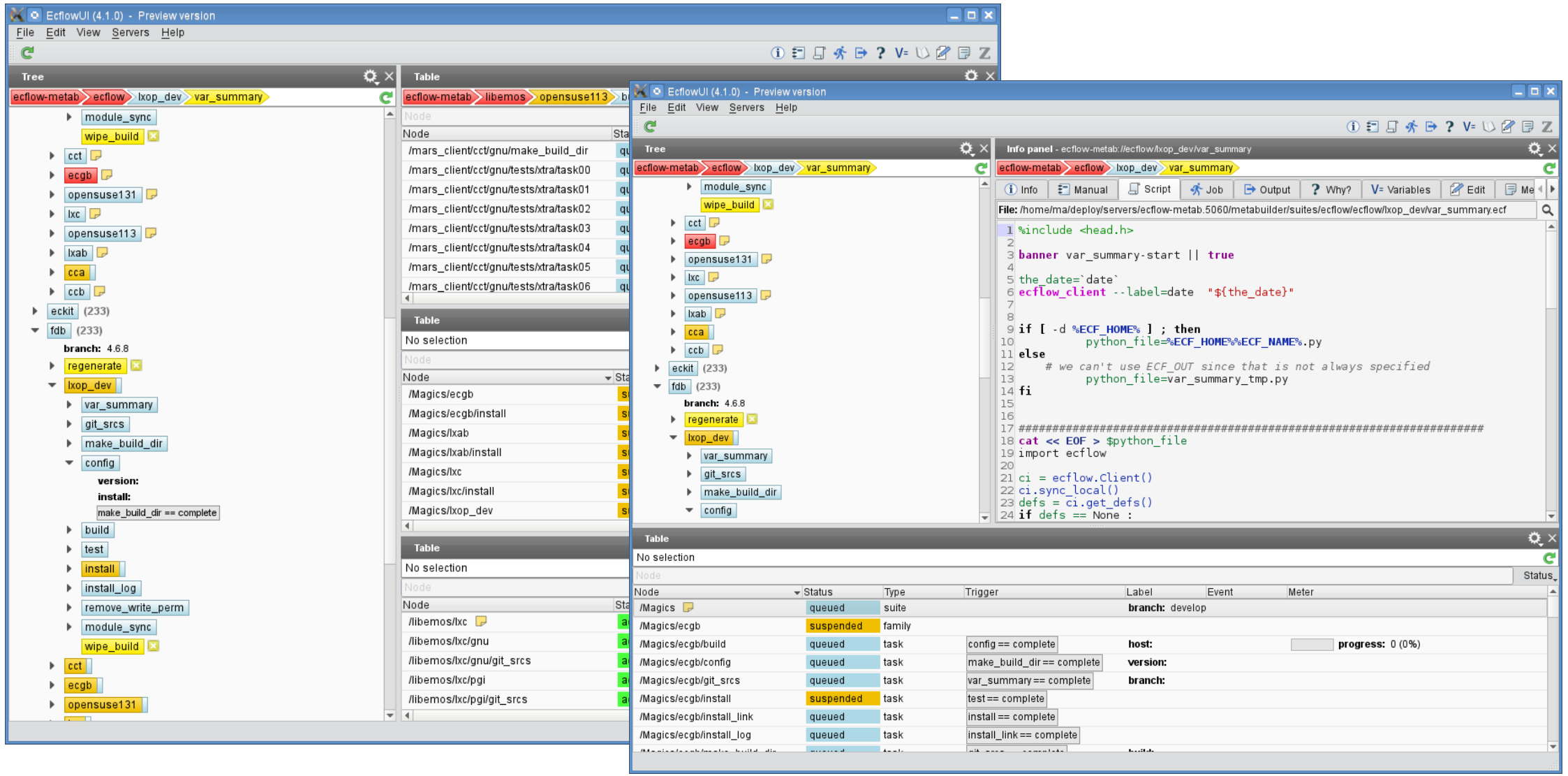
Products from the 4 cycles can be requested in Dissemination or retrieved from MARS

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

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



ecFlowUI : modern and reliable interface



Software support infrastructure

Available at

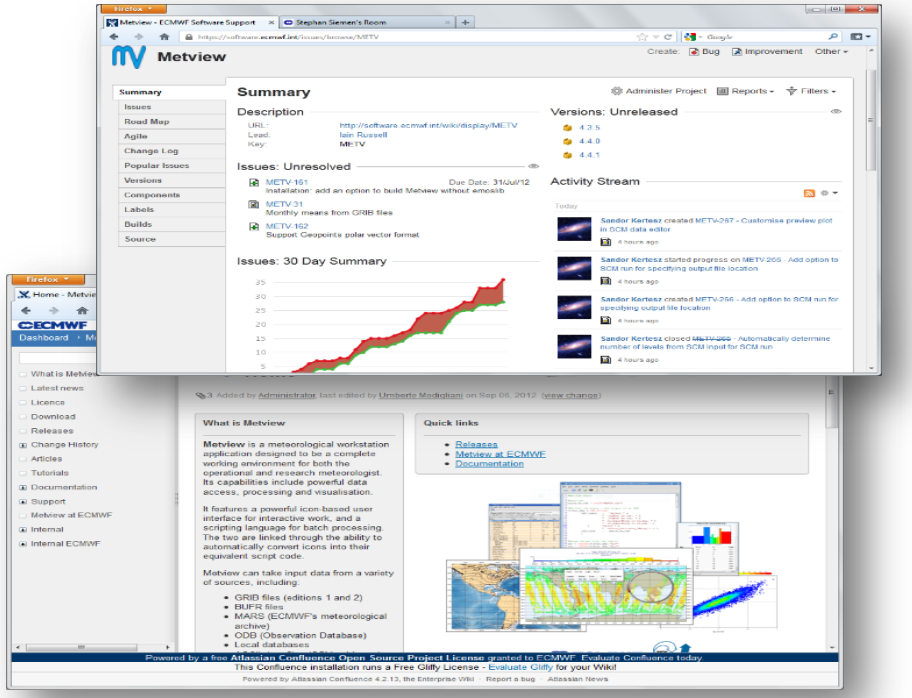
http://software.ecmwf.int/

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

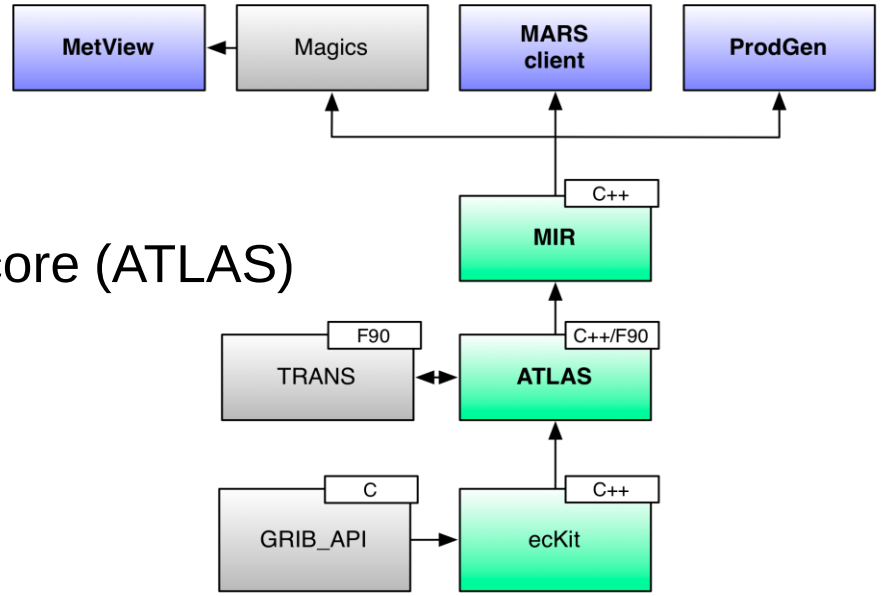
- JIRA (issues)
- Confluence (documentation wiki)
- Bamboo (Builds)



MIR New Interpolation package

Flexible and maintainable design

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



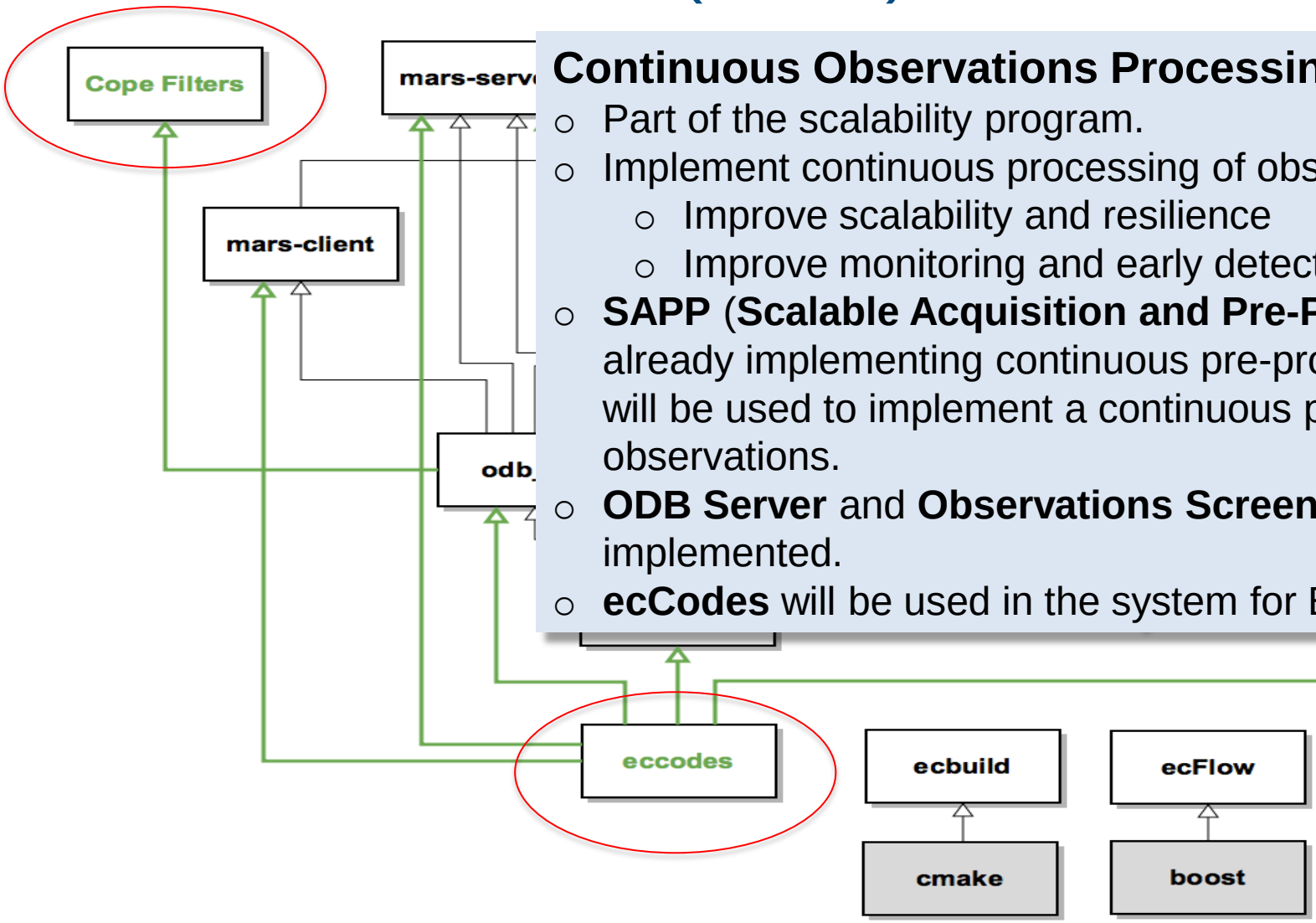
Any-to-Any Grid algorithm

- 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)



Continuous Observations Processing Environment (COPE)

