



# The EPS/Metop System with two satellites in orbit

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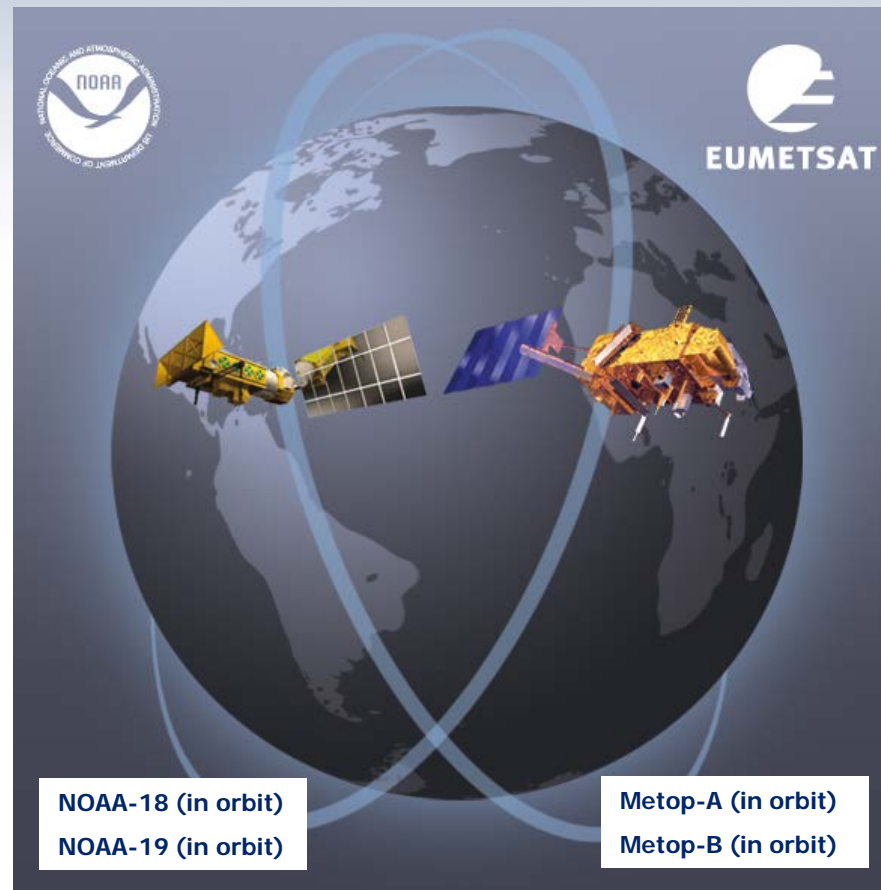
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# EUMETSAT-NOAA Initial Joint Polar System (IJPS)

## Joint Transition Activity Agreement (JTA)

- 1998: decision to have coordinated EUMETSAT-NOAA programmes with:

- Exchange of instruments (ATOVS from NOAA, MHS from EUMETSAT)
- Coordinated operations, data and services
- Usage of US Mc Murdo Station for Metop significantly improved timeliness was introduced later and is very successful wrt timeliness
- NOAA SUOMI NPP in orbit
- Metop C planned in 2017/18



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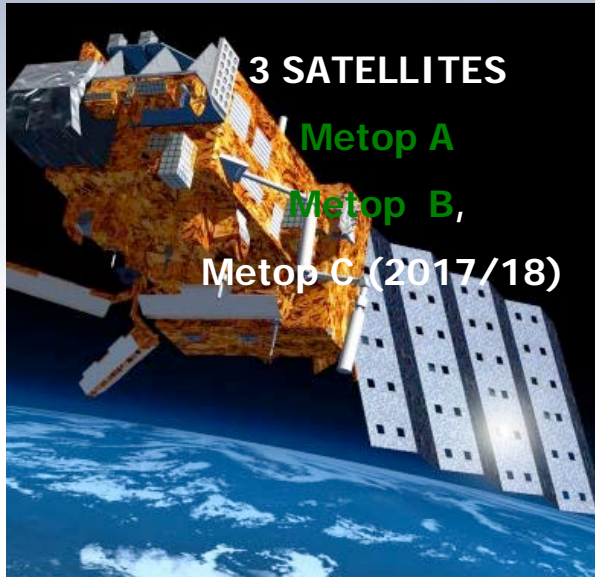


