EUCOS

The EUMETNET Composite Observing System

Geophysikalisch-Meteorologisches Kolloquium
Meteorologisches Institut Universität Bonn
Institut für Geophysik und Meteorologie der Universität zu Köln
Deutsche Meteorologische Gesellschaft ZV Rheinland
Köln, 16. Mai 2010

EUCOS Team: Stefan Klink, Sabine Hafner, Tanja Kleinert (DWD)

Acknowledgements:
Stig Carlberg (E-AMDAR), Rudolf Krockauer(E-ASAP),
Pierre Blouch (E-SURFMAR), Tim Oakley (E-WINPROF),
Henrik Vedel (E-GVAP), Asko Huuskonen (OPERA)

EUMETNET
European Meteorological Services Network

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- About EIG EUMETNET and EUCOS
- The current EUCOS network
- EUCOS Information System and Quality Monitoring
- E-AMDAR Humidity Trial
- EUCOS upper-air network redesign
- Data Targeting System
- EUMETNET Observation Roadmap

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About EIG EUMETNET and EUCOS

Domains

Observations
- EUCOS
- E-AMDAR
- E-ASAP
- SURFMAR
- OPERA
- EUMETFREQ
- WINPROF
- E-GVAP

Forecasting
- SRNWP
- EMMA
- SatRep

Environment & Climate
- ECSN
- WG-ENV

Research & Training
- EUMETCAL
- EUMETRep

Old Programmes
- AWS
- PWS
- SWS
- OBS-INFO
- UNIDART
- TIPS
- MAP-NWS

EUMETNET
The Network of European Meteorological Services

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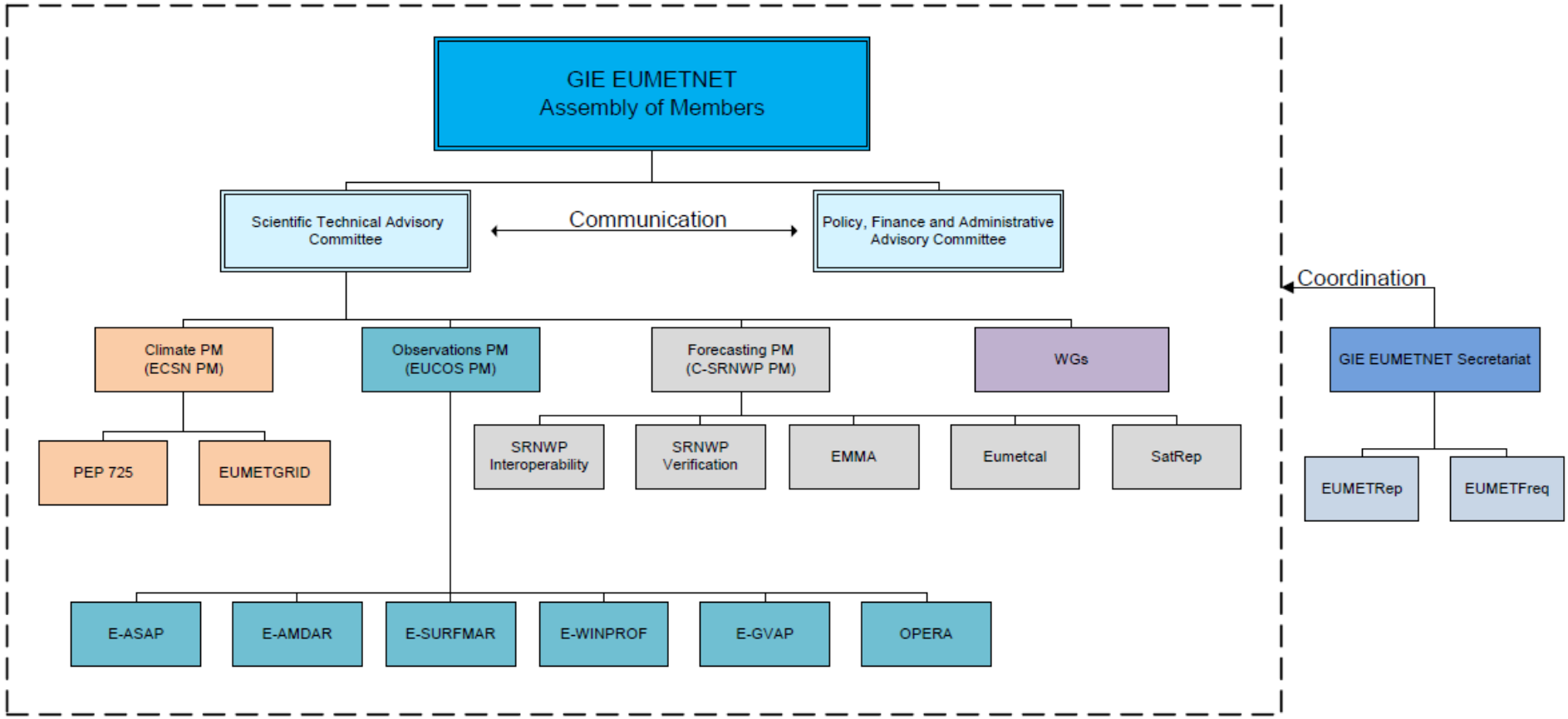
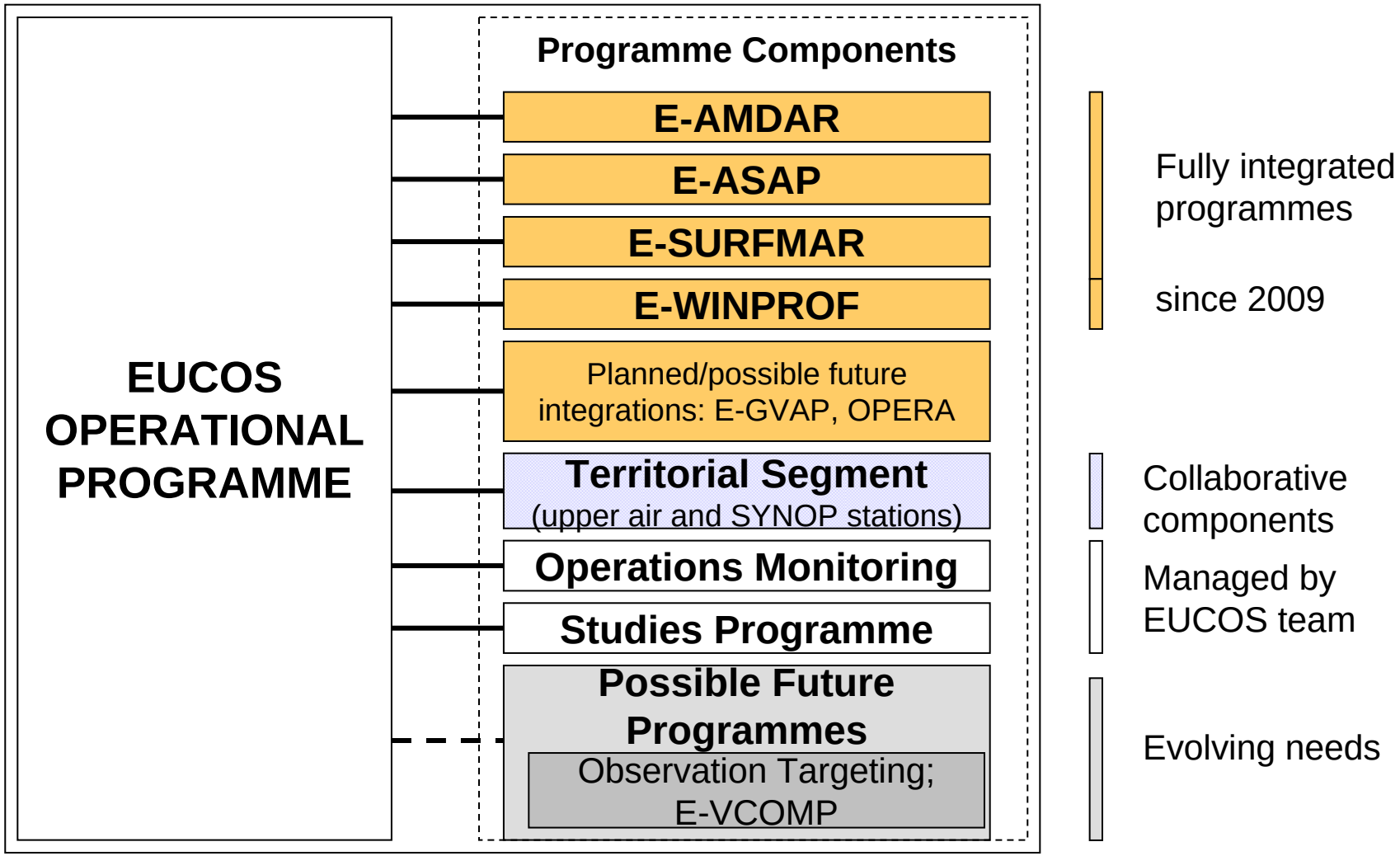
EUMETNET is a network grouping 26 European National Meteorological Services. EUMETNET provides a framework to organise co-operative programmes between the Members in the various fields of basic meteorological activities such as observing systems, data processing, basic forecasting products, research and development, training. Through EUMETNET Programmes, the Members intend to develop their collective capability to serve environment management and climate monitoring and to bring to all European users the best available quality of meteorological information. They will use EUMETNET to more efficiently manage their collective resources.

EUMETNET governance structure

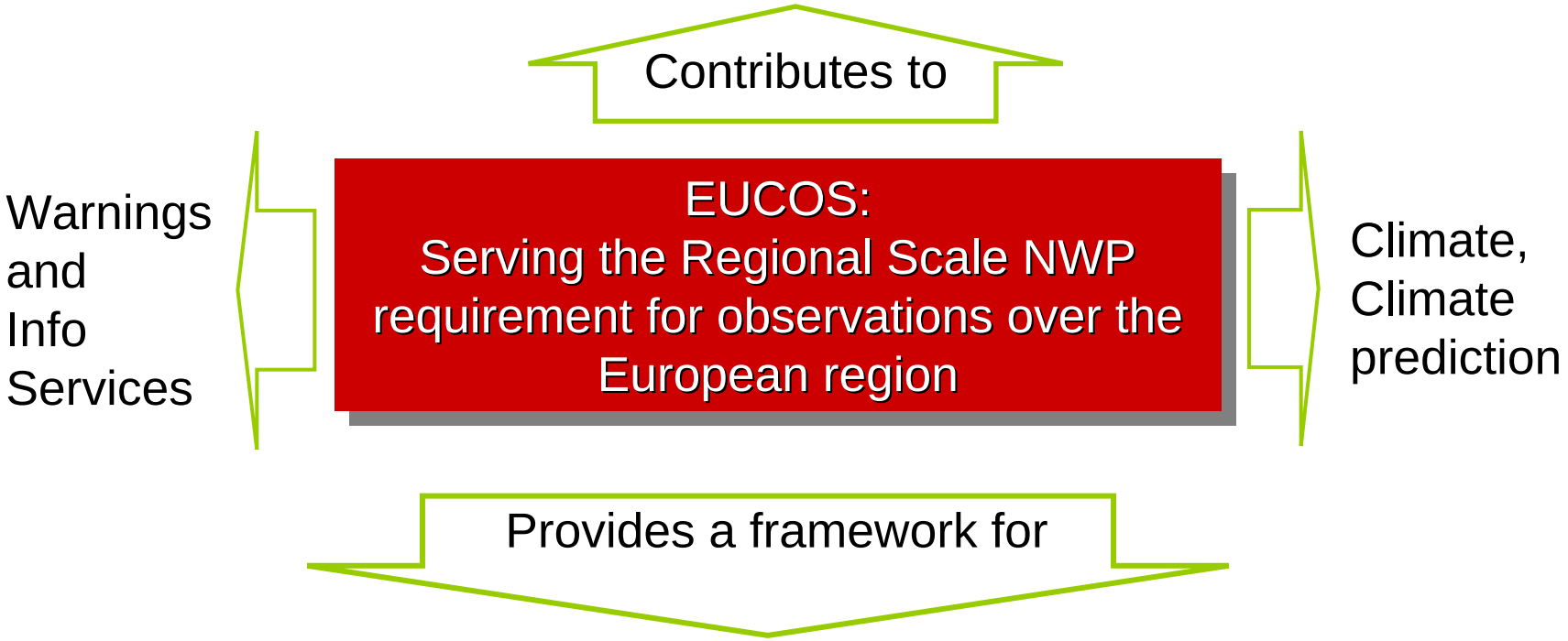


About EIG EUMETNET and EUCOS



EUCOS objectives

Medium and extended range weather prediction over the Globe



Very short range and nowcasting over national territories

EUCOS objectives

- Ensure integrated management for agreed components such as E-ASAP, E-AMDAR, E-SURFMAR and E-WINPROF
- Monitor and control the EUMETNET composite observing system (EUCOS) performance
- Design and coordinate the evolution of the ground based EUCOS to be optimized at European scale with a view to improve short range forecast over Europe without increasing the overall cost
- Support the evolution of EUCOS through a studies programme