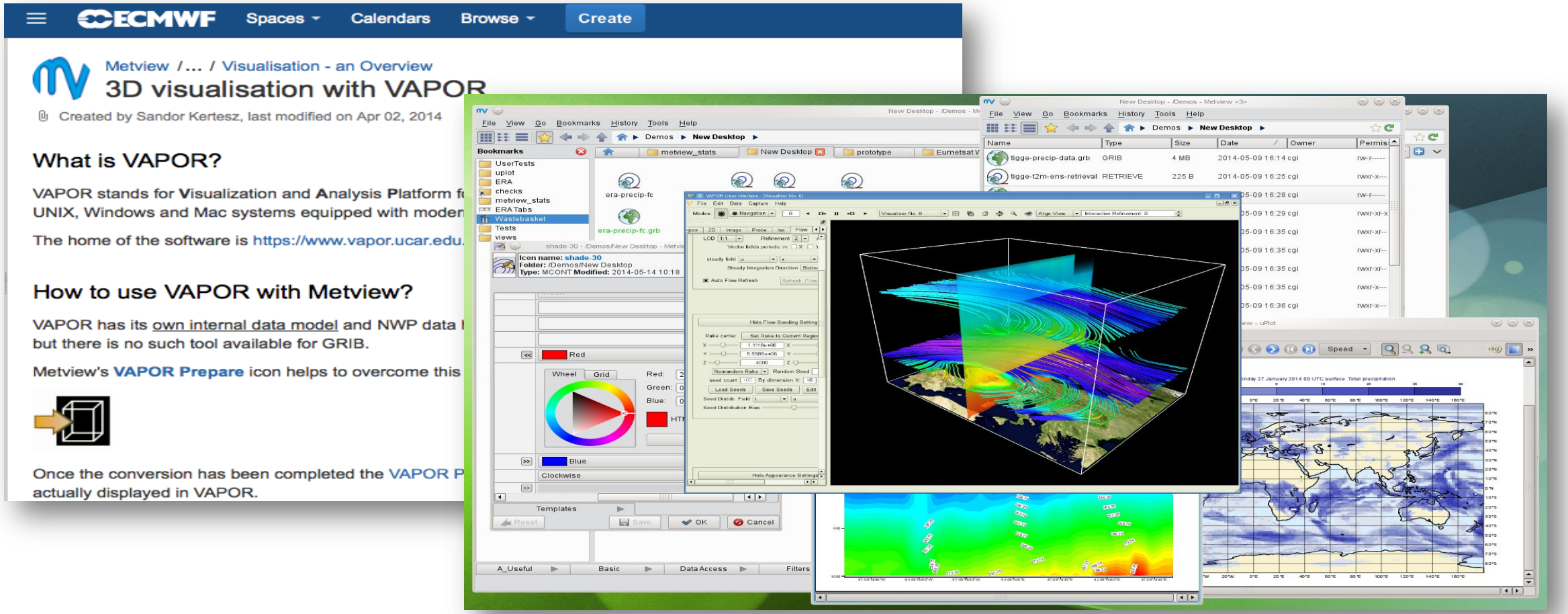
- Part of the scalability program.
- Implement continuous processing of observations with the aim to
  - Improve scalability and resilience
  - Improve monitoring and early detection of poor quality data
- **SAPP** (**Scalable Acquisition and Pre-Processing**) system is already implementing continuous pre-processing of observations. It will be used to implement a continuous pre-screening of observations.
- **ODB Server** and **Observations Screening Facility** will be implemented.
- **ecCodes** will be used in the system for BUFR and GRIB processing

ecCodes

= GRIB-API (GRIB decoder) + BUFR decoder + GTS headers decoder + METAR decoder + ???? decoder

- 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



http://software.ecmwf.int/metview)

Partnership

S2S (WWRP/THORPEX/ WCRP joint research project)

http://wwww.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.

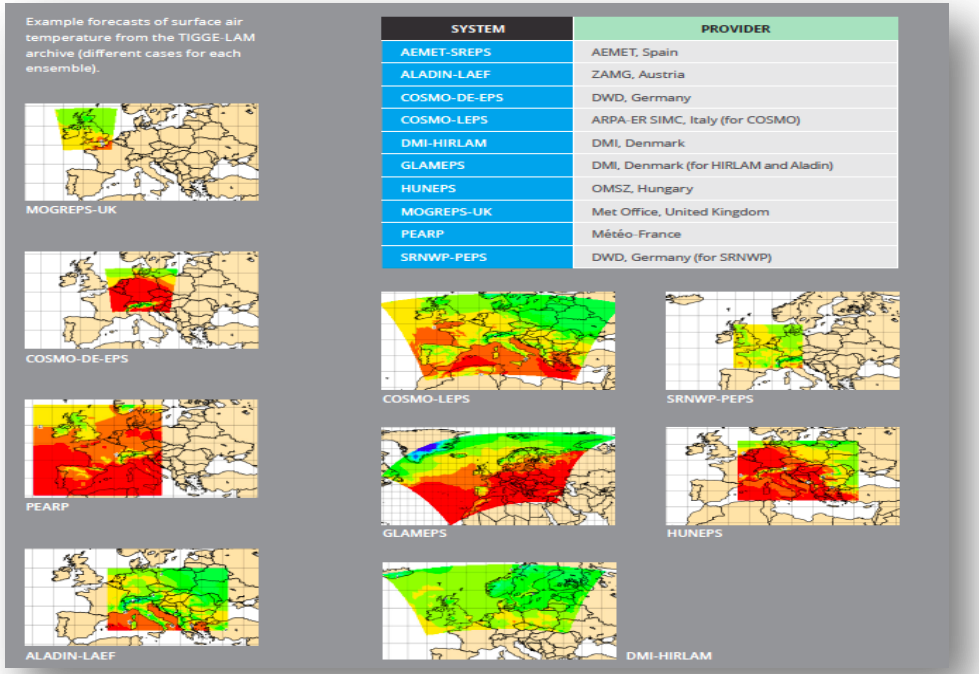
Specific attention will be paid to the risk of extreme weather, including tropical cyclones, droughts, floods, heat waves and the waxing and waning of monsoon precipitation.

Partnership

TIGGE-LAM

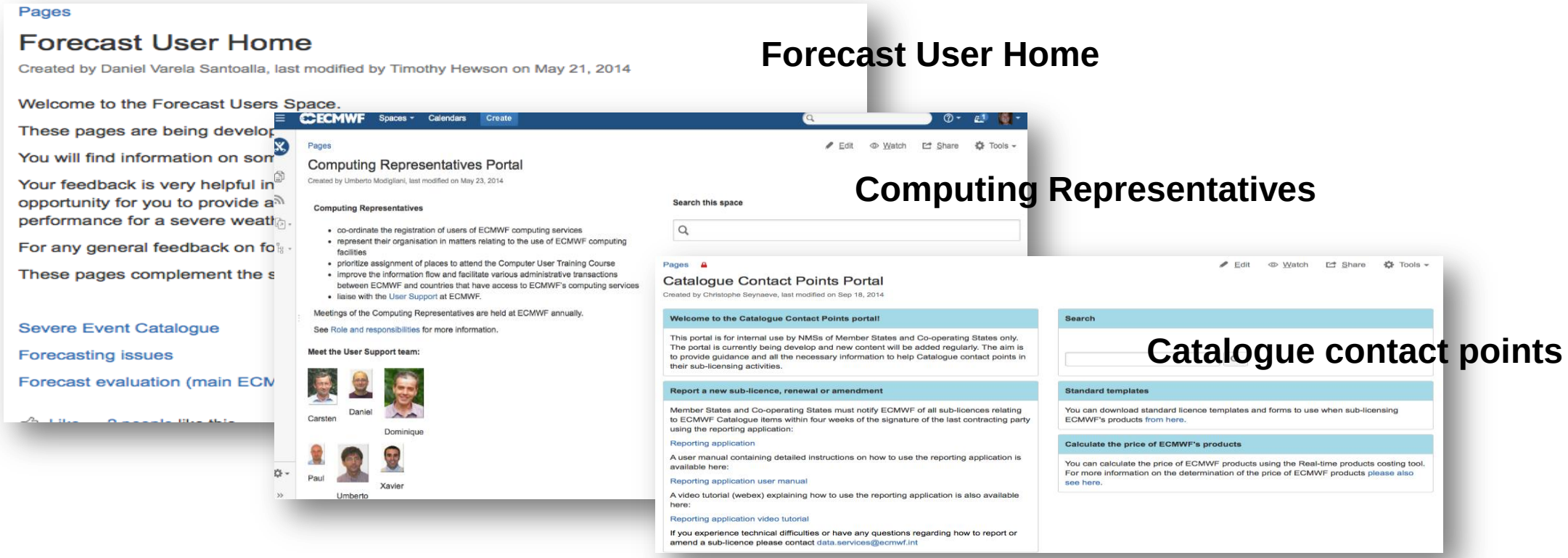
http://www.smr.arpa.emr.it/tiggelam/

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.



SYSTEM	PROVIDER
AEMET-SREPS	AEMET, Spain
ALADIN-LAEF	ZAMG, Austria
COSMO-DE-EPS	DWD, Germany
COSMO-LEPS	ARPA-ER SIMC, Italy (for COSMO)
DMI-HIRLAM	DMI, Denmark
GLAMEPS	DMI, Denmark (for HIRLAM and Aladin)
HUNEPS	OMSZ, Hungary
MOGREPS-UK	Met Office, United Kingdom
PEARP	Météo-France
SRNWP-PEPS	DWD, Germany (for SRNWP)