# The EUMETSAT Polar System Elements

**EUM SVALBARD STATION**  
**US Mc Murdo Station**



**3 SATELLITES**  
**Metop A**  
**Metop B,**  
**Metop C (2017/18)**



**SOYUZ 2.1.A,**  
**BAIKONOUR**  
**KOUROU**



**LEOP SERVICE**  
**ESA/ESOC**

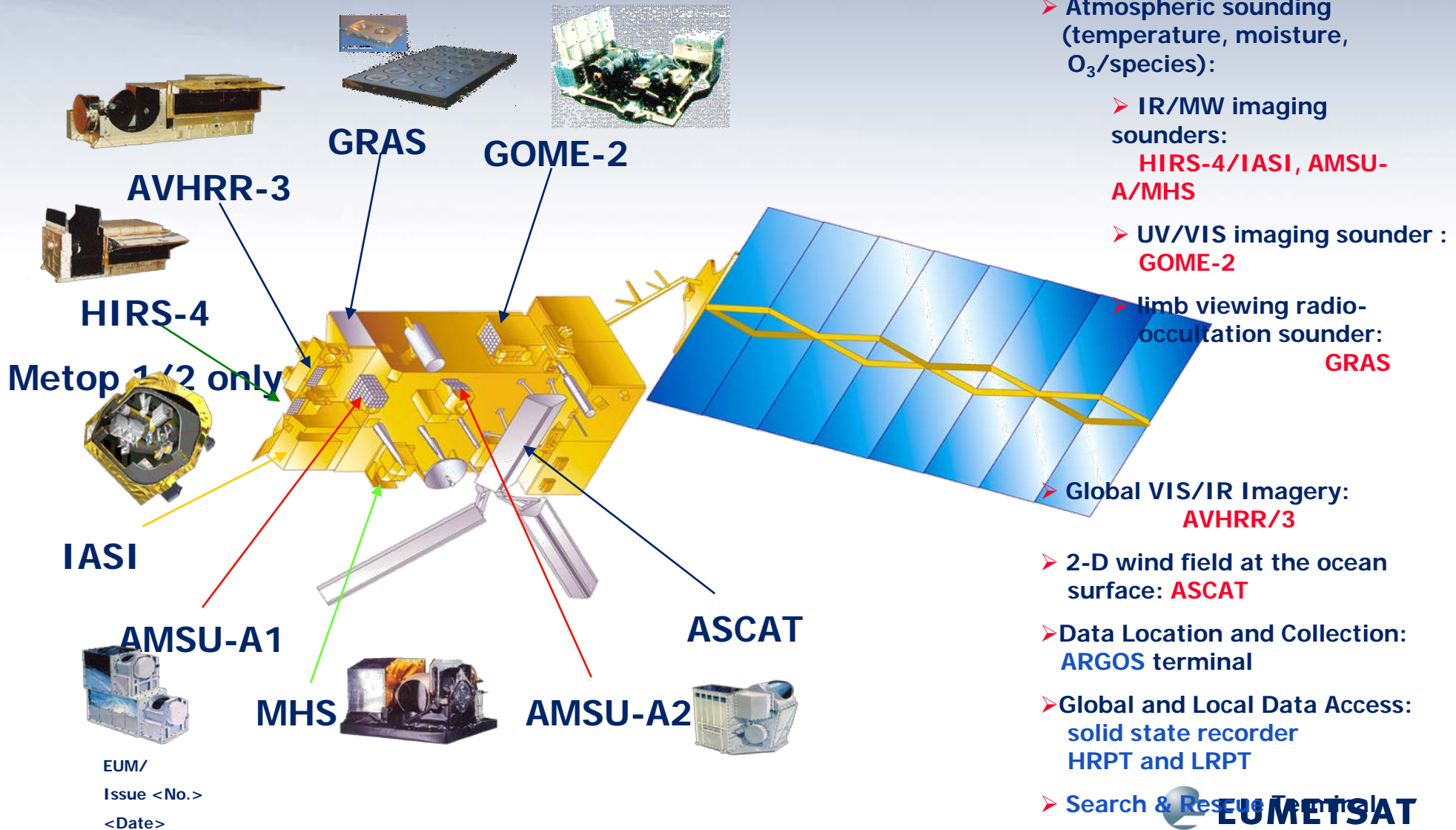


**EUMETSAT MISSION CENTRE**  
**8 SATELLITE APPLICATION**  
**FACILITIES**



- Sun Synchronous orbit
- 820 km, 9h30 LST, 100 min
- Sole source of mid-morning data
- 11 Instruments
- >14 years of operations

# Metop: Satellite, Instruments and Missions







# EPS - An Integrated European Effort

- EUMETSAT has the overall System responsibility and provides the majority of the funding
- Successful Cooperation between EUMETSAT, ESA, CNES and Industry
- EPS Space Segment:
  - Metop-A developed/co-funded with ESA; Metop-B&C jointly procured (single contract for Metop-A/B/C), fully funded by EUMETSAT; Joint ESA and EUMETSAT Single Space Segment Team leading the development at Customer level.
  - IASI-1 developed/co-funded by CNES, under CNES-EUMETSAT cooperation; IASI-2 & 3 procured by CNES, fully funded by EUMETSAT.
  - MHS instruments for NOAA 18/19 & Metop-A,B,C procured by EUMETSAT.
  - ARGOS instruments provided by CNES.
- Launch and LEOP Services procured by EUMETSAT
- EPS Ground Segment and sites developed and procured by EUMETSAT.
- Network of 8 satellite applications facilities (SAF) developed by EUMETSAT Member States in cooperation with EUMETSAT.
- IASI operational level 1 processor developed by CNES.
- EPS System operated by EUMETSAT (>14 years).