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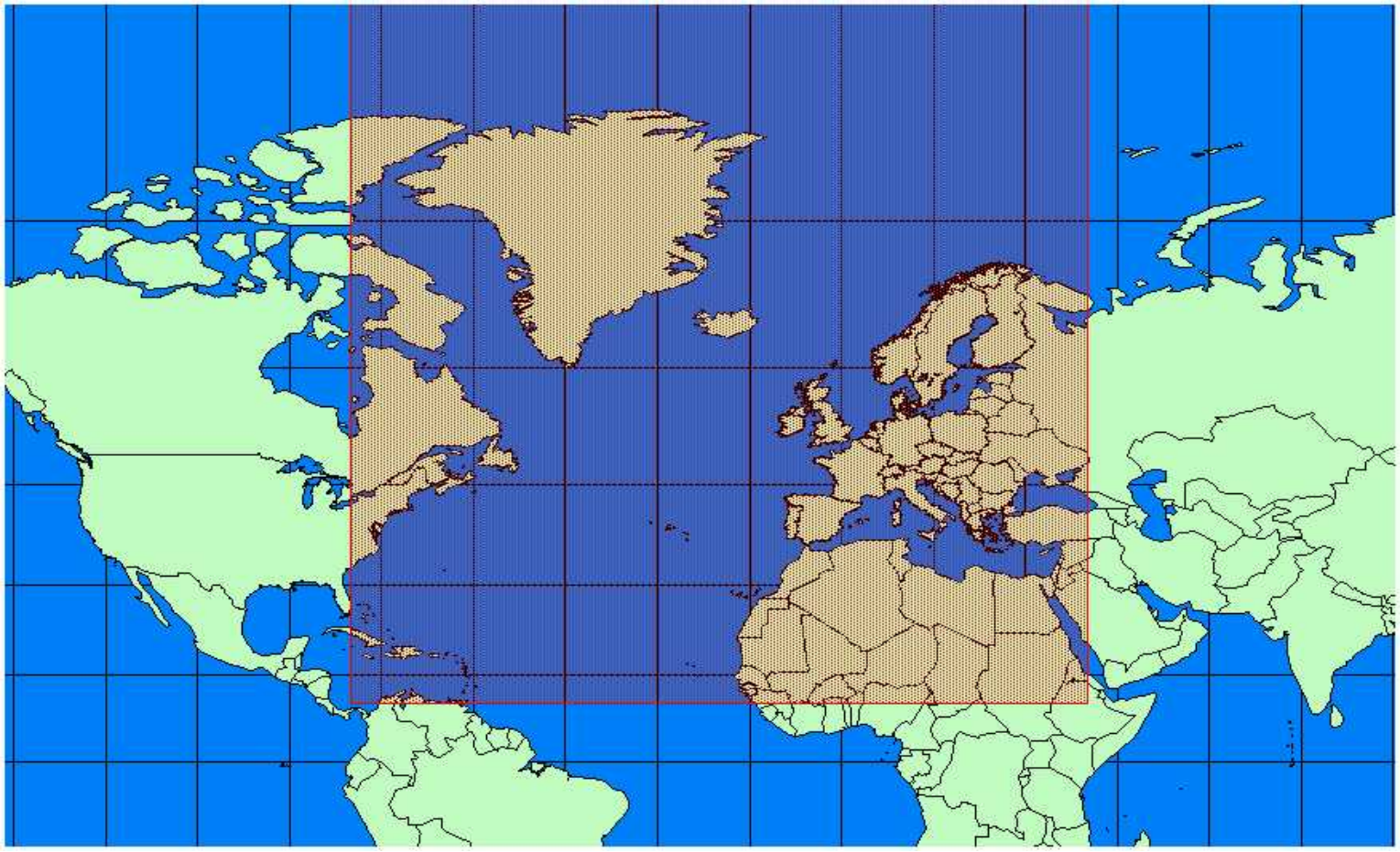
EUCOS area (10N-90N, 70W-40E)

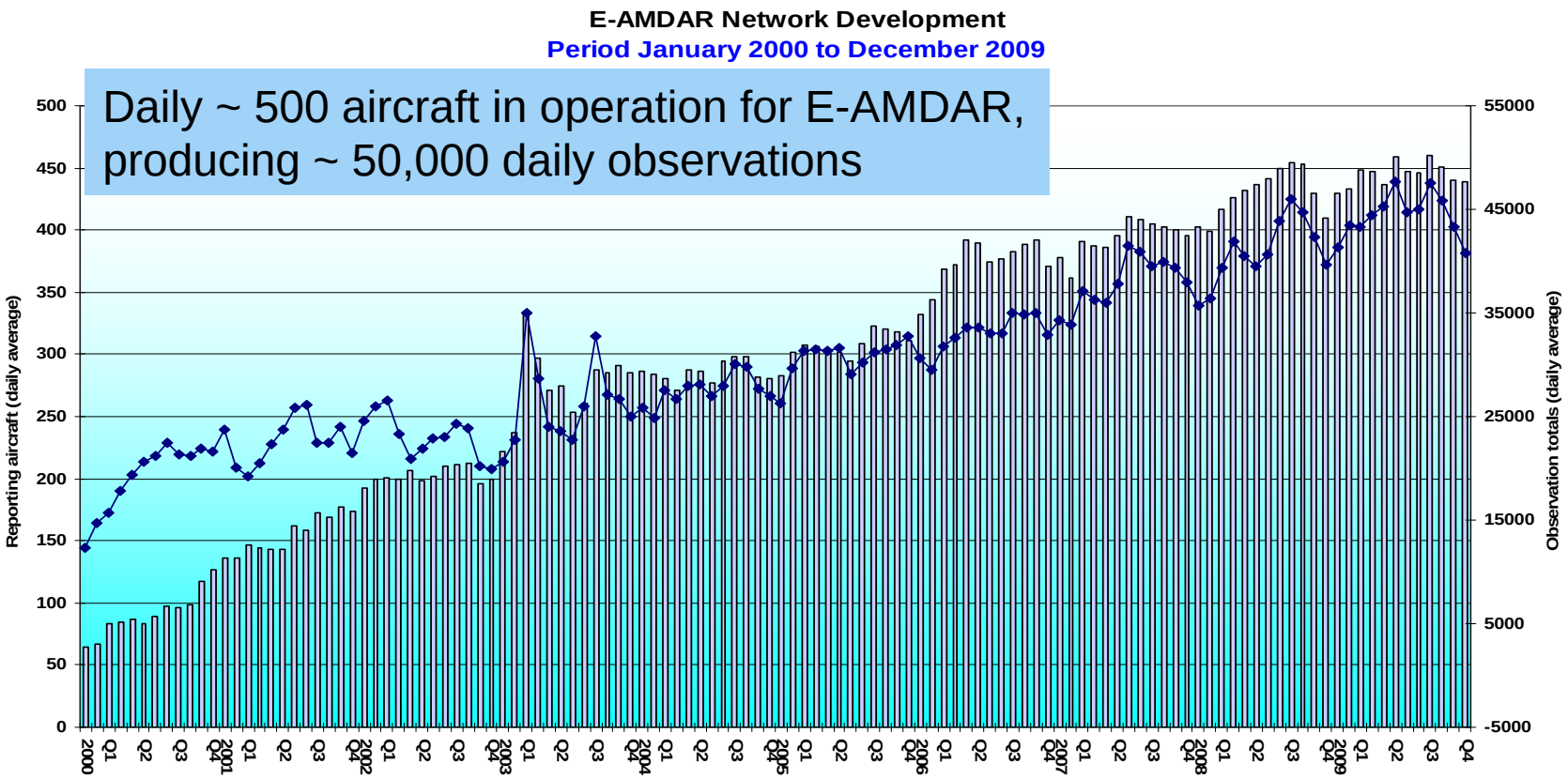


The current EUCOS network

- All European ships of the Automated Ship Aerological Programme (currently 18 ships)
- All measurements from European commercial aircraft (AMDAR)
- Selected moored buoys and all European drifting buoys
- European Voluntary Observing Ships
- Selected European radiosonde stations (incl. Ekofisk)
- Selected European synoptic weather stations
- Selected European wind profilers (+ wind profiles derived from weather radar data)