Knowledge exchange: the Portals

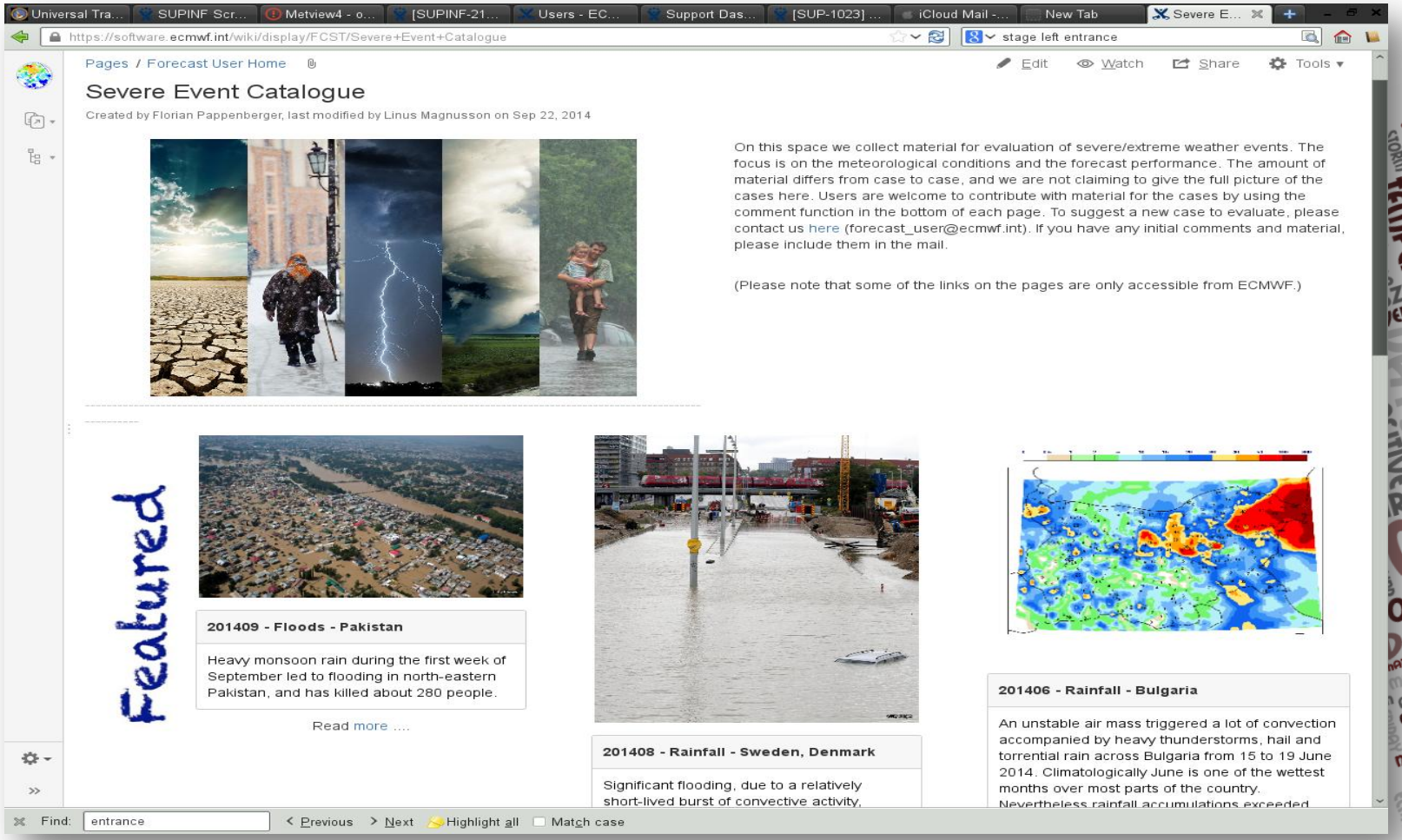


https://software.ecmwf.int/wiki/display/FCST/Forecast+User+Home

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

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

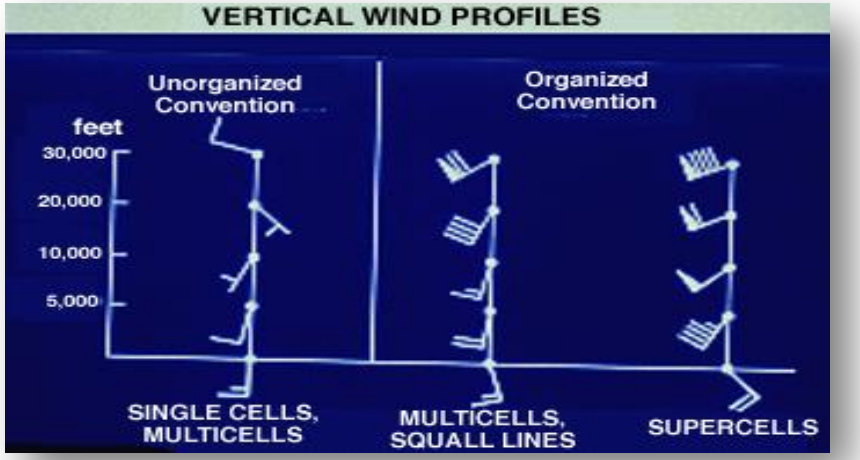
Severe event catalogue



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

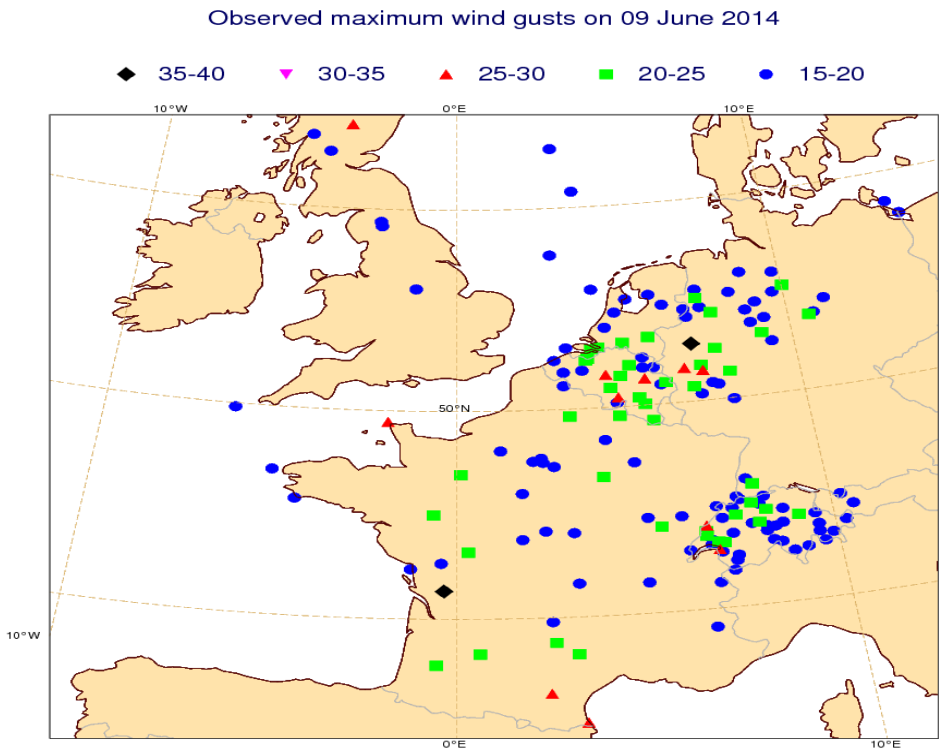
Severe convection: CAPESHEAR

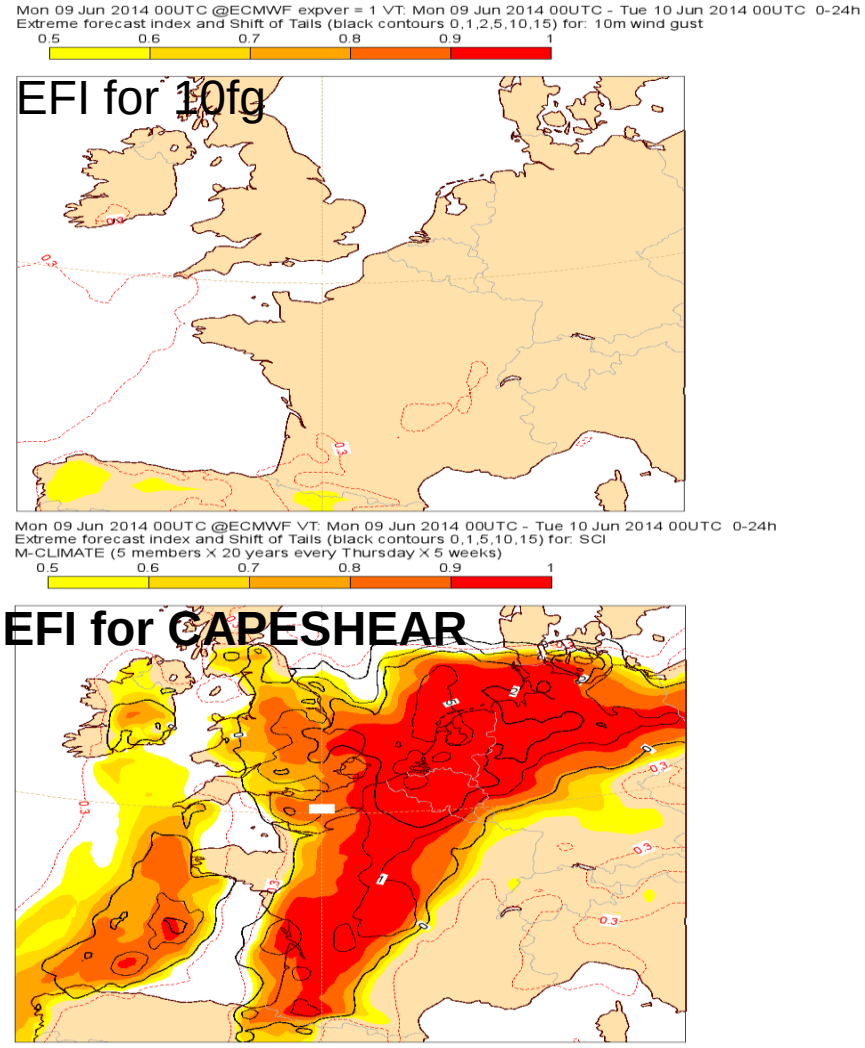
$$CAPESHEAR = [WindShear]_{L1}^{L2} * \sqrt{CAPE}$$



- 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)



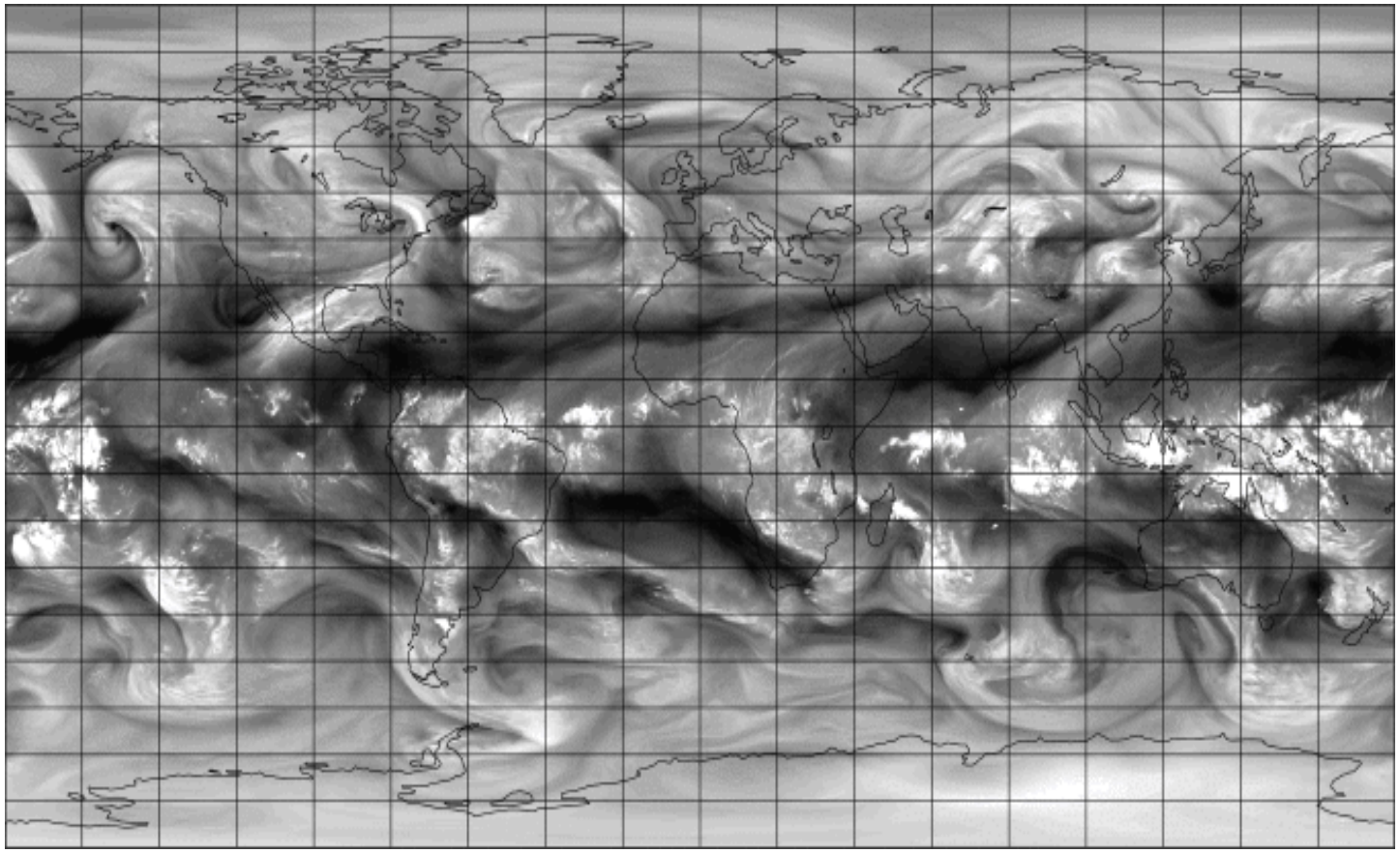


- Severe convection affected Western Europe from southern France to northern Germany on 9 Jun 2014.
- The maximum wind gust at Dűsseldorf airport was 42 m/s.

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)



Copernicus activities

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.

Copernicus: CAMS

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 SO_2); improvement of wildfire emissions; improvement of the UV processor*

Copernicus: C3S

C3S:

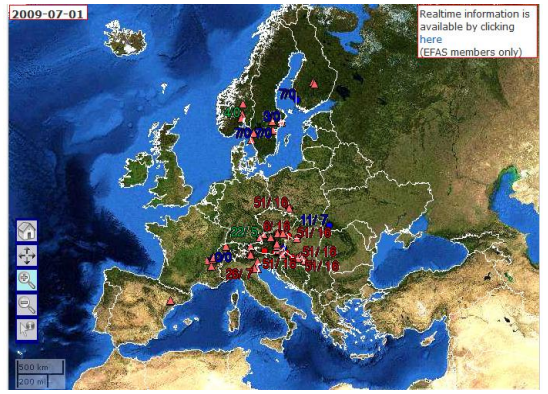
Set-up of the “Proof of Concept” phase, workshops and consultations
Global reanalysis and seasonal forecasts (ECMWF internal contributions)

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

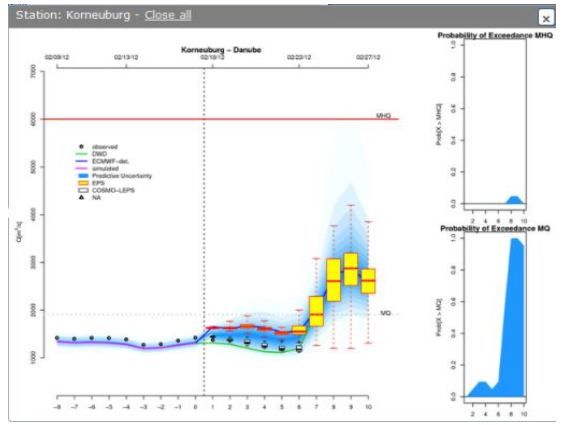
European Flood Awareness System (EFAS)