# The EPS Services

**Local mission :**  
real-time transmission of imaging  
and sounding data to local user  
stations.

**Global mission :**  
delivery of global  
measurements within 2¼  
hours of observation (GTS,  
EUMETCast)

**Search & Rescue**

**ARGOS mission:** *in situ* data.

**Data Dissemination**  
EUMETCast: Full NRT stream  
GTS: Subset

**Archiving & Retrieval**  
All data and products are  
archived in the UMARF

# Metop A and Metop B are in orbit



**METOP-A**

**BAIKONOUR COSMODROME**

**19 OCTOBER 2006**



**METOP-B**

**BAIKONOUR COSMODROME**

**17 SEPTEMBER 2012**

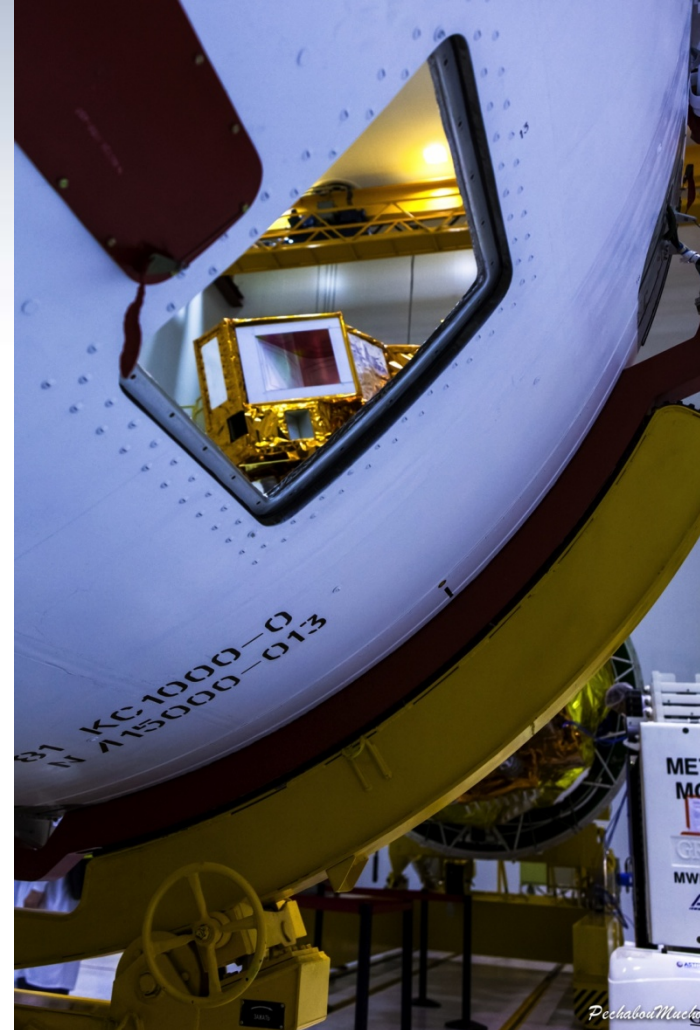
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# Metop-B before the encapsulation in the fairing



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# Metop-A Status

- DHSA: Redundant CCU I/O Board Recovered after last PLSOL
- HRPT:B unit in restricted operation. Complete longitudinal coverage zone active since 18<sup>th</sup> January 2011 (No transmission at higher latitudes in both hemispheres)
- AMSU A1: H7 is declared failed. NEDT on H3 is rising exponentially – at spec. threshold (0.4 K) in September 2013. H8 NEDT also starting to rise.
- MHS Local oscillator swap has improved H3/4 NEDT, but trend still continues – out of spec ca. Mid/late 2013
- GOME throughput loss in UV stabilised with limited performance degradations.

SVM	AOCS	→	POWER	→	DHSA	→
	COMMS	→	Housekeeping	→		
	Thermal	→	PMCIF	→		
PLM	PMC	→	TCU	→	PCU	→
	PDU	→	RTU	→	FMU	→
	SSR	→	XBS	→		
	A-HRPT	→	LRPT	Off		
INST	ASCAT	→	MHS	↘	ADCS	→
	AMSUA1	↘	GRAS	→	SARR	→
	AMSUA2	→	GOME	→	SARP	→
	HIRS	→	IASI	→		
	AVHRR	→	SEM	→		



# Metop-B satellite and instruments status

- HIRS: NEDN of 12 long wave IR channels is degrading. Channel 5 is out of spec.
- A-DCS, SARP, SARR: degradation of received signal by about 10 dB because of CRA antenna cable swap.
- GOME: throughput loss

SVM	AOCS	→	POWER	→	DHSA	→
	COMMS	→	Housekeeping	→		
	Thermal	→	PMCIF	→		
PLM	PMC	→	TCU	→	PCU	→
	PDU	→	RTU	→	FMU	→
	SSR	→	XBS	→		
	A-HRPT	→	LRPT	Off		
INST	ASCAT	→	MHS	→	ADCS	→
	AMSUA1	→	GRAS	→	SARR	→
	AMSUA2	→	GOME	↘	SARP	→
	HIRS	↘	IASI	→		
	AVHRR	→	SEM	→		