E-AMDAR

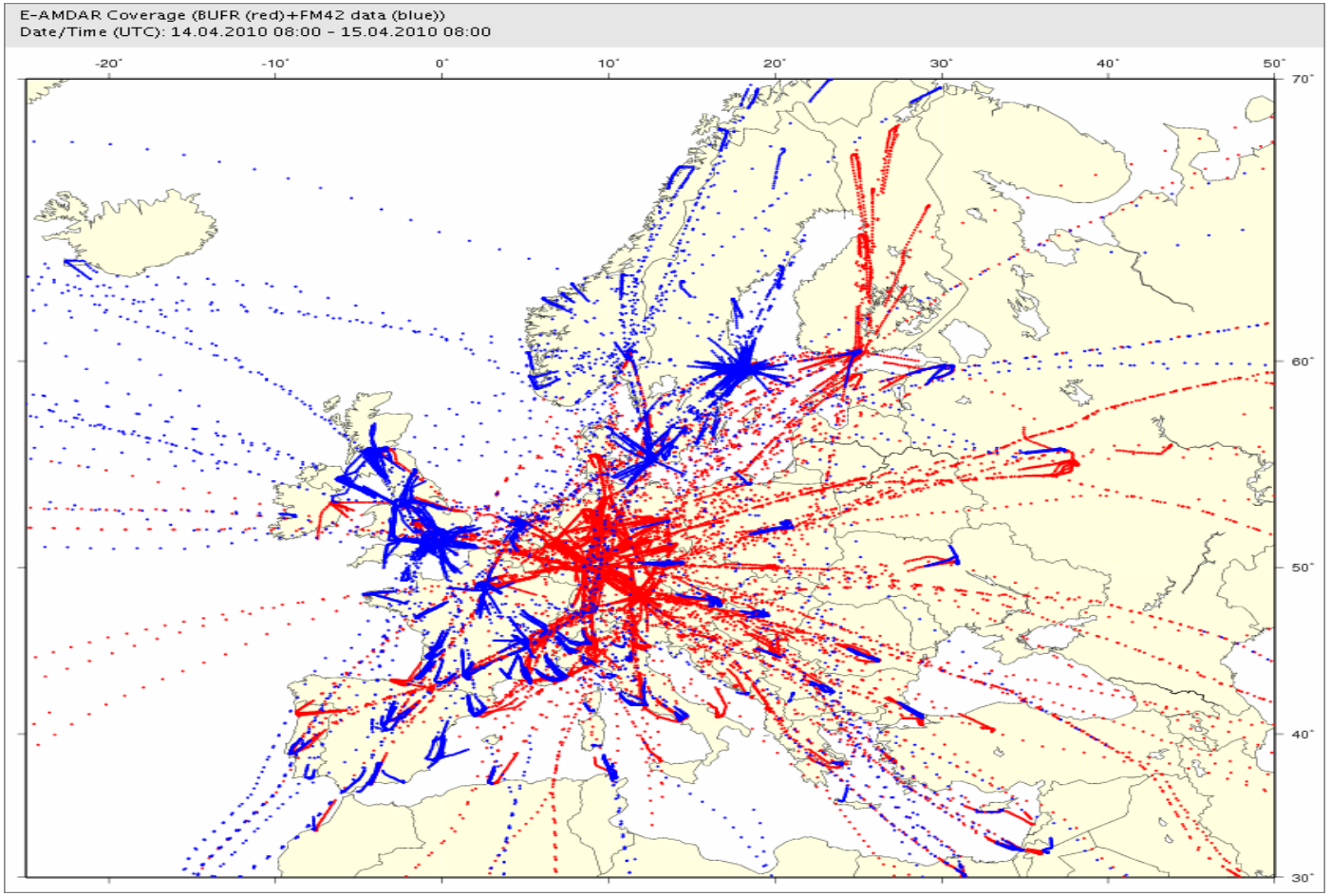
Coordinating Member: SMHI



Important current activity:

Extended E-AMDAR humidity trial: Installation of 3 + 6 water vapour sensors onboard E-AMDAR aircraft during 2011/2012, monitoring of performance, OSEs required before further rollout

E-AMDAR: Usual daily data coverage (example 14 April 2010)

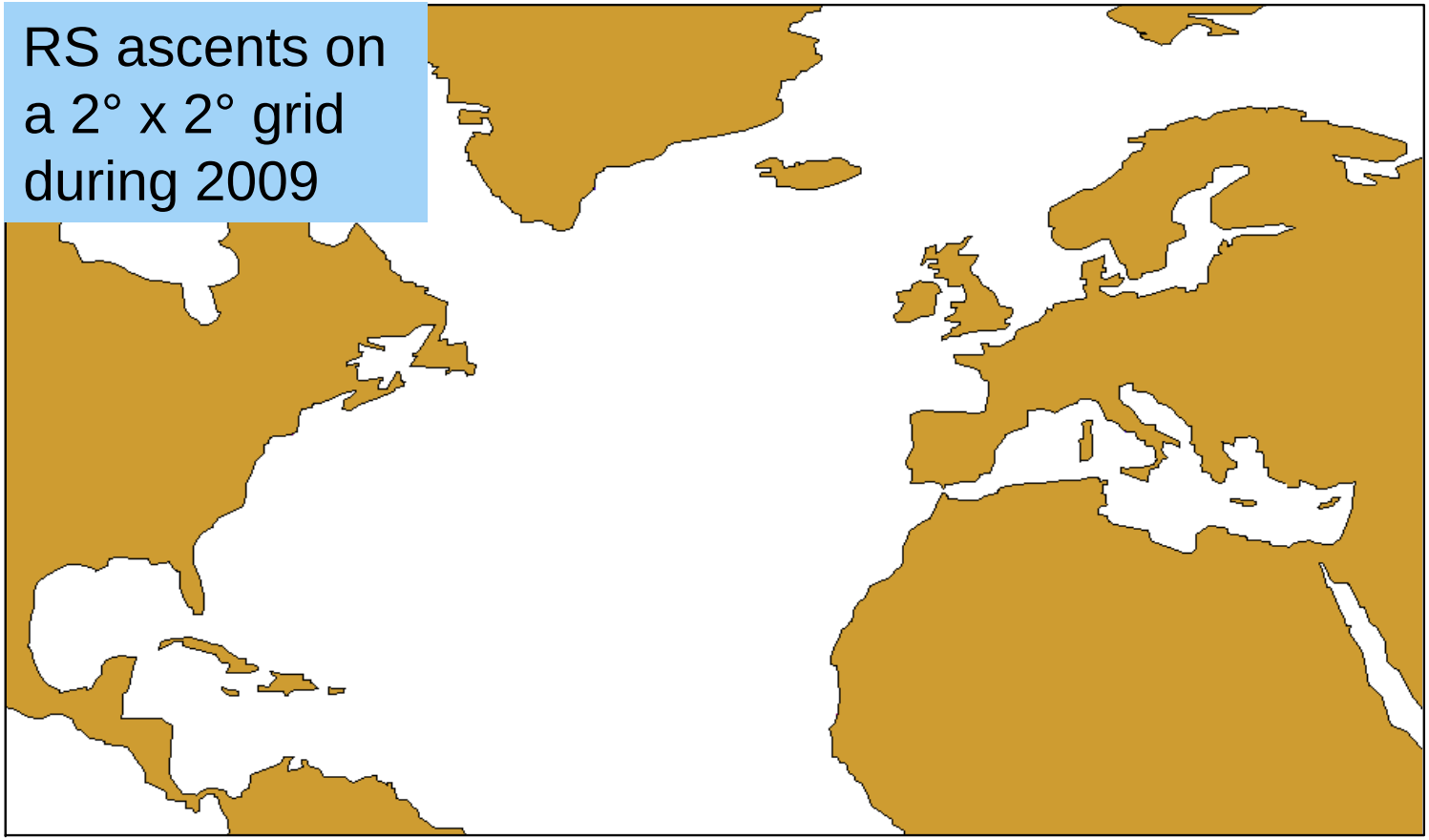


E-AMDAR Network Performance Q2/10

Network Performance	April	May	June	July
Number of Obs (Globally) (target 1,000,000)	1,350,269	1,086,519	1,500,489	1,514,594
Avg daily profiles (EUCOS area) (target 780)	1106	1159	1030	950
Avg daily airports (EUCOS area) (target 140)	142	145	139	142
Avg 3-hourly airports (target 40)	46	46	45	44
% received by T+50 (90%)	94.90%	94.51%	95.95%	94.22%
% received by T+100 (95%)	97.61%	97.10%	98.44%	96.84%

E-ASAP

RS ascents on a 2° x 2° grid during 2009



Bulletins per grid point:

3 5 8 10 14 18 22 28 35 45 55

Coordinating Member: DWD

Important current activity:

Replacement of INMARSAT-C by IRIDIUM satellite transmission systems (thus enabling transmission of binary data: 20 sec BUFR).

E-ASAP fleet September 2010

No	Station	Ship name	Operating area	Service
1	ASEU01	Maria S. Merian	Research vessel, mainly EUCOS area	Not Line
2	ASEU02	Liverpool Express	North Europe – Chile	Line
3	ASEU03	Endurance	Western Mediterranean – Montreal	Line
4	ASEU04	Power	Western Mediterranean – Montreal	Line
5	ASEU05	Atlantic Companion	North Europe – East coast US	Line
6	ASDE01	Atlantic Compass	North Europe – East coast US	Line
7	ASDE02	Meteor	Research vessel, worldwide	Not Line
8	ASDE03	Atlantic Concert	North Europe – East coast US	Line
9	ASDE04	Dublin Express	North Europe – Chile	Line
10	ASGB01	Mississauga Express	Montreal – North Europe	Line
11	ASFR1	Fort Saint Louis	North West Europe – French West Indies	Line
12	ASFR2	Fort Saint Pierre	North West Europe – French West Indies	Line
13	ASFR3	Fort Saint Georges	North West Europe – French West Indies	Line
14	ASFR4	Fort Sainte Marie	North West Europe – French West Indies	Line
15	ASDK01	Irena/ Naja/ Mary/ Arina/ Nuka Arctica	Denmark – West coast Greenland	Line
16	ASDK02		Denmark – West coast Greenland	Line
17	ASDK3		Denmark – West coast Greenland	Line
18	ASES01	Esperanza del Mar	Off Mauretania and Canary Islands	Not Line
19	ASIS01	*Ready, but not in operation yet*	Airport Egilsstaðir (NE Iceland)	Not Line