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

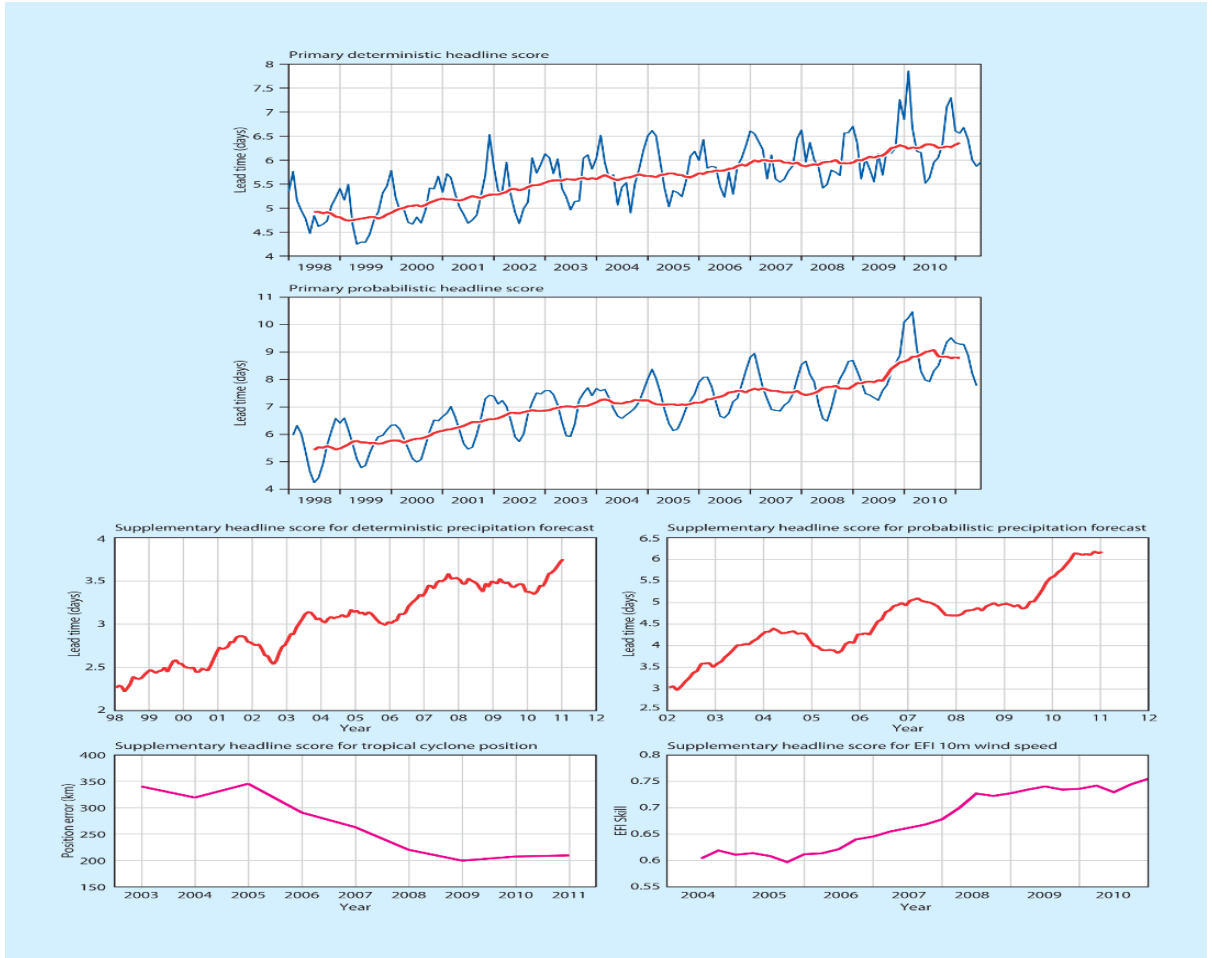
- HRES upper-air skill
- ENS upper-air skill

4 supplementary scores

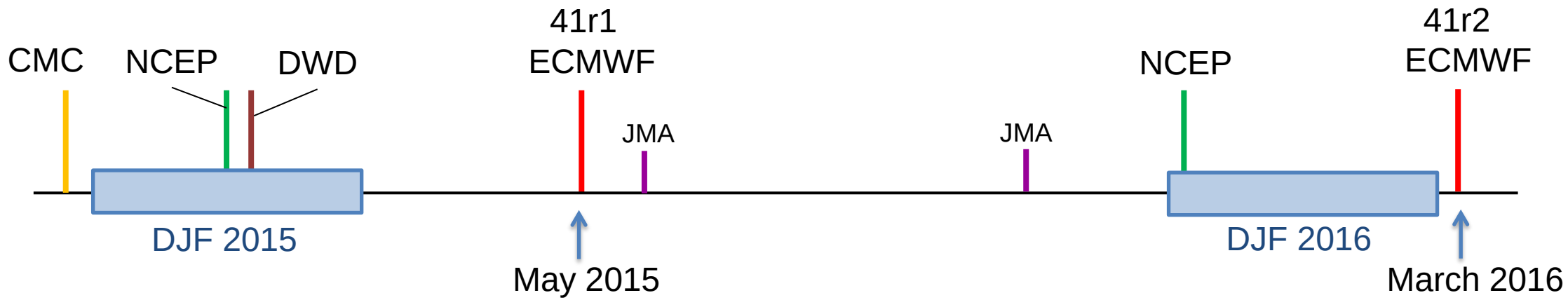
- Precipitation
- HRES skill
- ENS skill

Severe weather

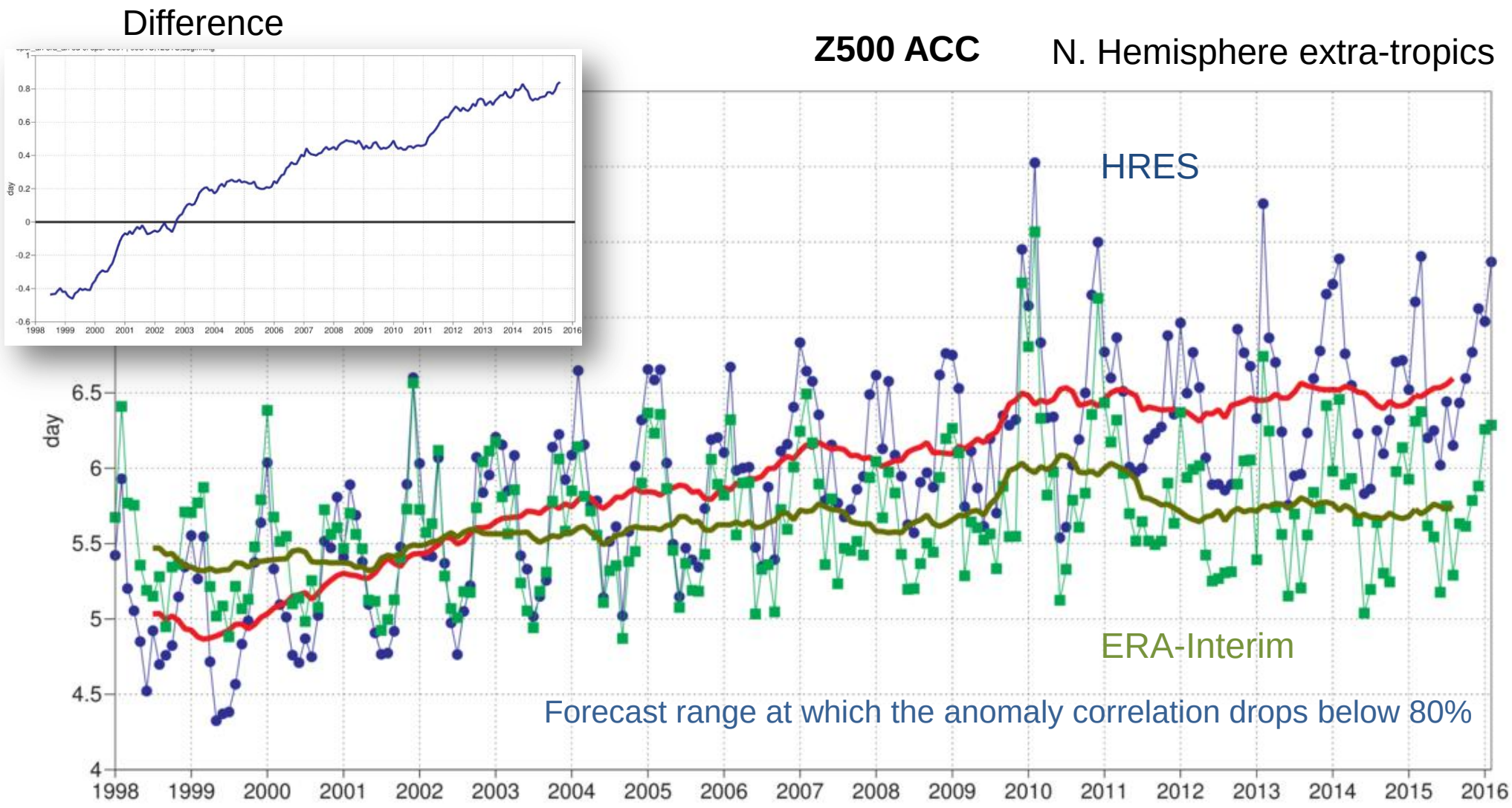
- Tropical cyclone track position error
- EFI skill



Global model upgrades



Model performance: HRES relative to ERA-I



Model performance: HRES relative to ERA-I

Difference

Z500 ACC S. Hemisphere extra-tropics

HRES

ERA-Interim

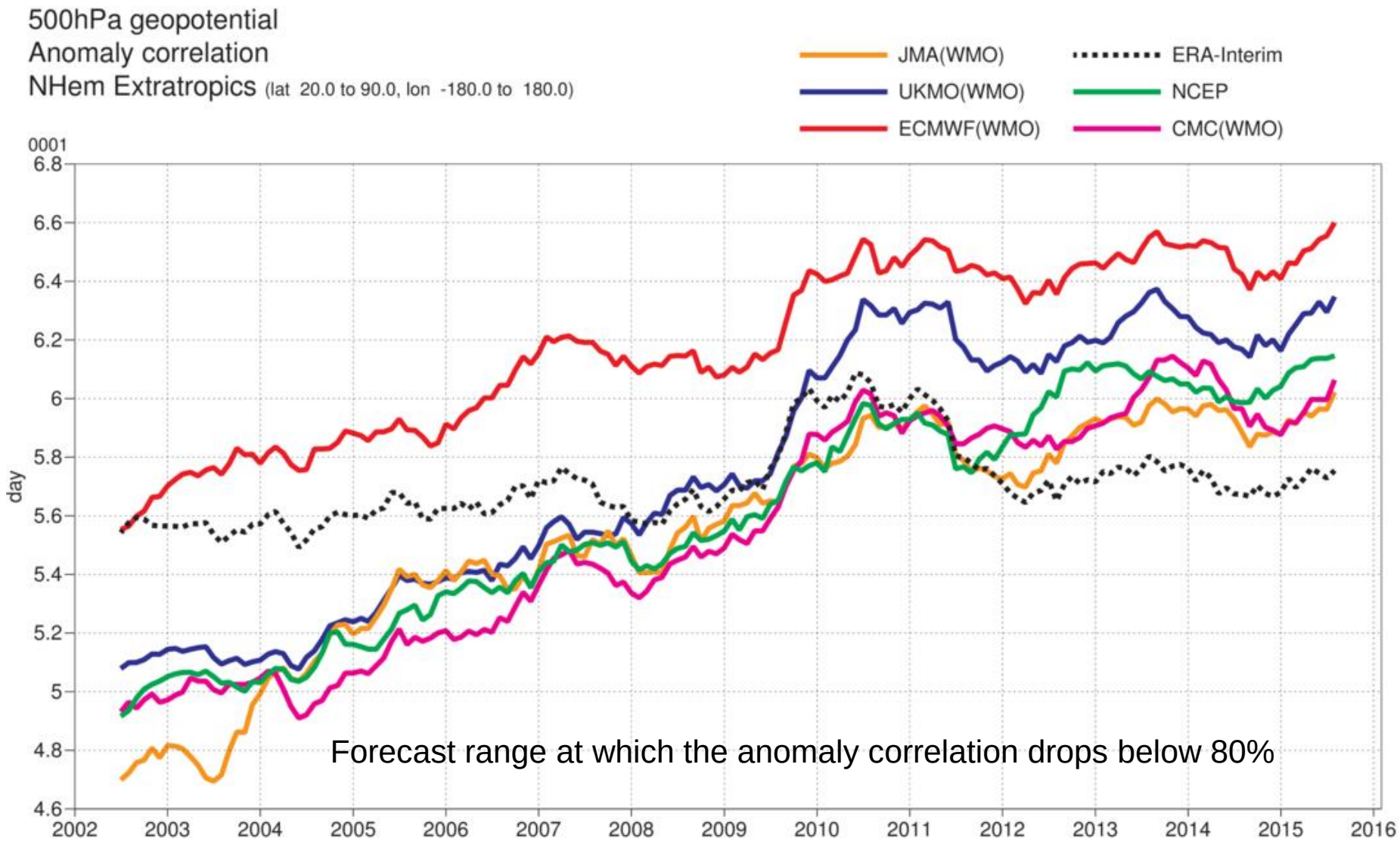
Forecast range at which the anomaly correlation drops below 80%