# CAL/VAL and dissemination status of L1 products

	Product Level	Special trial Dissemination	Pre-Op Dissemination	End of Cal / Val	Comments
AMSU-A	L1	28/09/12	11/12/12	07/12/12	
AVHRR	L1	05/10/12	11/12/12	07/12/12	
HIRS	L1	26/10/12*	11/12/12*	07/12/12*	Due to HIRS degradation not operational
MHS	L1	02/10/12	11/12/12	07/12/12	
ASCAT	L1	23/10/12	04/12/12	15/03/13	
GOME	L1	12/12/12	03/07/13	03/07/13	
GRAS	L1	01/10/12	15/11/12	26/10/12	
IASI	L1	22/01/13	20/03/13	08/04/13	
IASI	L2	01/03/13	31/07/13	31/07/13	
NDVI	L2	n/a	11/12/12	07/12/12	
AVHRR Winds	L2	01/03/13	02/04/13	02/04/13	TBD
ATOVS	L2	29/01/13*	23/03/13*	26/03/13*	Not possible as specified due to HIRS degradation
SOMO	L2	13/11/12	11/12/12	15/03/13	



# Summary of status and outlook

- Metop-B SIOV and CAL/VAL is performed benefiting from stable EPS ground segment and the experience and lessons learned from Metop-A acquired by all Parties,
- It is the time looking forward to see the positive impacts of IASI on improved weather forecasts from 2 IASIs in orbit (Other instruments as well like RO, ASCAT etc)
- Extended lifetime with good performance of Metop-A will enable a very good inter-calibration with Metop-B.
- EUMETSAT plans to promote Metop-B to Prime satellite in April 2013.
- Congratulations to CNES, ESA and Metop/IASI Industry for the excellent Metop A operational data, the support during the launch preparation and the successful commissioning of the second IASI instrument on Metop-B.
- The preparation of Metop-C for launch will commence in mid 2015 with a Soyuz launch planned in late 2017 from Kourou
- The preparation of the follow on programme is well underway with EPS SG, Metop-SG and IASI NG.
- The launch of the first satellite is now planned for end of 2020 and will allow operational continuity until 2040
- This is the consequence of the significant benefits brought by EPS/Metop over the past 6+ years