E-ASAP (Re-)installations 2009

ASDK3

ASEU01

ASEU02

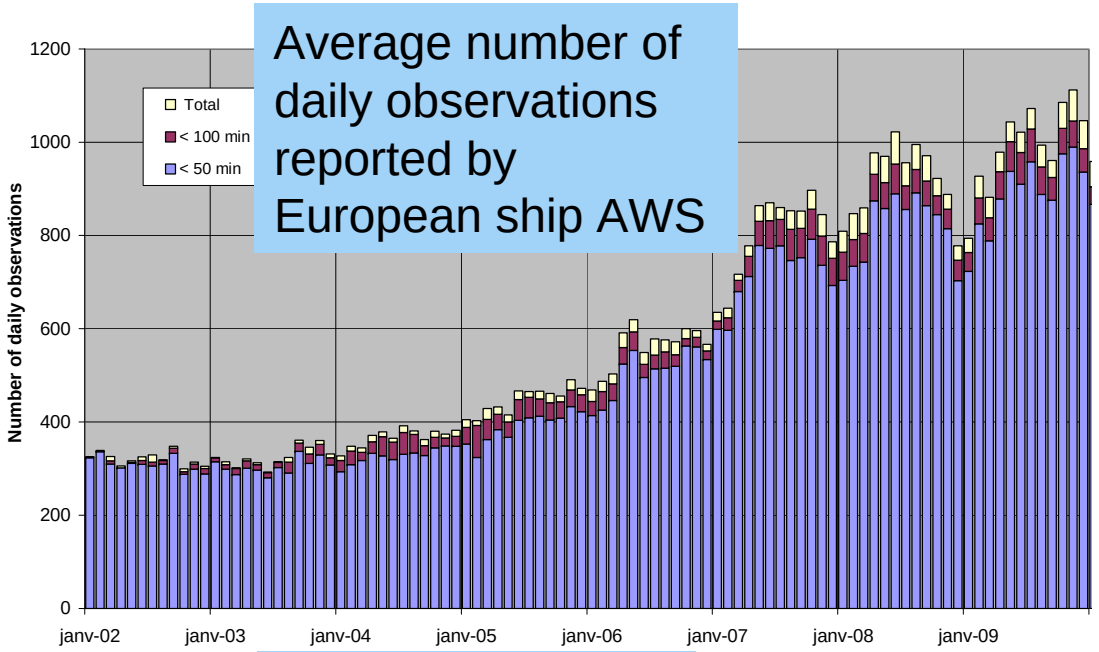
ASDE03

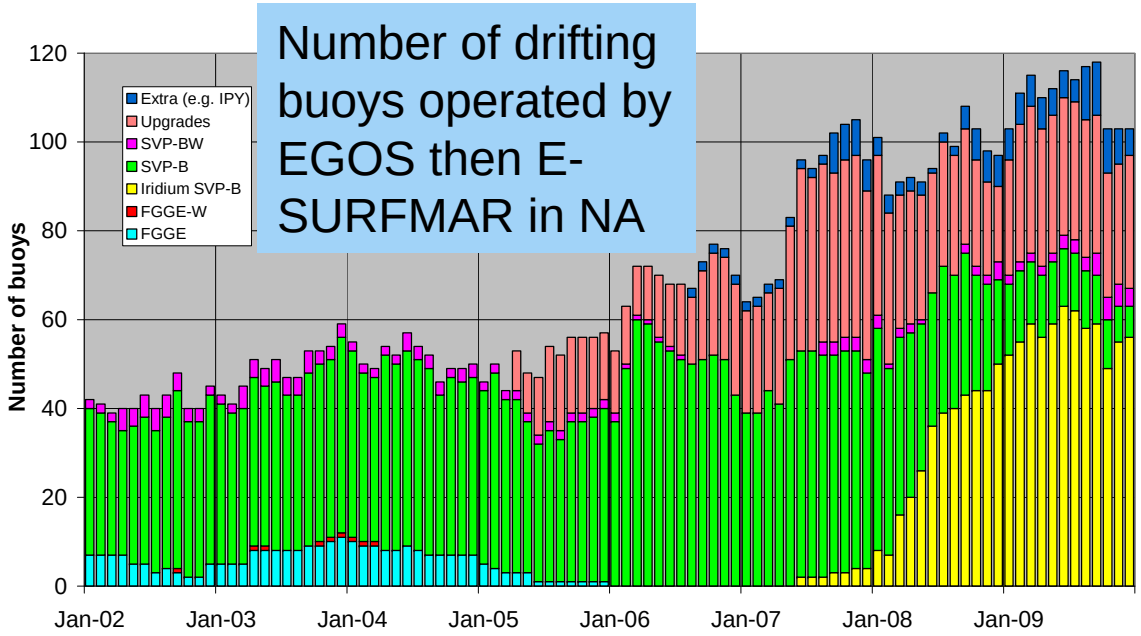
E-ASAP Re-installation ASDE04

DUBLIN EXPRESS, Hamburg, 29-30/Jan 2010

E-SURFMAR

Coordinating Member: Météo-France





Important current activity: Paving the way for a common procurement of automatic weather stations for ships (S-AWS) by EUMETNET members.

Drifting Buoys

Tracks

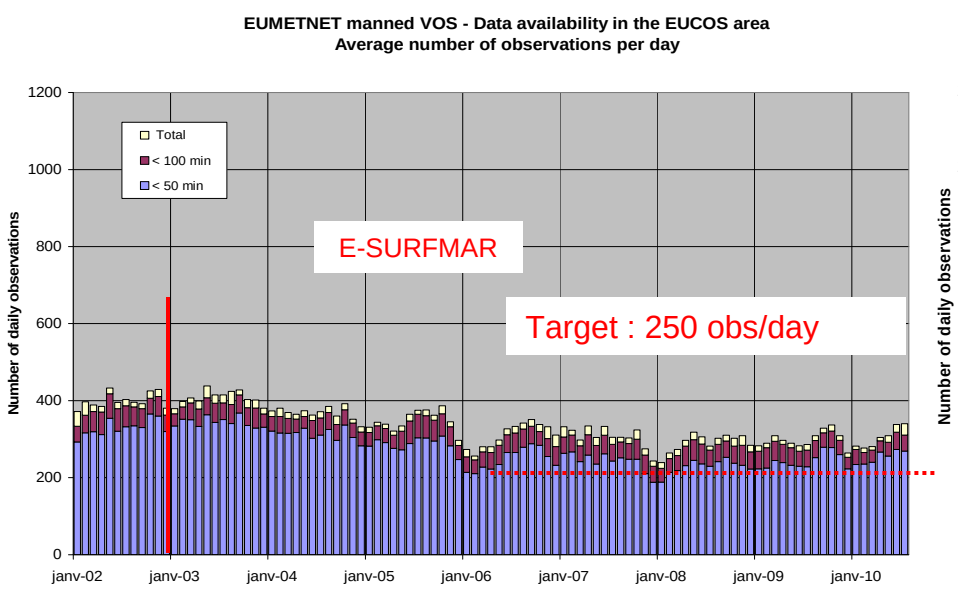
- Iridium SVP-B
- Argos SVP-B
- SVP-BW

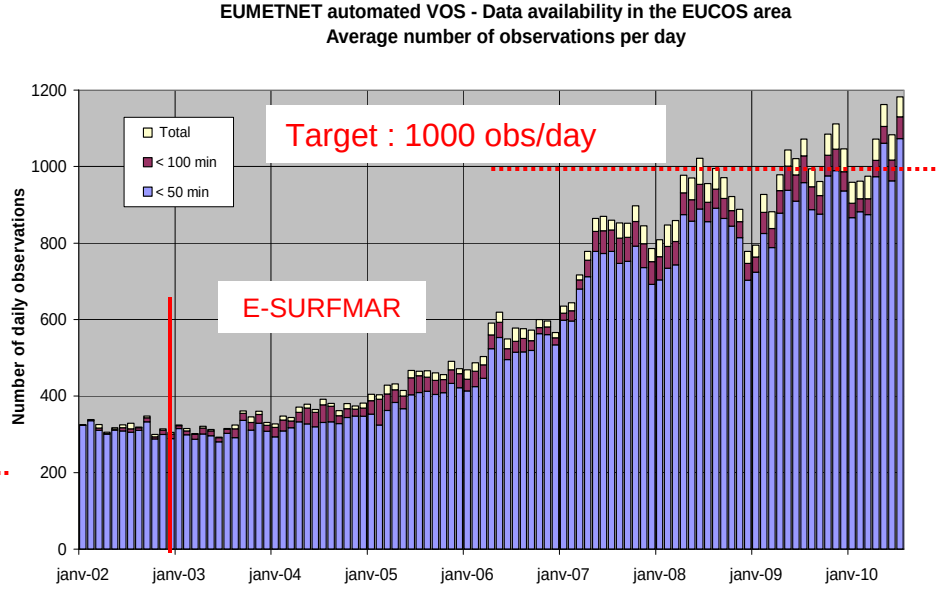
- *(moored buoys)*

July 2010

VOS Ships

Data Availability
Average number of daily reports from the EUCOS area





Conventional VOS

Automated VOS (AWS)

E-WINPROF: European wind profiler network








Coordinating Member: UK Met Office

E-WINPROF

Wind profilers, which reach a certain level of quality and availability

+

Weather Radar Wind Profiles (WRWP) from about 100 sites which reach certain quality

Important current activity: Formation of a technical support/ expert team in order to facilitate co-operation between Members.

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EUCOS information system

www.eucos.net

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Deutscher Wetterdienst
Wetter und Klima aus einer Hand

EUCOS public

- About EUCOS
- EUCOS networks
- E-AMDAR
- E-ASAP
- E-SURFMAR
- E-WINPROF

EUCOS restricted

- EUCOS HL reports
- Subprogrammes
- Quality Monitoring
- Studies Programmes
- Meetings
- E-VCOMP
- Documents, Protocols

Related Activities

› EUCOS public

EUCOS Information System

The **EUMETNET Composite Observing System (EUCOS)** Operational Programme was established in 2002, based on recommendations resulting from the EUCOS Implementation Programme (1999-2001). It aims to operate a European observing network under the auspices of the EIG EUMETNET European Meteorological Services Network (EIG EUMETNET), to deliver increased efficiency, leading to better-quality numerical and general forecasts on a European scale.

Currently the Deutscher Wetterdienst (DWD) is coordinating member of the EUCOS Programme Phase 2007-2012.

This website was established to provide all EUCOS members with necessary background information, documents and quality monitoring results. Due to this most of the topics are restricted by password login. Only general information about EUCOS and its subprogrammes provided under the topics About EUCOS and EUCOS networks are open to public. Please contact the EUCOS Team to receive login details.

News about the EUCOS programme

Last news update: 10.01.2011

› More

Contact Information

Contact the EUCOS Programme Management Team at DWD

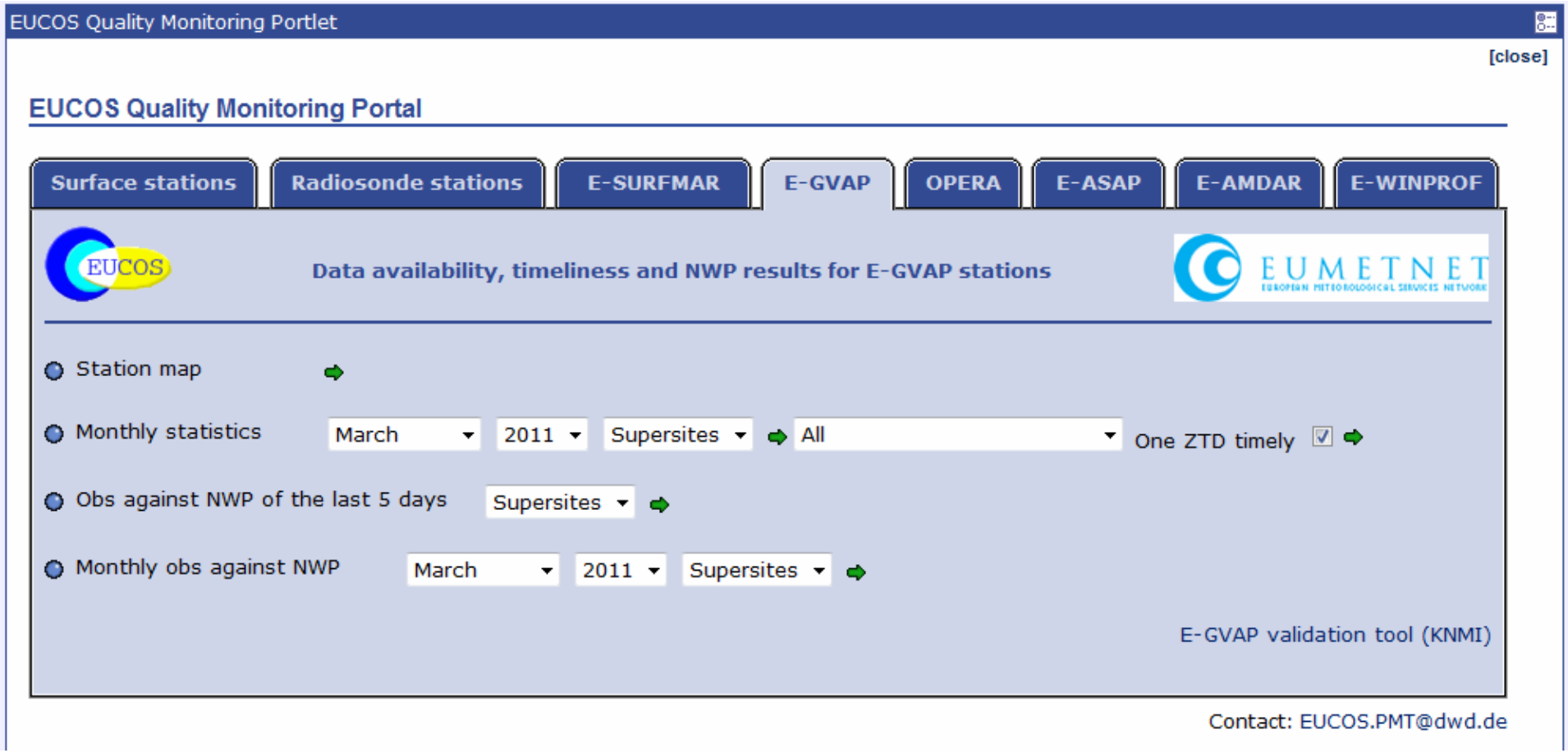
› More

Related programmes and organizations

Links to EUMETNET, EUMETSAT, OPERA, ECMWF and others.