day

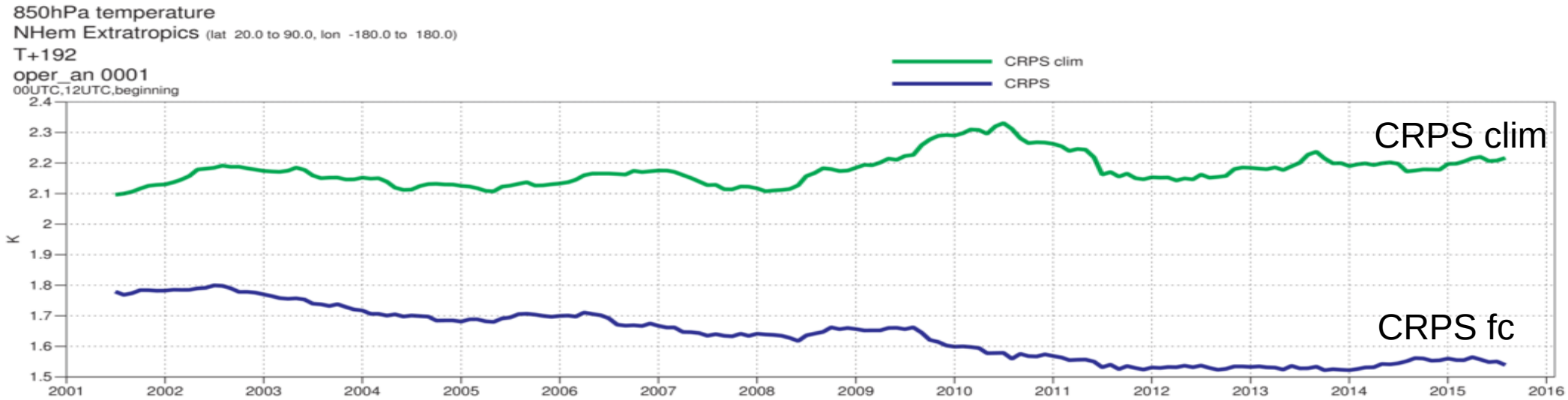
6.5
6
5.5
5
4.5
4

1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016

Model performance: comparisons with other centres



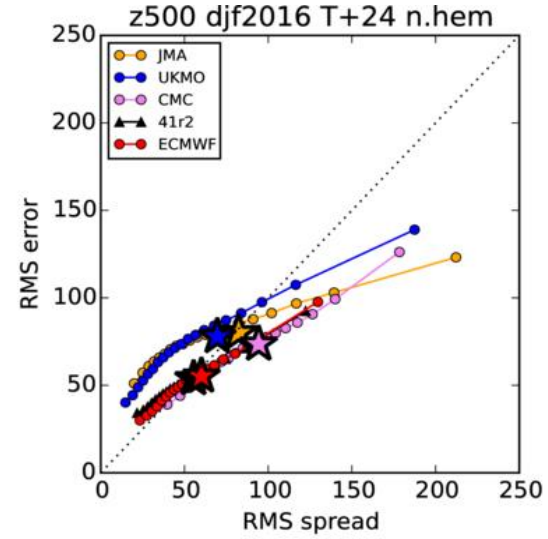
Model performance: ENS

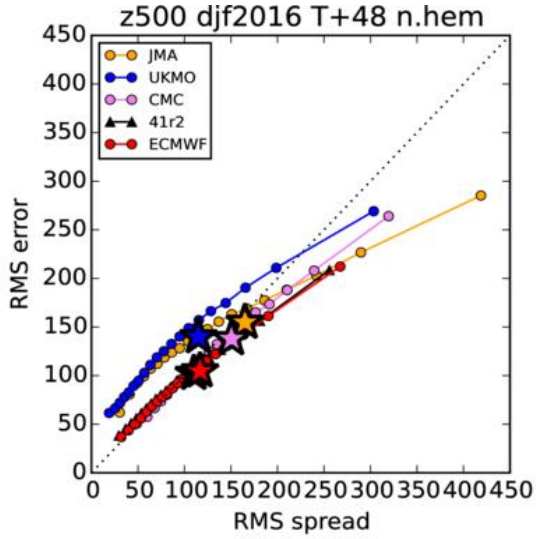


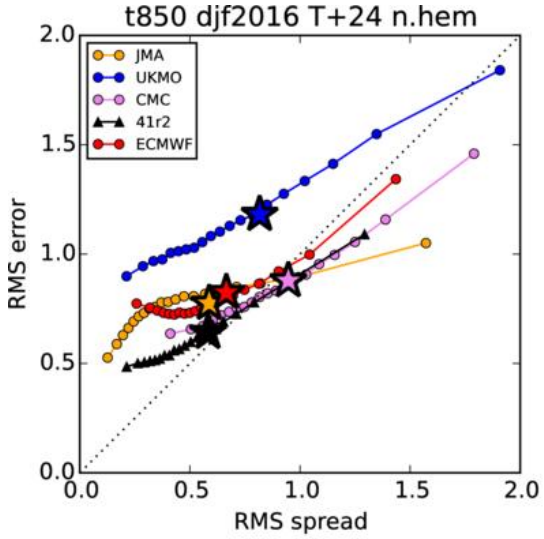
ECMWF

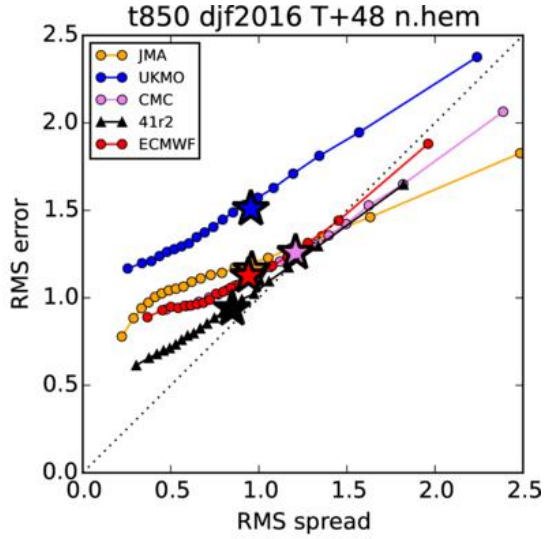
ENS spread reliability

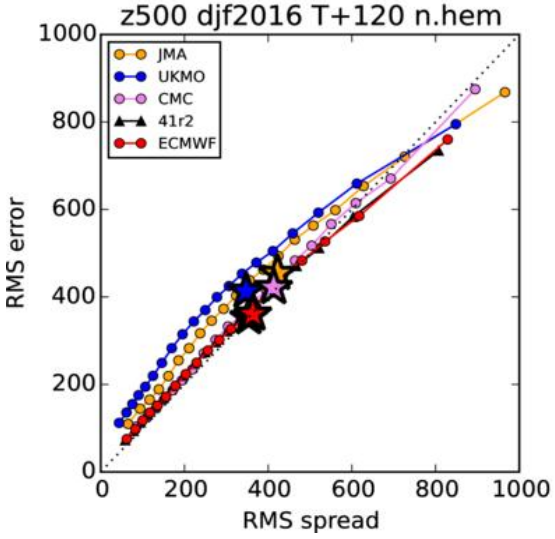
Extra-tropics

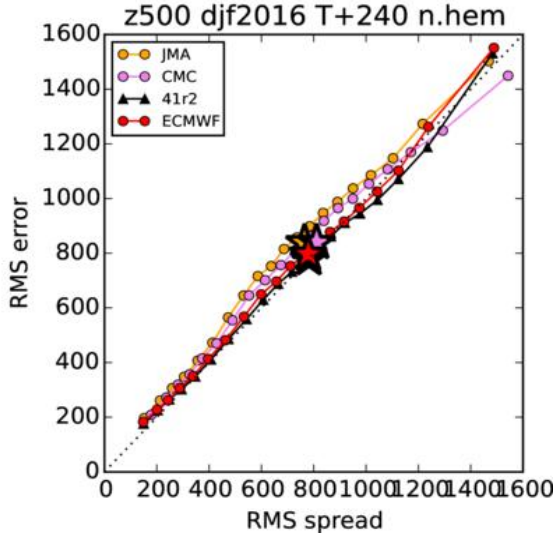