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# BENEFITS

# Benefit areas of weather forecasting



**Safety of life, property  
and infrastructure...**



**Transport ...**



**....Energy, agriculture,  
tourism....**



**...Climate policy and  
environment protection**

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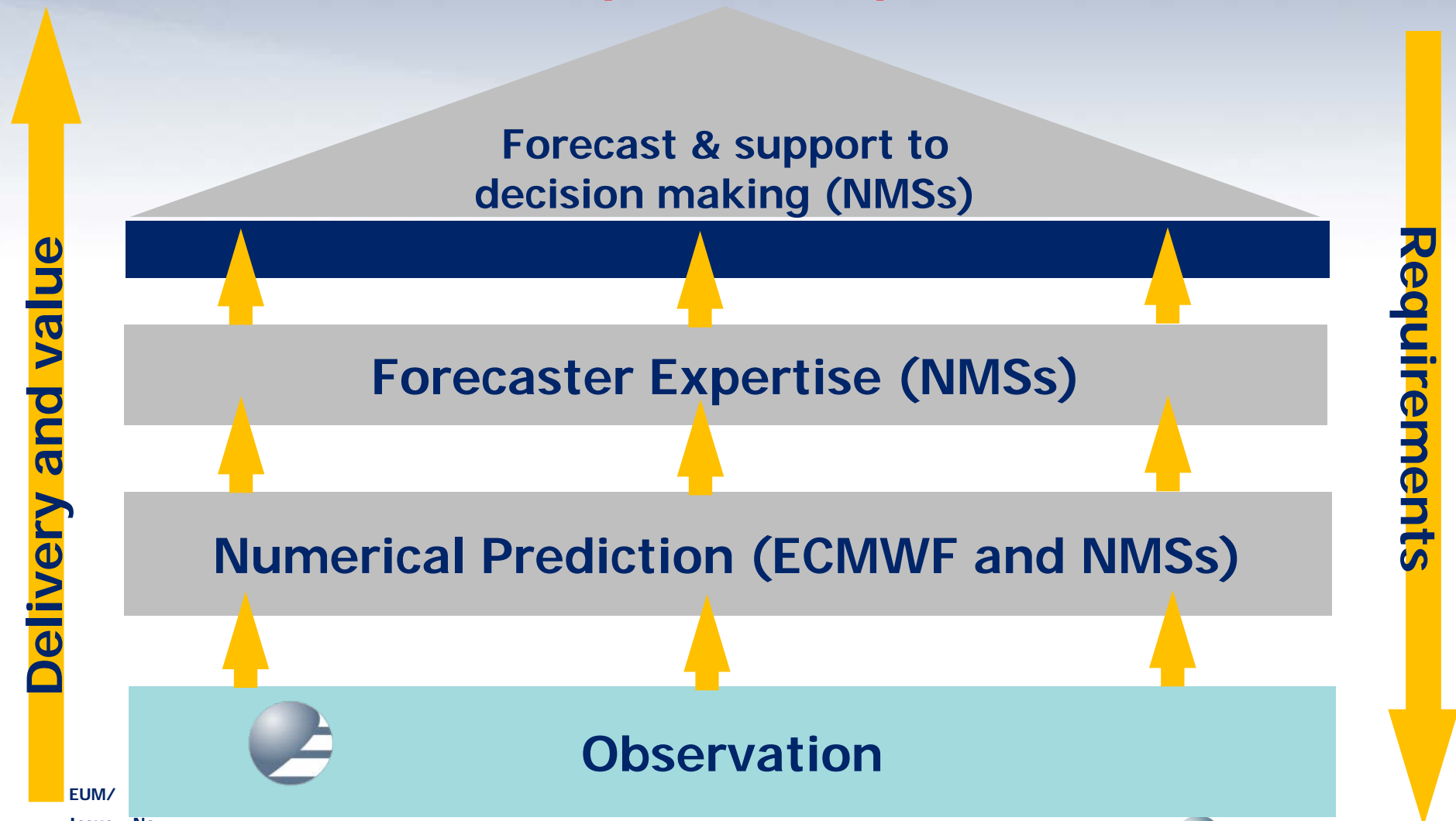
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# From observation to socio-economic benefits

## Benefits from public and private decisions



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<Date>



# How to assess some benefits of observations ?

Estimate *some* Socio-Economic  
Benefits of weather Forecasts  
in selected areas



Assess impact of (current) satellite  
Observations on forecasts



Attribute a fraction of estimated Socio-  
Economic Benefits to satellite observations

*Satellite Programme Costs*



Estimate benefit of current satellites  
and likely benefit to cost ratio  
of future programme



# Estimated benefits of weather forecasting in the EU

BENEFIT AREA	MINIMUM	LIKELY
Protection of property and infrastructure	€1.32 billion/year	€5.4 billion/year
Added value to the European economy	€10.23 billion/year	€41.0 billion/year
Private use by European citizens	€4.0 billion/year	€15.0 billion/year
<b>TOTAL</b>	<b>€15.55 billion/year</b>	<b>€61.4 billion/year</b>

- Value of hundreds of lives saved each year, benefits to defense and security not captured
- Also ignored: additional benefits from specialised forecasts of weather-dependent phenomena, e.g. air quality, marine forecasts, pollution

# Assessing the impact of satellite observations on forecast accuracy

Parallel investigations undertaken to provide 3 different perspectives :



Statistical assessment of the relative contributions of the various observation sources to forecast accuracy

Joo, Eyre et al. (adjoint-based forecast sensitivity method)



Statistical assessment of impact on forecast accuracy using Observing System (data denial) Experiments