› More

EUCOS Quality Management Portal



EUCOS network performance 2010

2010 Network	Data availability	Timeliness HH+50 (Radiosondes: TEMP AB)	Timeliness HH+100 (Radiosondes: TEMP CD)	Achieving 100 hPa	Achieving 50 hPa	Individual targets subprogrammes
Surface stations	**Target: 95%** **95%**	**Target: 90%** **99%**	**Target: 95%** **100%**	---	---	---
Radiosonde stations	**Target: 95%** **86%**	**Target: 75%** **81%**	**Target: 95%** **96%**	**Target: 97%** **96%**	**Target: 95%** **91%**	---
ASAP units	**Annual target:** **4453 obs** **5157 obs** **(equals 116%)**	**Target: 75%** **82%**	**Target: 95%** **95%**	**Target: 90%** **91%**	**Target: 75%** **82%**	**Loss rate** **Target: max. 20%** **13%**
Ocean platforms **Ekofisk**	**Target: 95%** **85%**	**Target: 75%** **86%**	**Target: 95%** **96%**	**Target: 95%** **95%**	**Target: 90%** **88%**	---
E-AMDAR	**Annual target:** **12 Mio. obs** **17.01 gross *** **13.60 net** **(equals 113%)**	**Target: 90%** **95%**	**Target: 95%** **98%**	---	---	***Profile distribution*** **daily profiles** **Target: 780** **959** **daily airports** **Target: 140** **133**
Moored buoys	**Target: 90%** **87%**	**Target: 90%** **78%**	**Target: 95%** **97%**	---	---	---
Drifting buoys	**Target: 88%** **93%**	**Target: 70%** **73%**	**Target: 85%** **93%**	---	---	---
Automated VOS ships	**Daily avg target:** **1,000** **1060** **(equals 106.0%)**	**Target: 90%** **93%**	**Target: 95%** **98%**	---	---	---
Conventional VOS ships	**Daily avg target:** **250** **305** **(equals 122%)**	**Target: 90%** **80%**	**Target: 95%** **95%**	---	---	---
E-WINPROF		**Timeliness HH+60**				
Wind profiler	**Target: 85%**	**Target: 85%**		---	---	---
Total WP network	**88%**	**87%**				
20 operational WP	90%	98%				
6 non-operational WP	75%	41%				
Weather radars	**No target defined****	**Target: 85%**		---	---	---
Total WRWP network	**66%**	**97%**				
33 operational WRWP	78%	100%				
68 non-operational WRWP	61%	96%				

*: The AMDAR target bases on an annual target of 12 Mio. messages. The 2010 performance displays the AMDAR observations including additional data e.g. DWD, Met Office and Météo France sub-3-hourly data (gross) and the EUCOS funded observations (net).

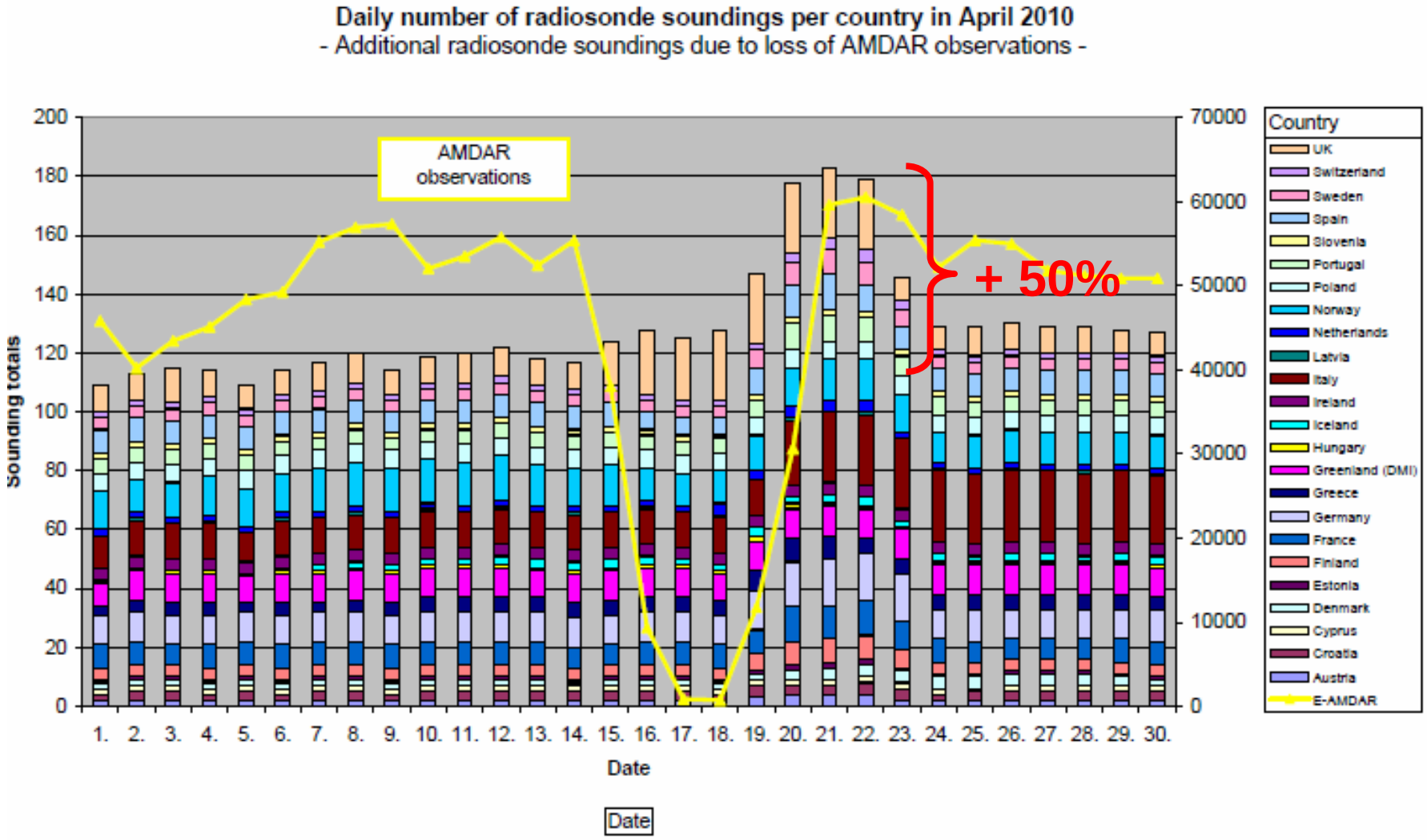
**: Because WRWP systems only provide data if hydrometeors are detected no target on data availability is defined.

target achieved

<10% below target

≥ 10% below target

Impact of the volcanic ash cloud on conventional observing systems



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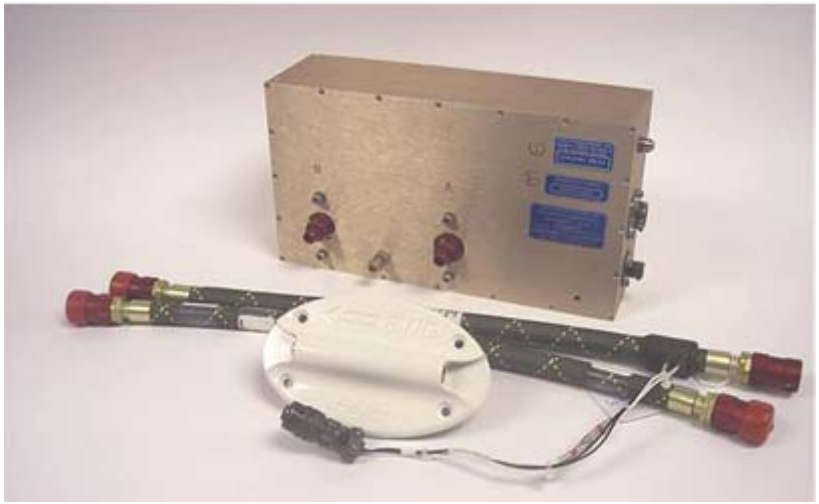
The E-AMDAR Humidity Trial

- Profile measurements are important for the improvement of Regional NWP
- Commercial aircraft measurements complement and partly replace traditional radiosonde soundings
- For km-scale models there is a strong requirement for humidity profile measurements
- Diode laser systems seem to fulfil the requirements on accuracy and operational stability

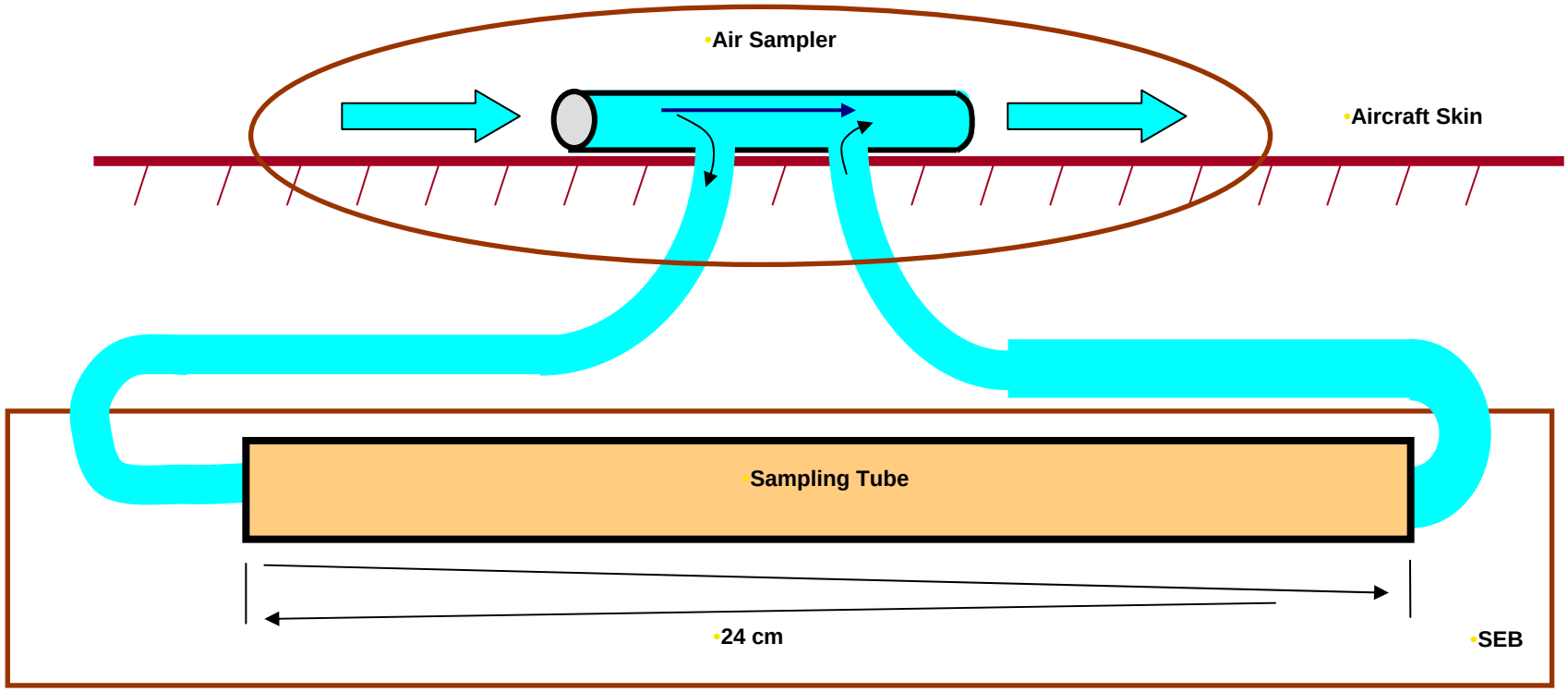
The WVSS-II sensor system

The complete sensor system consists of:

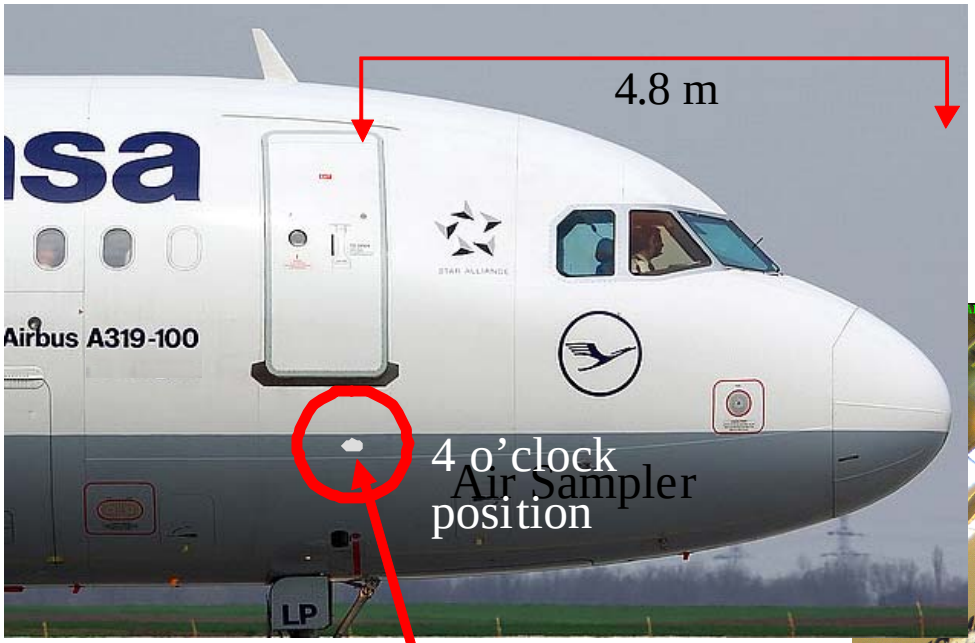
- the Air Sampler to be mounted on the aircraft skin,
- the System Electronics Box (SEB), consisting of the Laser, the sampling tube for the absorption path, and the corresponding electronics,
- the hoses for the connection between the Air Sampler and the SEB.

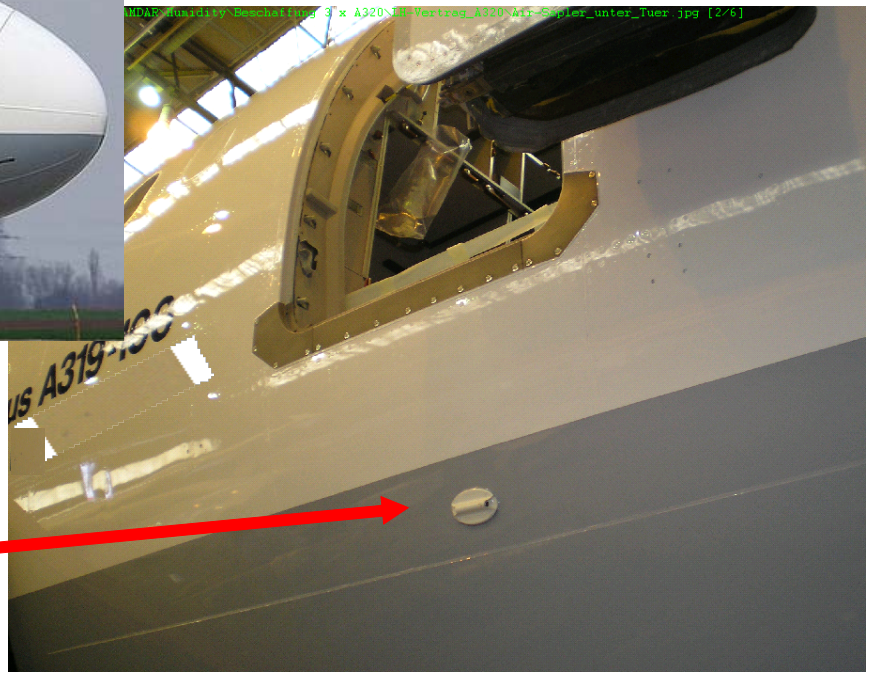


The functionality of the WVSS-II components



Humidity sensor integration on the aircraft





Air Sampler

E-AMDAR humidity trial – next steps

- Replacement of the three sensors with the improved WVSS-II version 3 system
- Extended trial with 3 + 6 additional sensors in 2012/2013
- Close cooperation with WMO AMDAR Panel and NOAA which plan an AMDAR humidity program of 1000 systems in the next years

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EUCOS upper-air network redesign – Motivation

- The EUCOS upper-air network required a redesign because:
  - Of the need to take into account the significant evolution of the E-AMDAR network;
  - Members were not able to install the proposed EUCOS radiosonde network design with 4 ascents per day at most of the sites;
  - Results from the Space Terrestrial Studies are available with recommendations for the network design;
  - Data assimilation of NWP models has improved significantly with advanced capability to make use of high time resolution data.

EUCOS upper-air network redesign – Setup

- **Scenario no 1: Baseline:**
  All current satellite observations used in NWP (radiances, cloud-drift winds, scatt winds) + GUAN radiosonde network + GSN + hourly buoys (no ship data);

- **Scenario no 2: Control:**
  All currently available data in the EUCOS area.

EUCOS upper-air network redesign – Setup

- **Scenario no 3a:**
  Experiment with horizontal spacing of 100 km for profiles. Control "–" those land-based radiosondes which are beyond a network with 100 km horizontal spacing, thereby replacing radiosonde sites with AMDAR data if 3-hourly AMDAR measurements are available at those locations

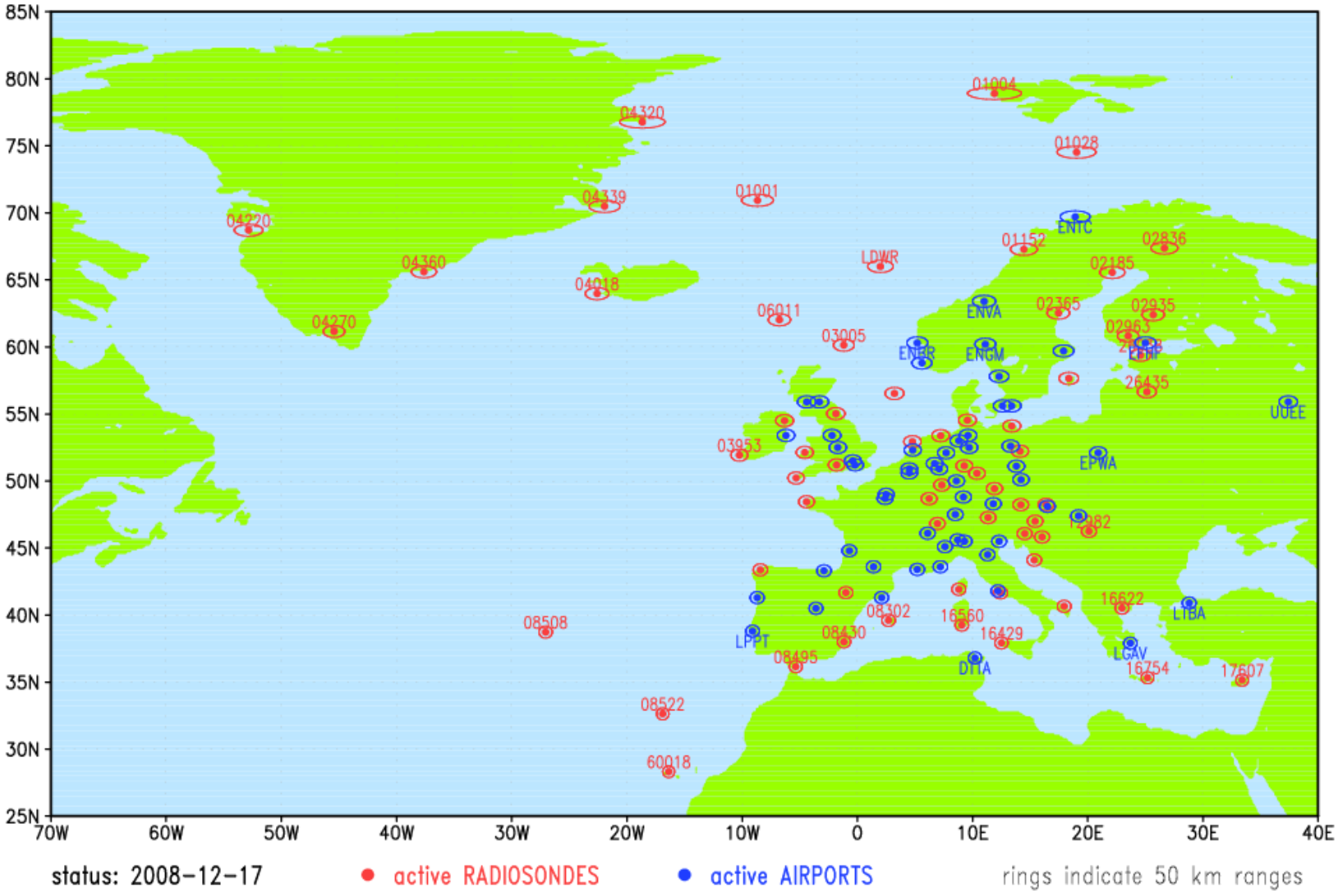
- **Scenario no 3b:**
  The same as for 3a but keeping 0 UTC radiosonde ascents at those sites which are replaced in scenario 3a because of the vicinity to an airport

EUCOS upper-air network redesign – Setup

- **Scenario no 4:**
  Experiment with horizontal spacing of 250 km for profiles from radiosondes and aircraft; all other settings like those of scenario 3a.

- **Scenario no 5:**
  Experiment with horizontal spacing of 500 km for profiles from radiosondes and aircraft; all other settings like those of scenario 3a.