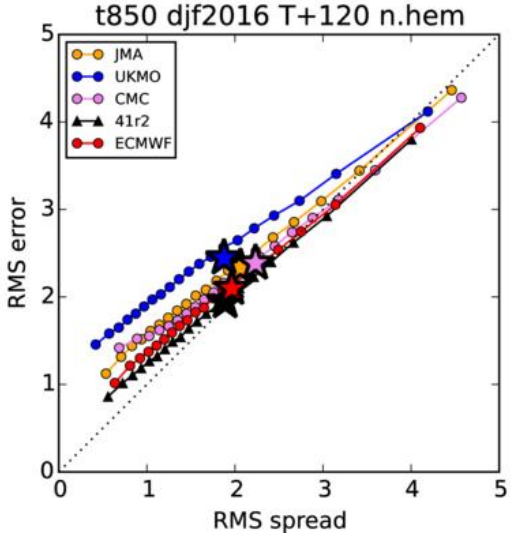


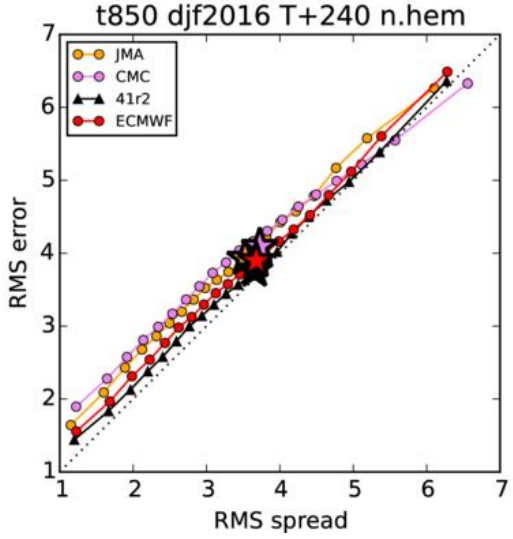












Z500 **T850**

Precipitation skill – comparison with other centres

24-hour precipitation

Verification against SYNOP observations

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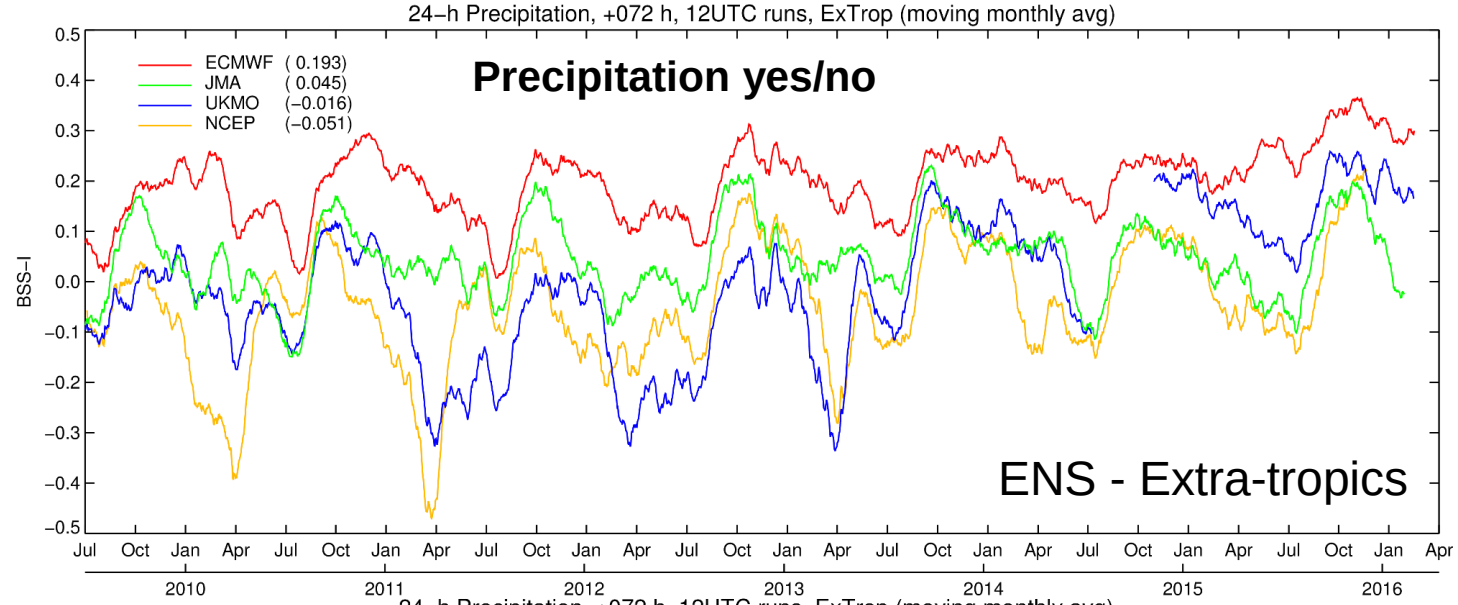
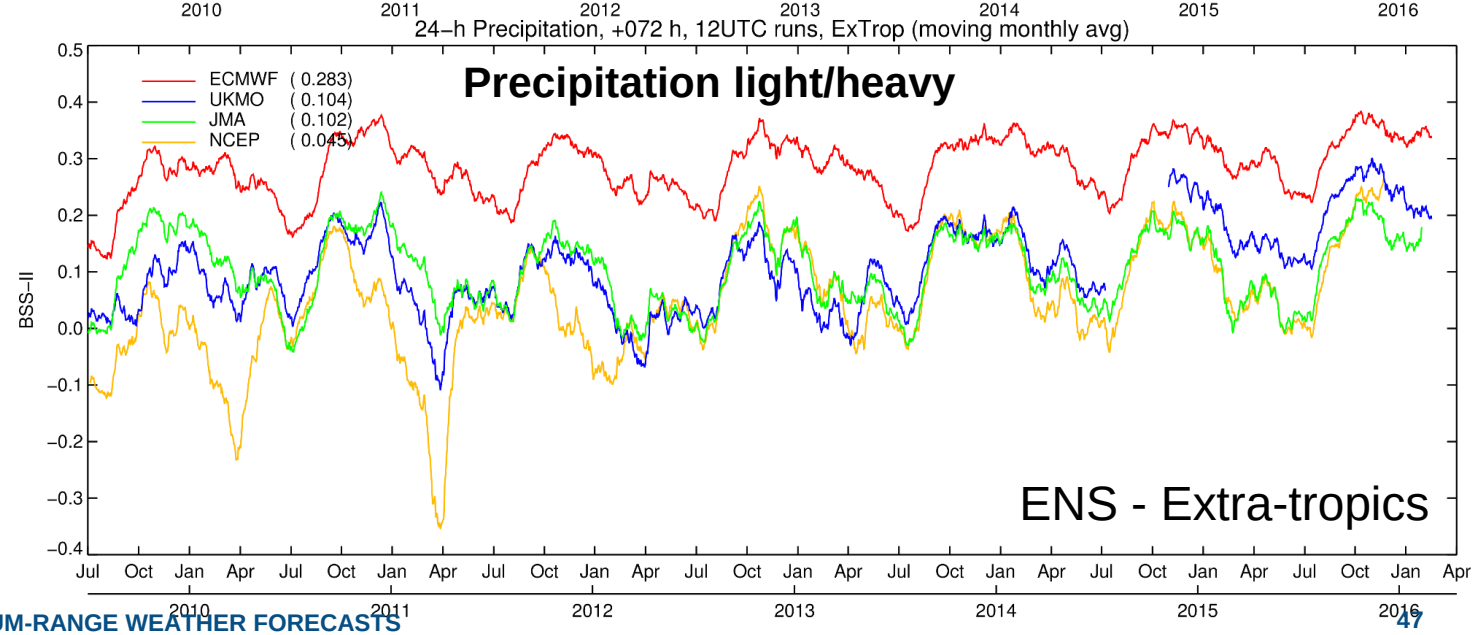
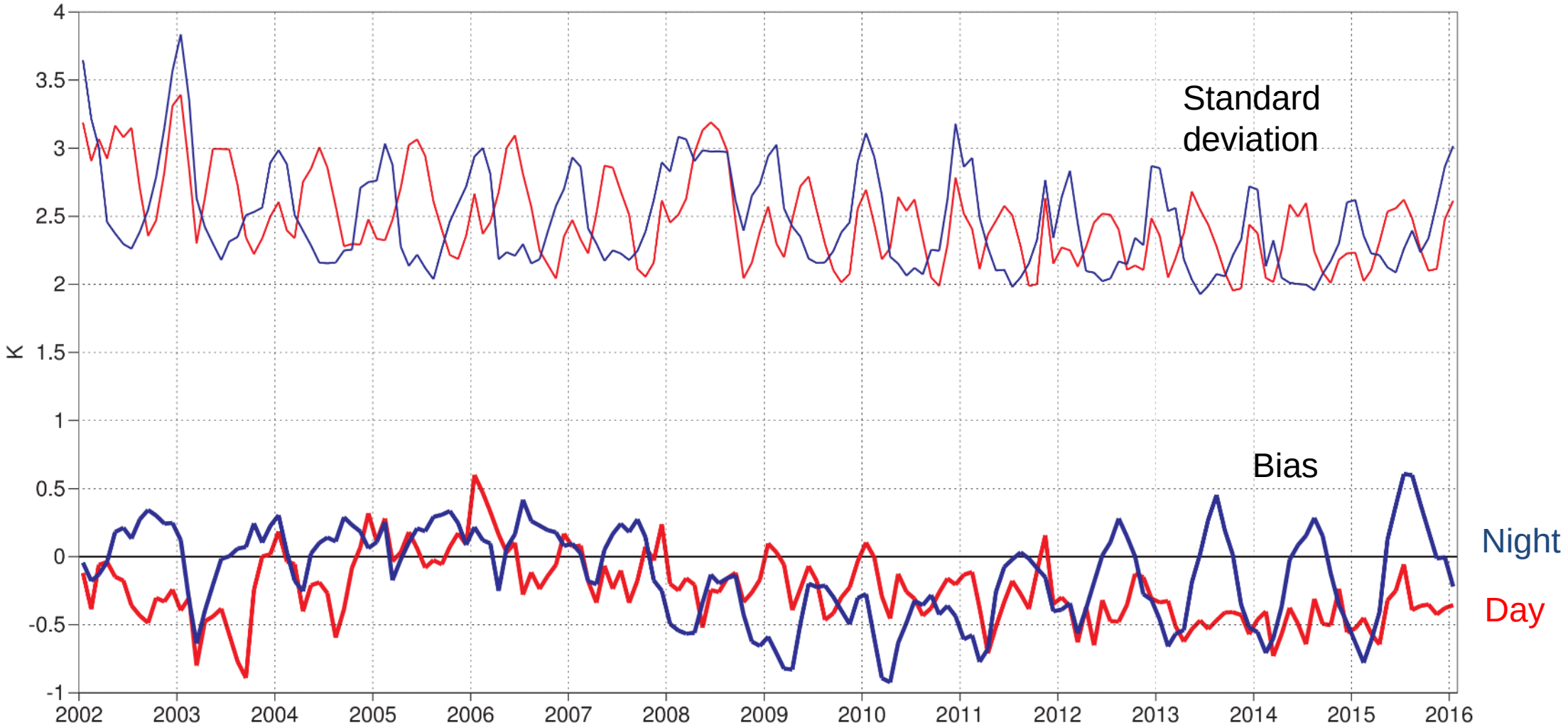
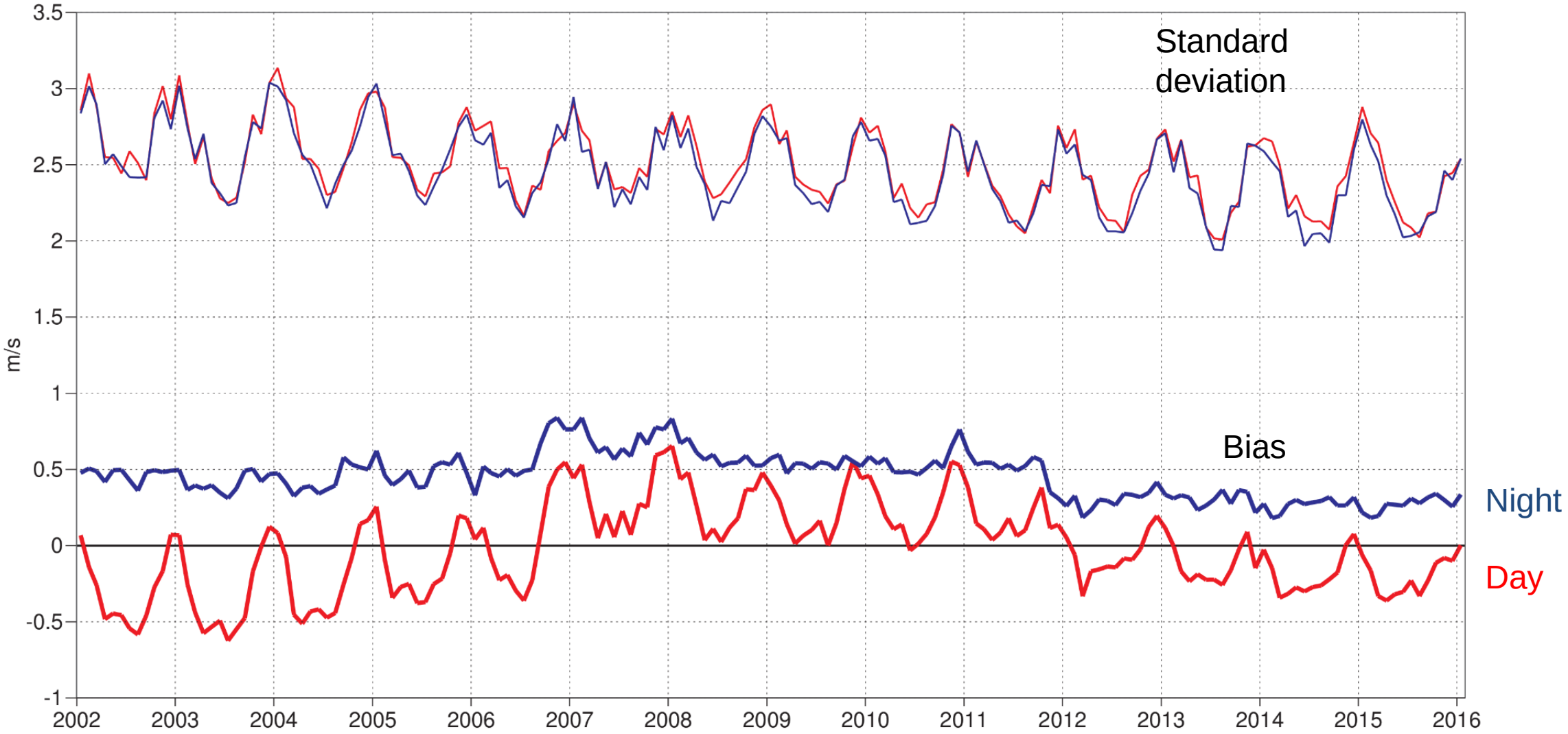




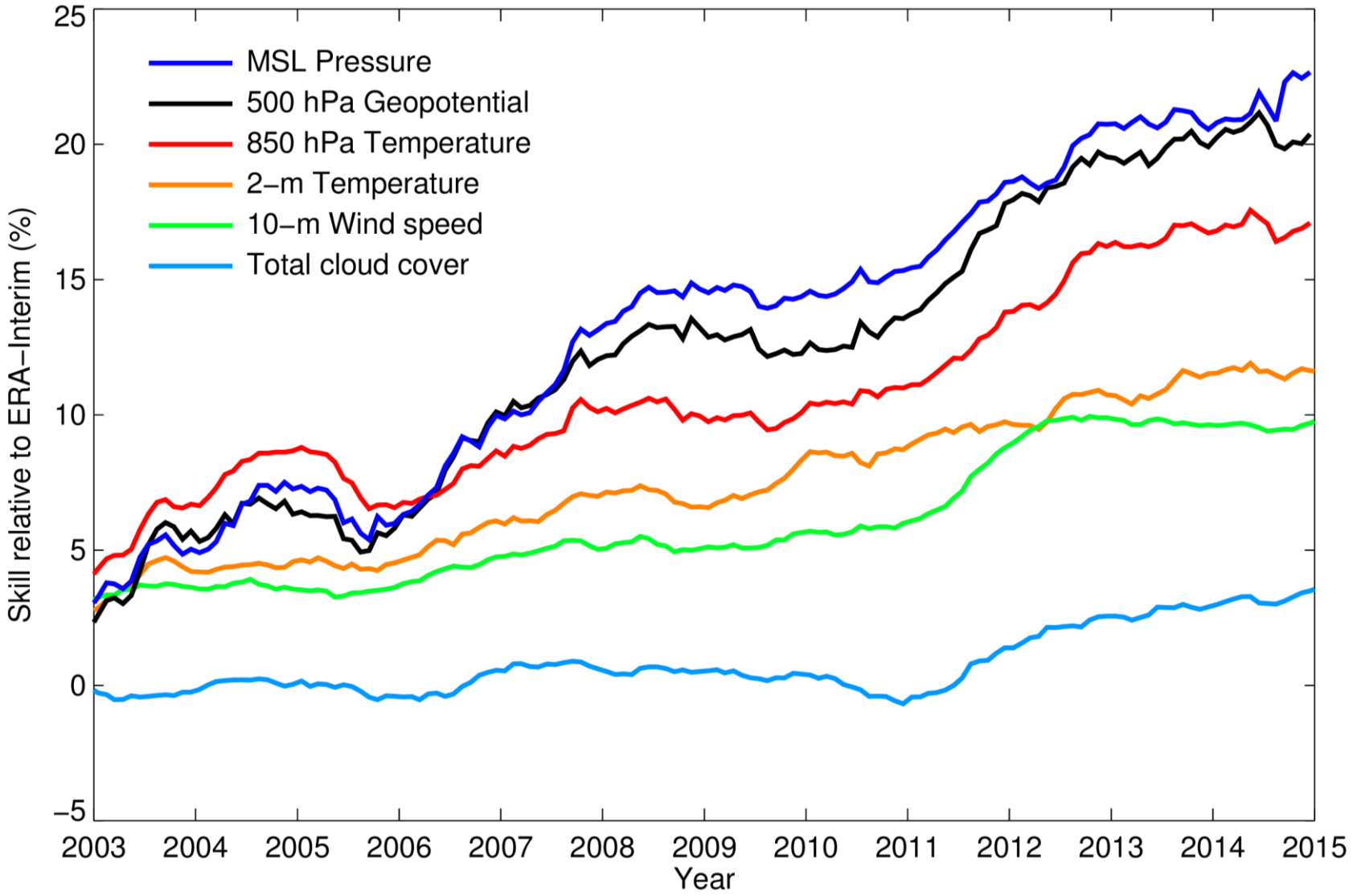
2m temperature Europe (verified against SYNOP)