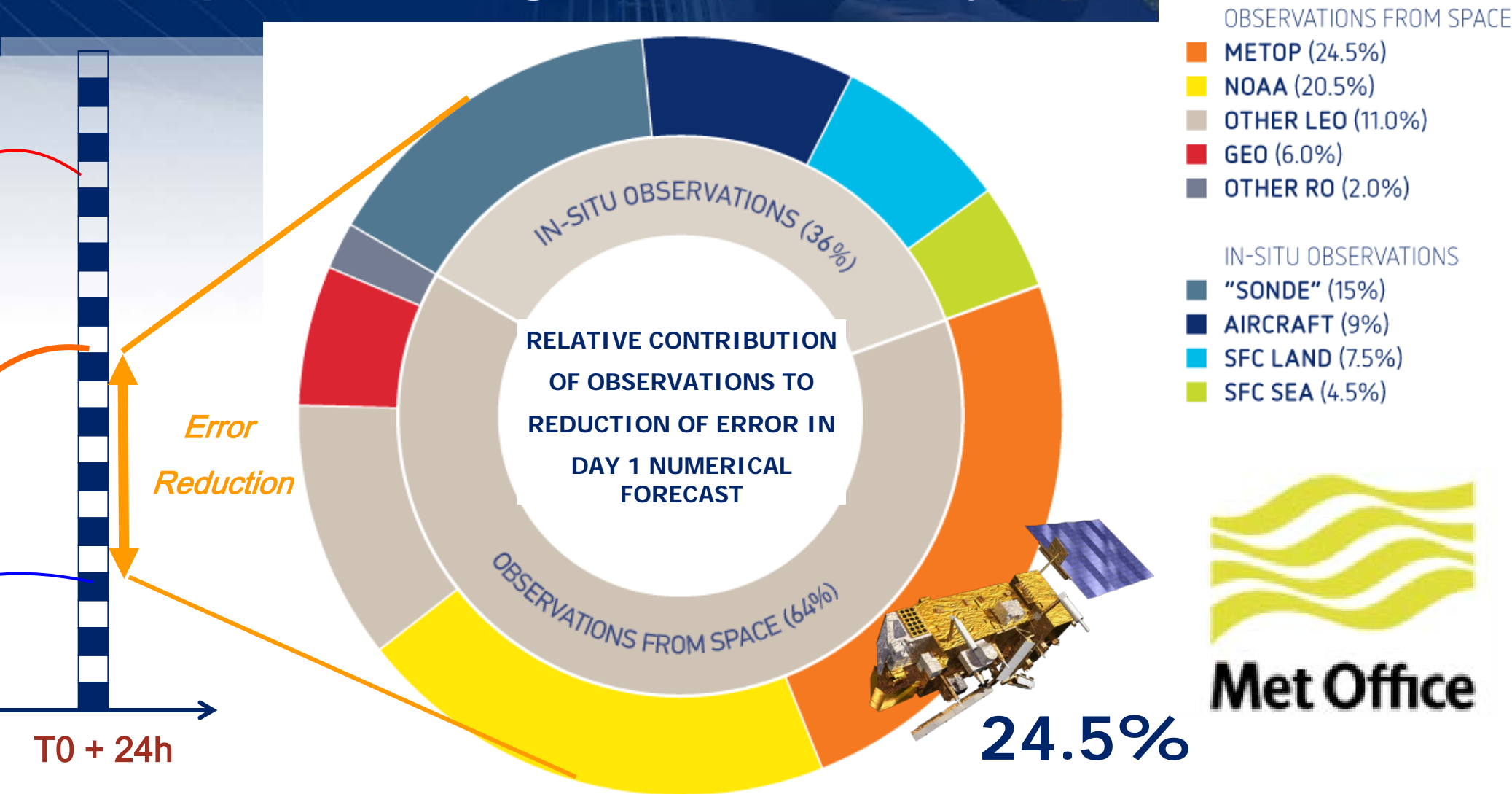
Mc Nally et al.



Case study on the impact of observations from polar satellites on forecasts of winter storms over Europe (data denial experiments)

Potthast et al.