Scenario no 3a: all active radiosondes and 3-hourly airports



EUCOS upper-air network redesign – Setup

- Periods:
  - Winter: 15th Dec 2006 – 31st Jan 2007
  - Summer: 1st Jun 2007 – 15th Jul 2007
- Participants:
  - ECMWF
  - OMSZ
  - HIRLAM (SMHI, Icelandic Met. Service, KNMI, met.no)

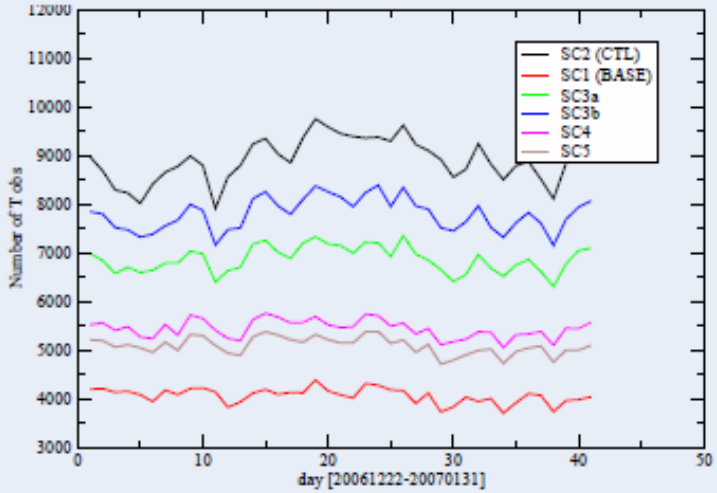
- Acknowledgements:
  E-SAT members,
  Gabor Radnoti (ECMWF), Edit Adamcsek (OMSZ), Nils Gustafsson (SMHI), Roger Randriamampianina (met.no), John De Vries (KNMI), Sigurdur Thorsteinsson (IMO)

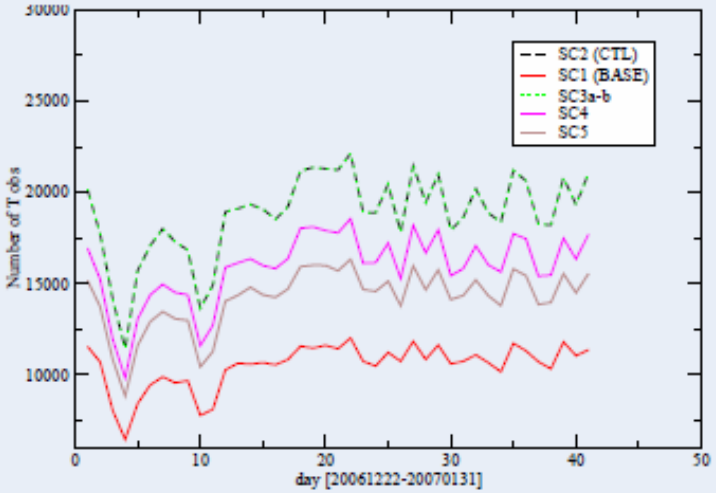
ECMWF: Cross-checking the experiment setup

Observation usage scenarios (cont.)

IMPORTANT: observation usage outside Europe is exactly the same in all scenarios, even in the baseline

Daily assimilated *radiosonde temperatures(left)* and *aircraft temperatures (right)* over Europe



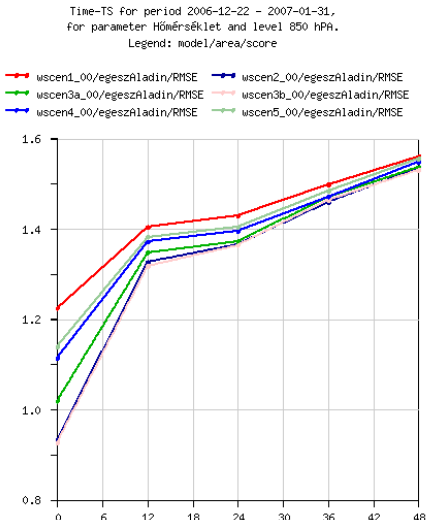


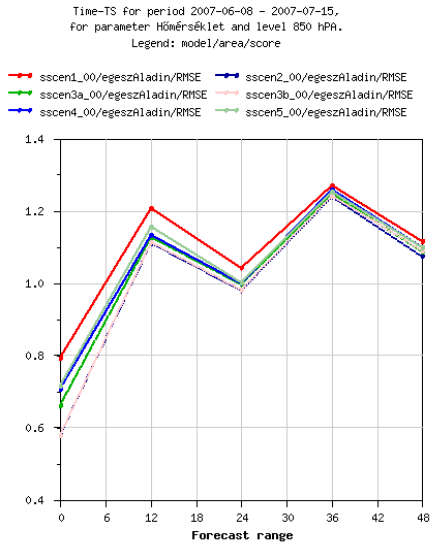
OMSZ: Overall results

winter

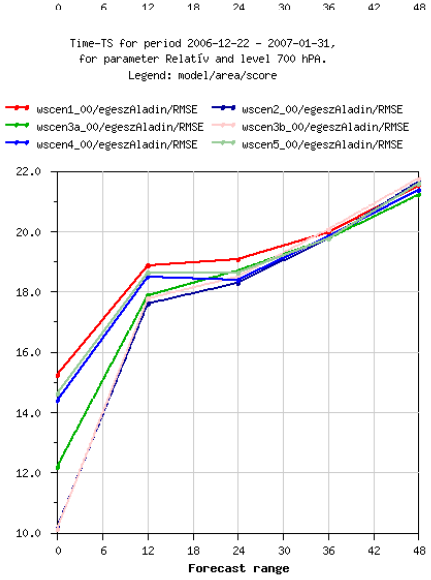
summer

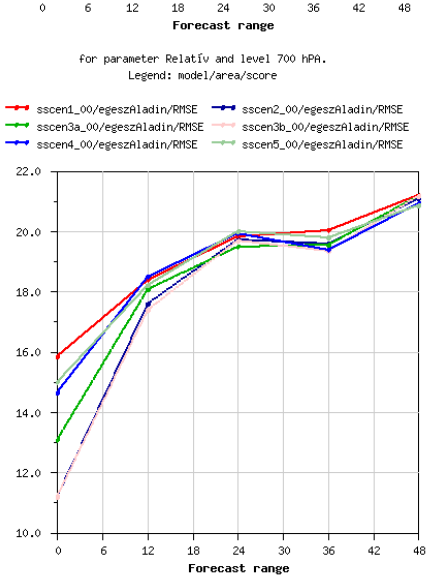
T850





RHU700





EUCOS UANR – Scientific results overall scores ECMWF (example)

850hPa temperature, 700hPa relative humidity and 500hPa geopotential height forecast error increase (in %) for selected denial experiments.

Forecast length	Baseline	Sc3a	Sc3b	Sc4	Sc5
Winter:					
T850+12 hours	+8	0	0	+2	+2
T850+24 hours	+4	0	0	0	+1
T850+48 hours	0	0	0	0	0
T850+60 hours	0	0	0	0	0
RH700+12 hours	+10	+1	0	+2	+4
RH700+24 hours	+5	0	0	+1	+1
RH700+48 hours	+1	0	0	0	0
RH700+60 hours	+1	0	0	0	0
Z500+12 hours	+3	0	0	0	+1
Z500+24 hours	+2	0	0	+1	+1
Z500+48 hours	+1	0	0	0	0
Z500+60 hours	0	0	-1	0	0

EUCOS UANR – E-SAT conclusions

- The OSE studies concerning the EUCOS upper-air network redesign (UANR) were conducted with the **global model** of ECMWF and the limited area models of OMSZ and several HIRLAM members. **In general** the experiments show **similar results**.

- In agreement with the previous Space-Terrestrial study the **baseline scenario** shows a significant and the **strongest reduction in forecast skill**.

- Scenarios 3a and 3b which **removed radiosonde sites collocated to 3-hourly visited E-AMDAR airports** show **almost no degradation in forecast skill**. Results from OMSZ' regional model show better results for a scenario where 0 UTC radiosonde observations –in vicinity to airports- are kept.

EUCOS UANR – E-SAT conclusions

- **Further thinning** of upper-air observations to **250 km or 500 km spacing** show a **significant degradation** of forecast skill for most parameters, and for summer and winter periods.

- When **thinning radiosonde observations** the parameter **most negatively affected** is relative **humidity** in lower troposphere.

- **Biases** are observed **between radiosonde and AMDAR temperature** measurements. More investigations are needed to correct biases of AMDAR observations.

EUCOS UANR – E-SAT recommendations

- A **collocation** of operational **radiosonde** observations and 3-hourly **AMDAR profile** measurements **should be avoided**. Scenario 3b is recommended for implementation.

- Humidity information in the lower troposphere should not be degraded, **E-SAT** therefore **recommends to improve** the **coverage** of lower tropospheric **moisture observations**.

- E-SAT recommends to work towards a **horizontally more homogeneous distribution of upper-air observing sites**.

EUCOS UANR – proposal after consultation with the Programme Board for Observations (heads of OBS departments)

- Definition of a combined radiosonde and E-AMDAR network comprising of
  - 90 operational radiosondes of EUMETNET members
  - 40 airports – visited 3-hourly by E-AMDAR aircraft

- EUCOS recommends
  - to fill gaps in the European upper-air network where the average distance of profiles still exceeds 100 km;
  - to work towards a denser network of humidity profile measurements in the lower troposphere.

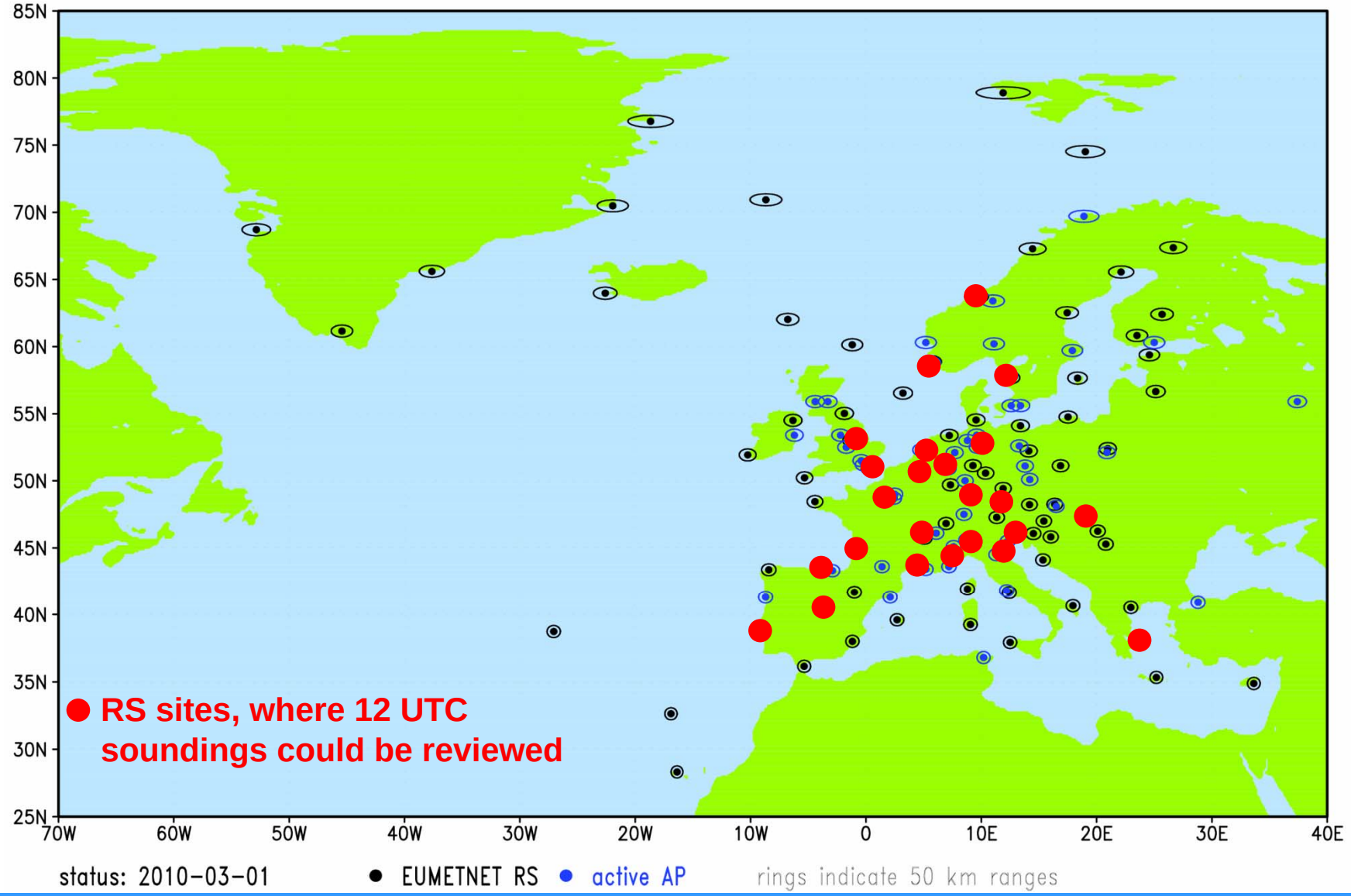
EUCOS UANR – proposal after consultation with the Programme Board for Observations (heads of OBS departments)