10m wind Europe (verified against SYNOP)

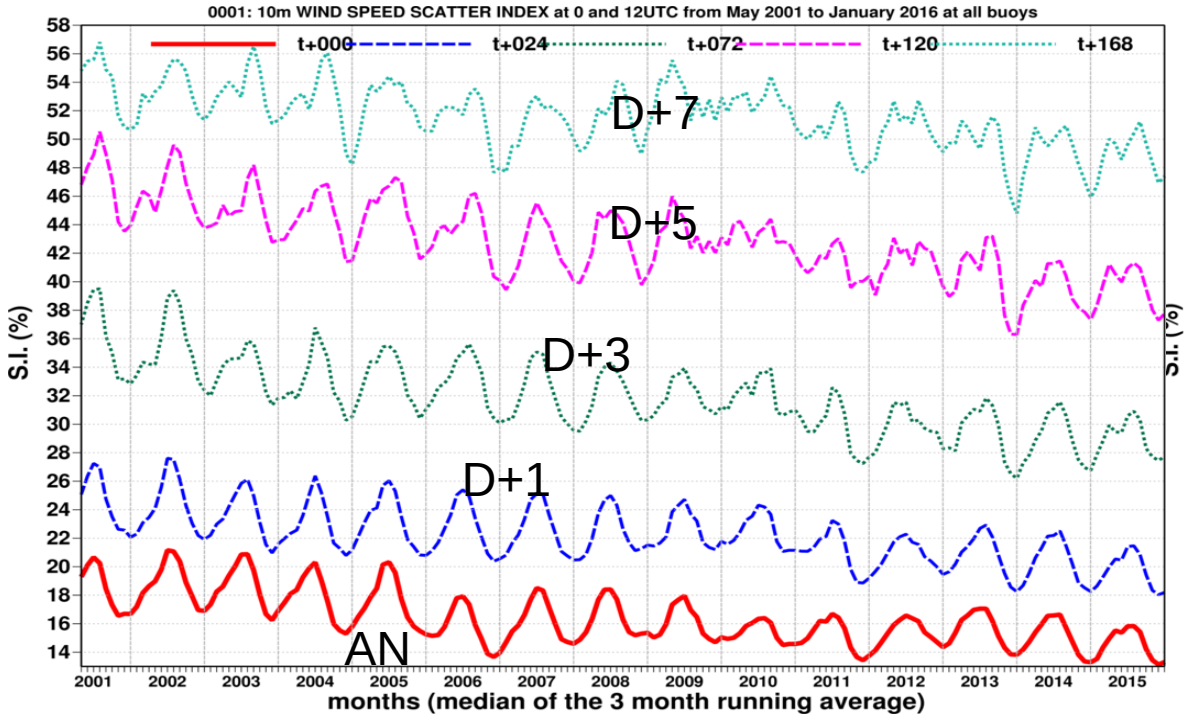


Model performance: skill gain relative to ERA-Interim

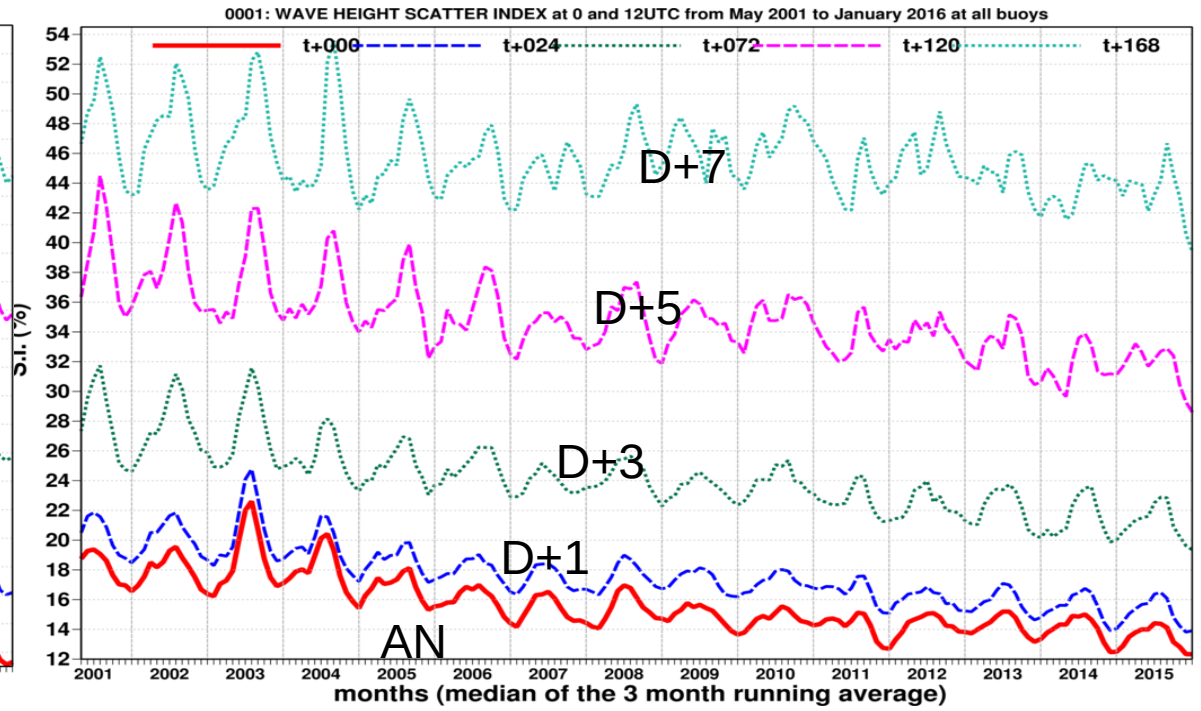


Forecast range: Day 5

Model performance: ocean waves



Wind speed

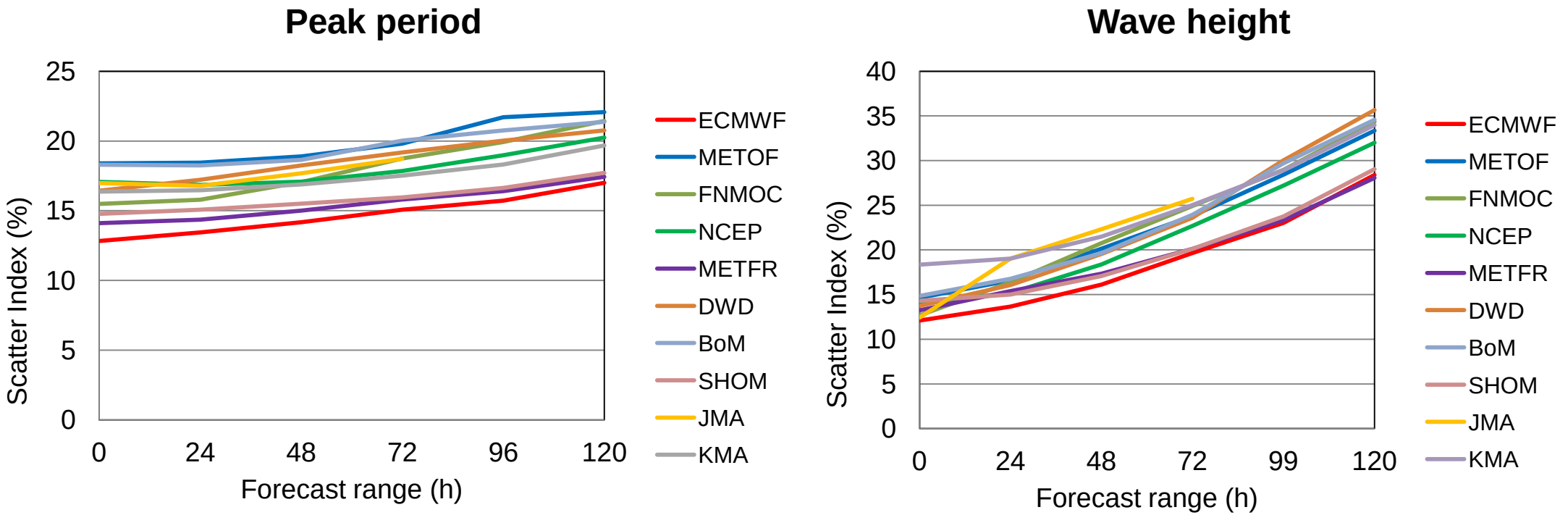


Wave height

Ocean waves – comparison to other centres

Verification against buoys

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



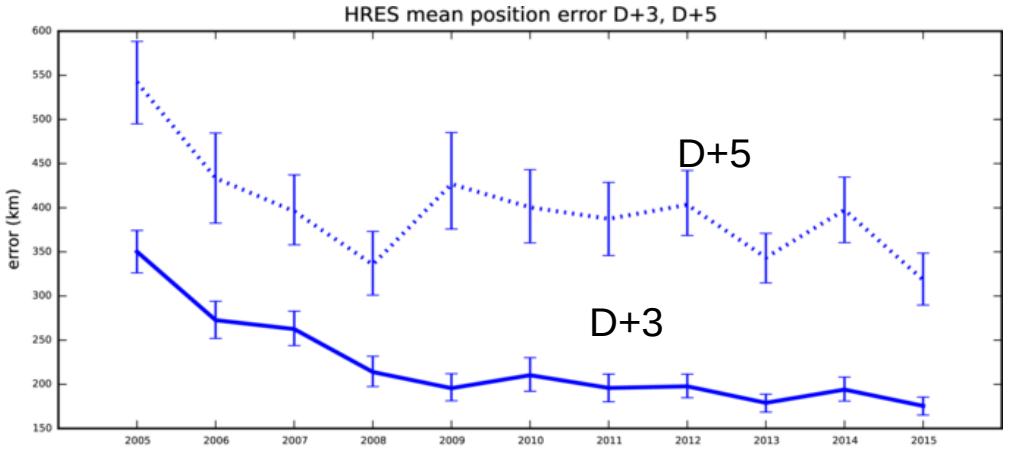
Tropical cyclones

Lowest position and speed errors so far

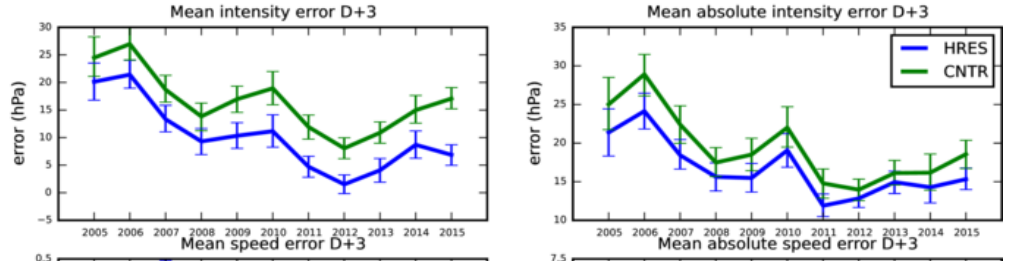
Intensity still a challenge

Good match position spread/error

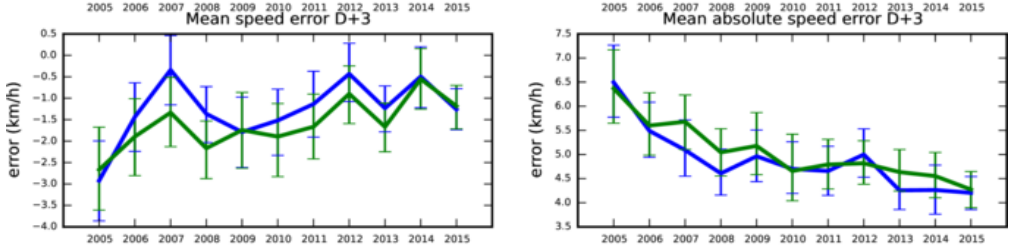
Position



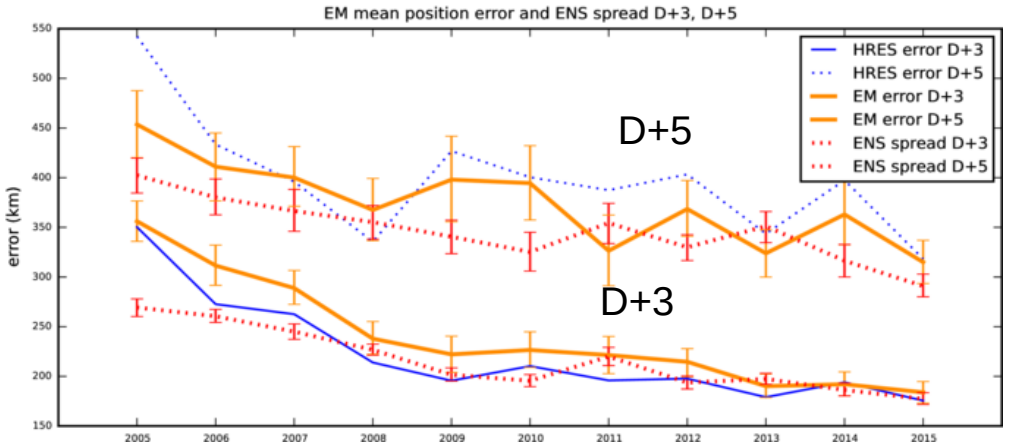
Intensity



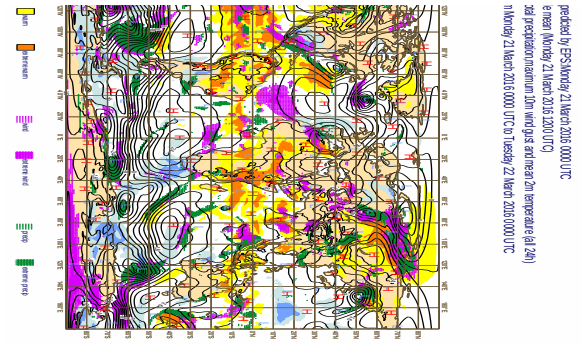
Speed



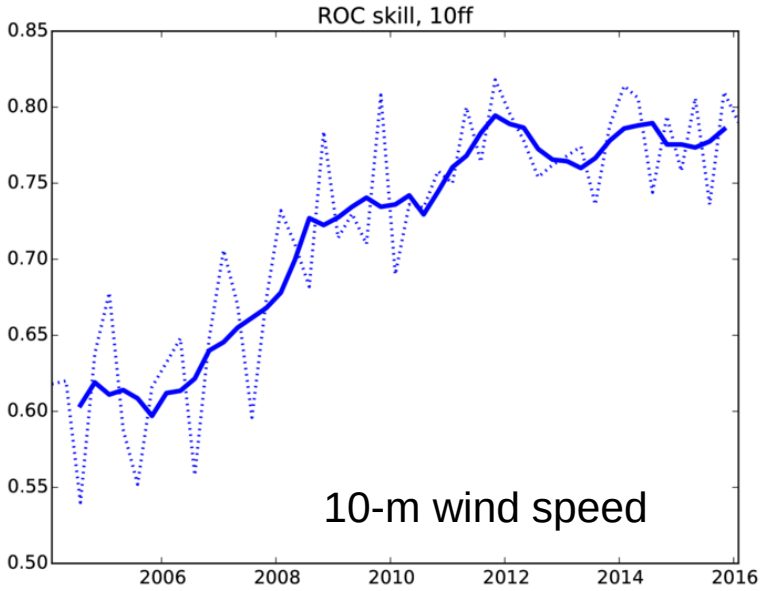
Position error/spread

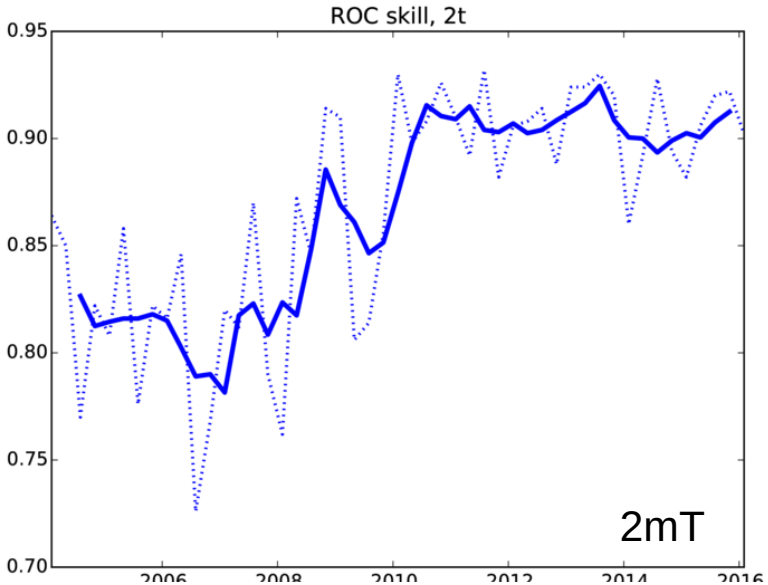


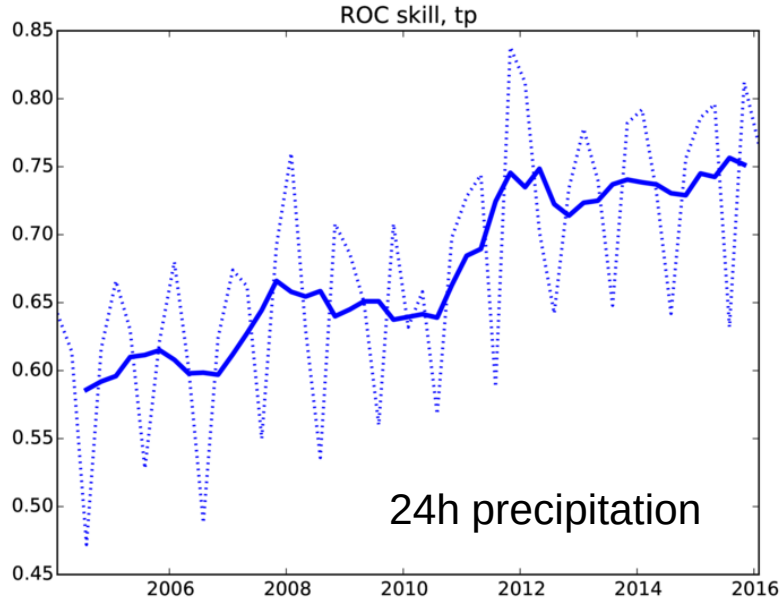
Model performance: EFI skill



Forecast range: Day + 4

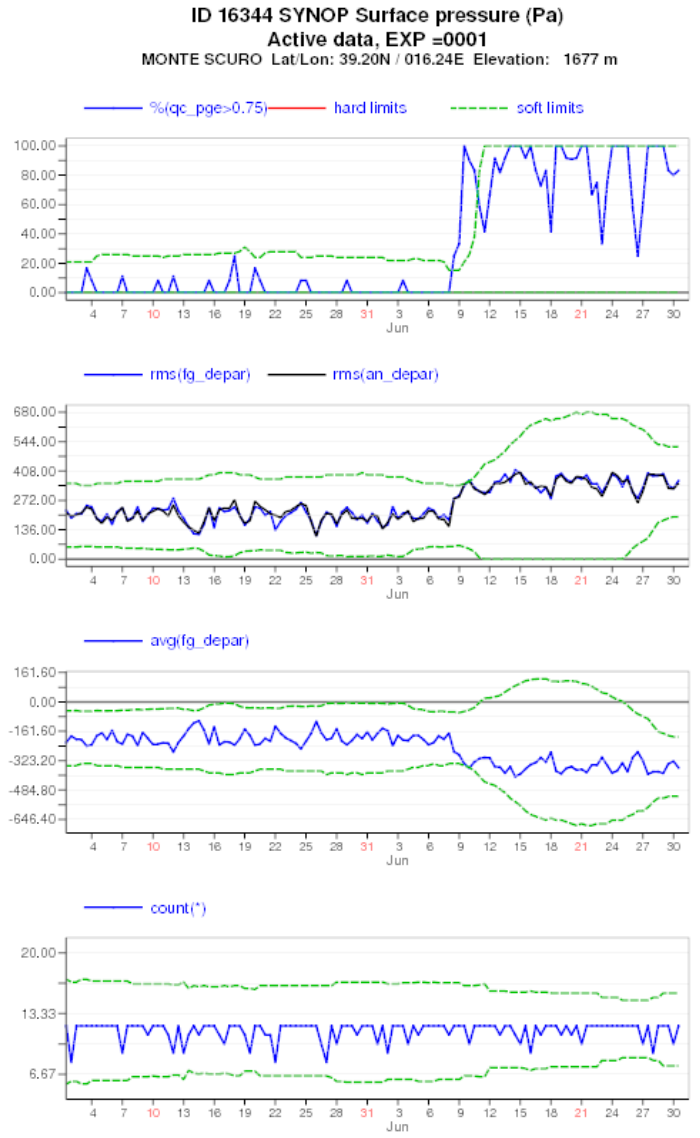






Observations statistics

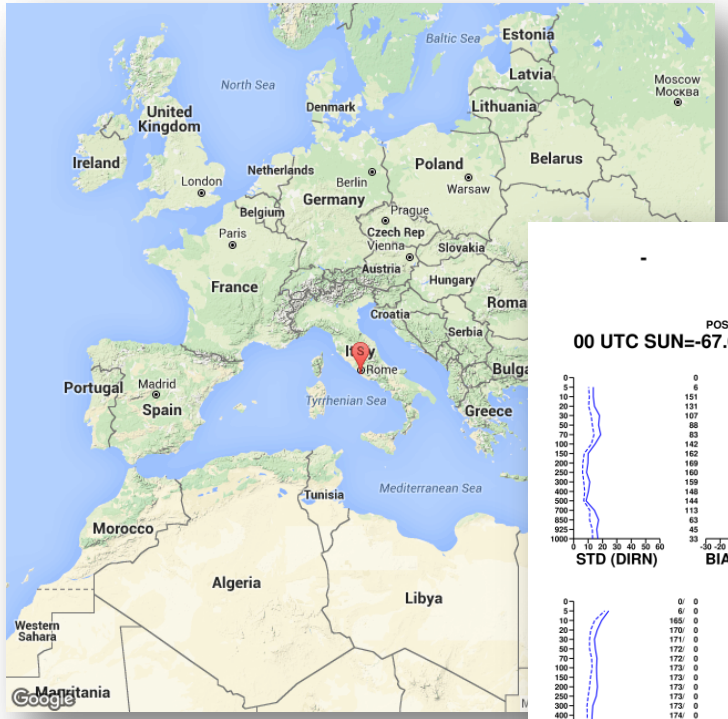
WMO Id	Valid Date (YMDH)	Station Name	Country	Position	Subtype Description	varr
16312	2015050200	Gioia Del Colle	Italy	See on Google Maps	1=>SYNOP(Manual Land SYNOP)	Sur pre (Pa
16111	2015050412	Monte Settepani	Italy	See on Google Maps	3=>SYNOP(Automatic Land SYNOP)	Sur pre (Pa
16060	2015072900	Torino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

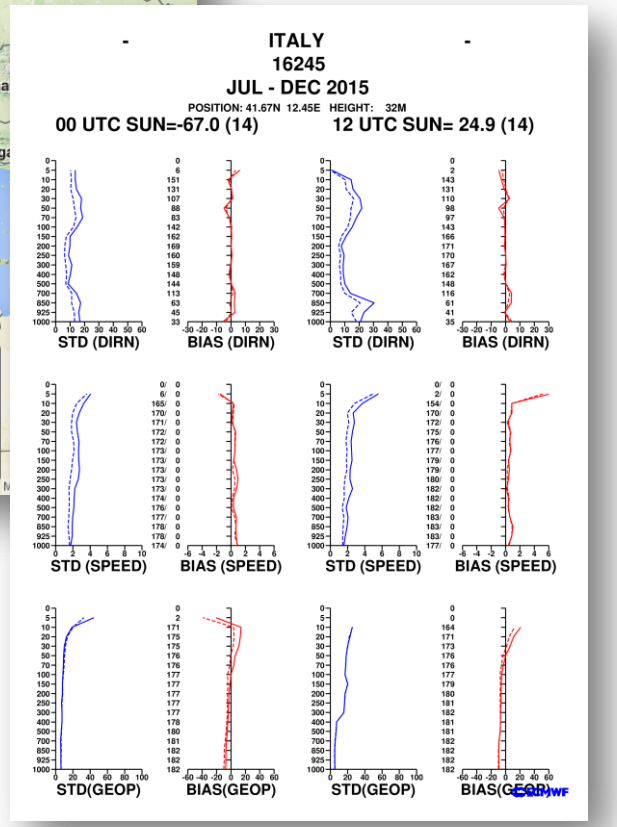


Observation statistics

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