- Until aircraft do not provide operational humidity measurements recommendation for 2 radiosonde launches per day even if E-AMDAR measurements are available at airports in the vicinity

  Therefore:

  EUCOS currently pushes installation of humidity sensors onboard E-AMDAR aircraft

EUCOS UANR 2010 - proposal



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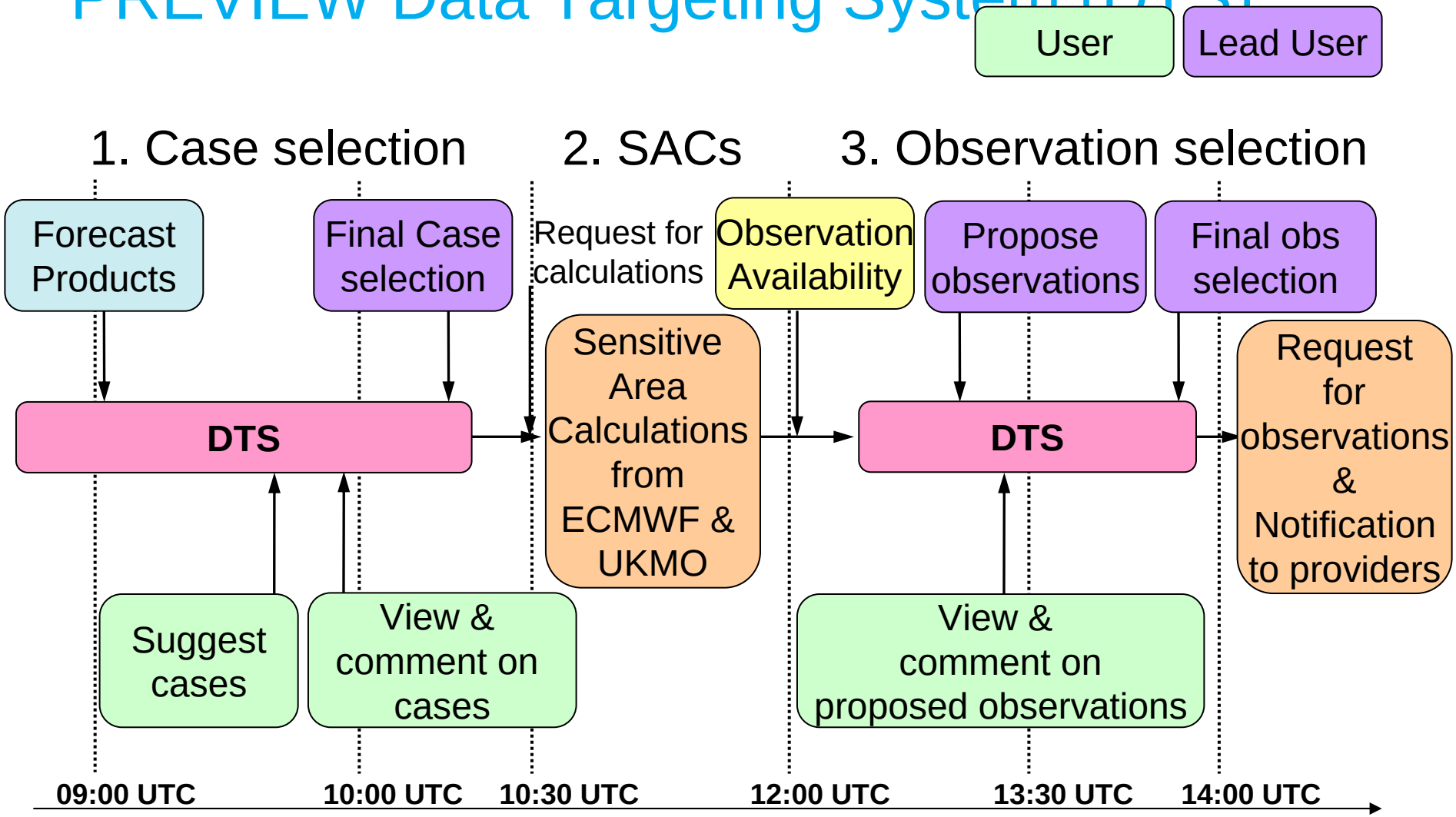
- About EIG EUMETNET and EUCOS
- The current EUCOS network
- EUCOS Information System and Quality Monitoring
- E-AMDAR Humidity Trial
- EUCOS upper-air network redesign
- Data Targeting System
- EUMETNET Observation Roadmap

Data Targeting System

- Aim: make additional observations when and where they will be most beneficial to subsequent forecasts
- 50% / 50% funding from EUCOS and EC under the framework of PREVIEW (www.preview-risk.com)
- A pre-operational Data Targeting System (DTS) has been developed at ECMWF to assess the feasibility of operational adaptive control of the observing system
- DTS is described in issue No. 117 of the “ECMWF newsletter”
- Data Targeting might become operational within EUMETNET/EUCOS, if proven to be beneficial for NWP

PREVIEW Data Targeting System (DTS)



Data Targeting system – results

- During the 2008 trial phase 505 high impact cases were proposed and 446 accepted by the lead user;
- 87% of requested radiosonde ascents from land stations had been deployed; 54% of requested ASAP soundings; in 181 cases E-AMDAR data were requested: availability figure not yet available;
- The DTS is described in the latest issue of the “ECMWF newsletter”, to be soon published on the web
- DTS Trail 2008: Cataloguing of available cases has been finalised
- MEDEX Phase 2: DTS campaign 2nd Oct – Dec 2009

EUMETNET
European Meteorological Services Network

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EUMETNET Observation Goals

I. EUMETNET will develop an integrated composite observing system for Global, Regional and 1 km Scale Convection Resolving Models and for Climate, building on existing infrastructure.

II. EUMETNET will ensure that observational and climate data gathered by the composite observing system will be of appropriate quality to meet the requirements of NWP and climate by working with Members to share and implement best practice and methodologies within the system.

Observation Roadmap Development

- Brainstorming
- Gap analysis
- Collecting proposals for key activities
- Ranking key activities
- Review of existing Obs Programmes

[Breakdown of prioritised key activities]

EUMETNET
European Meteorological Services Network

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EUMETNET
European Meteorological Services Network

Questions and comments?

OSE scenarios - summary

no	scenario description	# EUMETNET radiosondes		# airports
		non GUAN	**total**	
1	BASELINE	0	**13**	**0**
2	BASELINE + all available data in EUCOS area	80	**93**	**58**
3	BASELINE + 100km spaced RS + all airports	50	**63**	**58**
4	BASELINE + 250km spaced (RS + airports)	33	**46**	**40**
5	BASELINE + 500km spaced (RS +airports)	10	**23**	**~ 20**

EUCOS upper-air network redesign – Setup

- Periods: Winter: 15th Dec 2006 – 31st Jan 2007,
  Summer: 1st Jun 2007 – 15th Jul 2007

- Participants:
  - **ECMWF** CY35R2 of IFS (operational in 2009),
    T511 (40km horiz. res.), 91 vert. levels, 4D-Var
    2 runs daily: 0 and 12 UTC, range 4 days
  - **OMSZ** ALADIN/HU (cy30), LAM domain: Central Europe,
    8 km horiz. res., 49 vert. levels, LBC: from ECMWF, local data assimilation: upper air: 3D-Var, surface: OI,
    2 runs daily: 0 UTC, range 54 hours,
    6 UTC, range 48 hours

EUCOS upper-air network redesign – Setup

- Participants:
  - **HIRLAM**(SMHI, Icelandic Met. Service, KNMI, met.no)

    Winter period: HIRLAM, LAM domain: NA + Europe, 0.15° horiz. res., 60 vert. levels, LBC from ECMWF, 4D-Var, 4 runs daily, range 48 hours

    Summer period:

    - HIRLAM, LAM domain: Europe, 0.10° horiz. res., 60 vert. levels, LBC from ECMWF, 4D-Var, 4 runs daily, range 48 hours
    - HARMONIE, LAM domain: Norway, 0.04° horiz. res., 60 vert. levels, LBC from HIRLAM, 3D-Var, 1 run daily: 0 UTC, range 24 hours

OMSZ: overall results table

Scenario	Initial time	WINTER			SUMMER			**"SCORE" ON SCENARIO**
		T_{850}	RH_{700}	Z_{500}	T_{850}	RH_{700}	Z_{500}	
Baseline (Sc1)	00 UTC	12	12	12	12	06	12	**114**
	06 UTC	18	06	06	06	06	06	
Sc3a	00 UTC	12	00	12	00	00	00	**48**
	06 UTC	06	06	06	00	06	00	
Sc3b	00 UTC	00	-12	-24	00	00	00	**-36**
	06 UTC	00	00	00	00	00	00	
Sc4	00 UTC	12	12	12	6	30	12	**126**
	06 UTC	18	12	06	00	06	00	
Sc5	00 UTC	12	12	12	12	30	12	**150**
	06 UTC	18	18	06	06	06	06	
"SCORE" ON VARIABLES		**108**	**66**	**44**	**42**	**90**	**48**	
"SCORE" ON SEASONS		**218**			**180**			
"SCORE" ON INITIAL TIME		**228** (00 UTC)			**174** (06 UTC)			

Table 1: The integration ranges, up to when the impact of the given scenario is significantly negative with respect to the control (sc2) for 850 hPa temperature, 700 hPa relative humidity and 500 hPa geopotential for summer and winter for the 00 UTC and 06 UTC integrations. The bold face lines/column summarise the obtained ranges into a cumulative indicator, which gives and overall assessment of the given aspect.

HIRLAM: overall results table

Winter runs results:

850 hPa temperature, 700 hPa relative humidity and 500 hPa geopotential height RMS error increase (in %) for selected denial experiments

Forecast length	Baseline	Sc3a	Sc3b	Sc4	SC5
Winter HIRLAM:					
T850+12h	+5	-1	0	+2	+2
T850+24h	+1	-4	0	-5	+1
T850+48h	+5	+2	+2	-1	+2
RH700+12h	+1	+5	+1	+2	+1
RH700+24h	+2	0	0	-1	+2
RH700+48h	+5	+3	+2	0	+2
Z500+12h	+6	+1	0	+2	+2
Z500+24h	+7	-1	+1	+1	+4
Z500+48h	+5	0	+1	+3	+2

HIRLAM: overall results table

Summer runs results:

850 hPa temperature, 700 hPa relative humidity and 500 hPa geopotential height

RMS error increase (in %) for selected denial experiments

European domain:

Summer HIRLAM:					
T850+12h	+12	+2	+2	+4	+5
T850+24h	+12	+6	+7	+10	+10
T850+48h	+2	+1	0	+1	+3
RH700+12h	+6	+4	+4	+1	+4
RH700+24h	+5	0	-2	0	+5
RH700+48h	+3	0	0	+3	+1
Z500+12h	+1	-1	-2	0	-3
Z500+24h	+6	-2	+1	+3	+3
Z500+48h	+3	0	-1	+6	+5

Norwegian mesoscale domain:

Summer HARMONIE:					
T850+12h	+5	+1	-2	0	+3
T850+24h	+3	0	0	+2	+4
RH700+12h	+6	0	-2	0	+1
RH700+24h	+2	-6	-3	-1	-4
Z500+12h	+4	-6	-1	+3	-1
Z500+24h	+5	-1	0	+4	+2

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