# Adjoint-based forecast sensitivity study: major impact of polar orbiting satellites on Day 1 NWP forecast



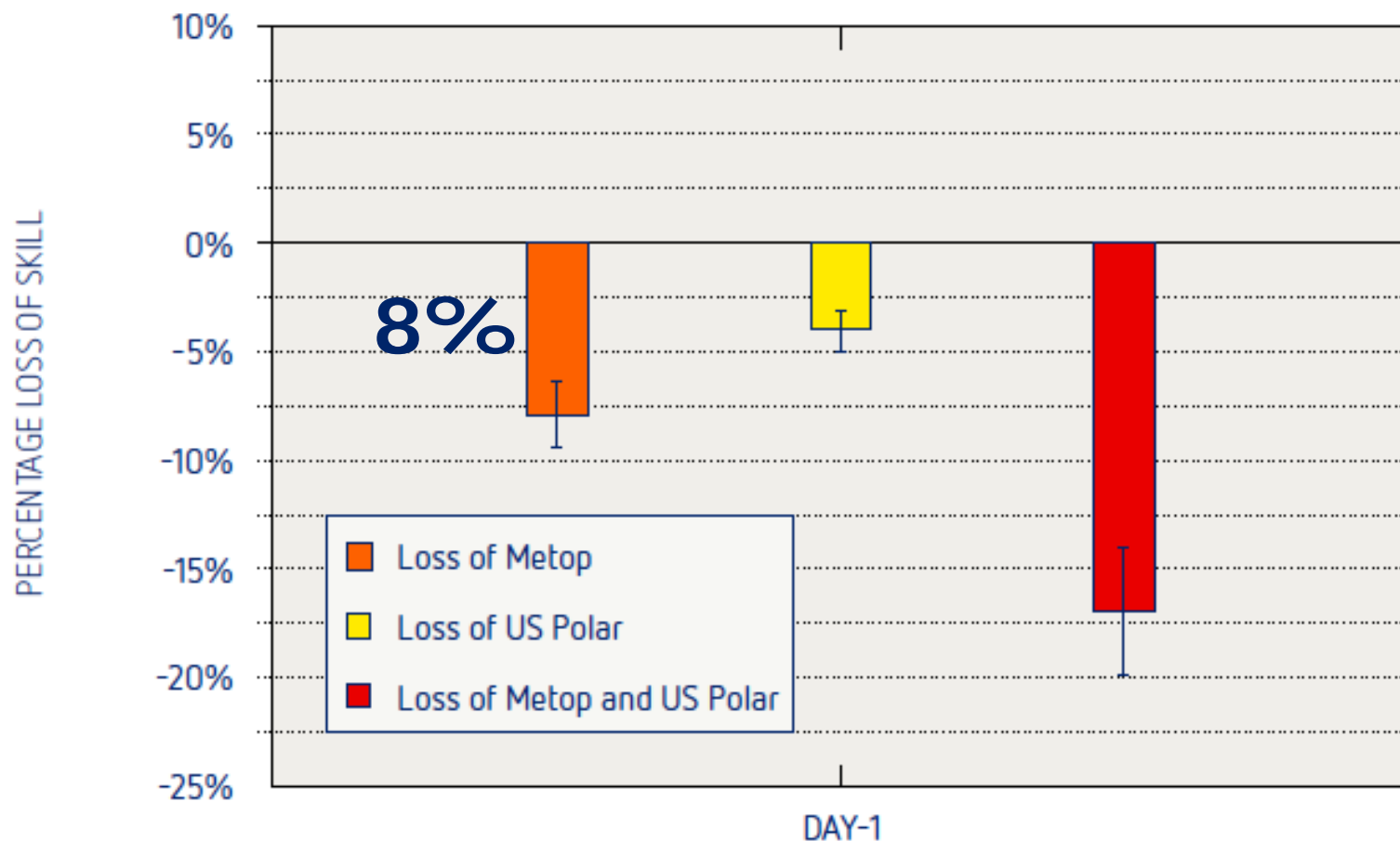


# IMPACT OF POLAR OBSERVATIONS ON DAY-1 FORECAST ACCURACY



## EUROPEAN REGION

(Loss of skill relative to baseline that includes Metop + US Polar)



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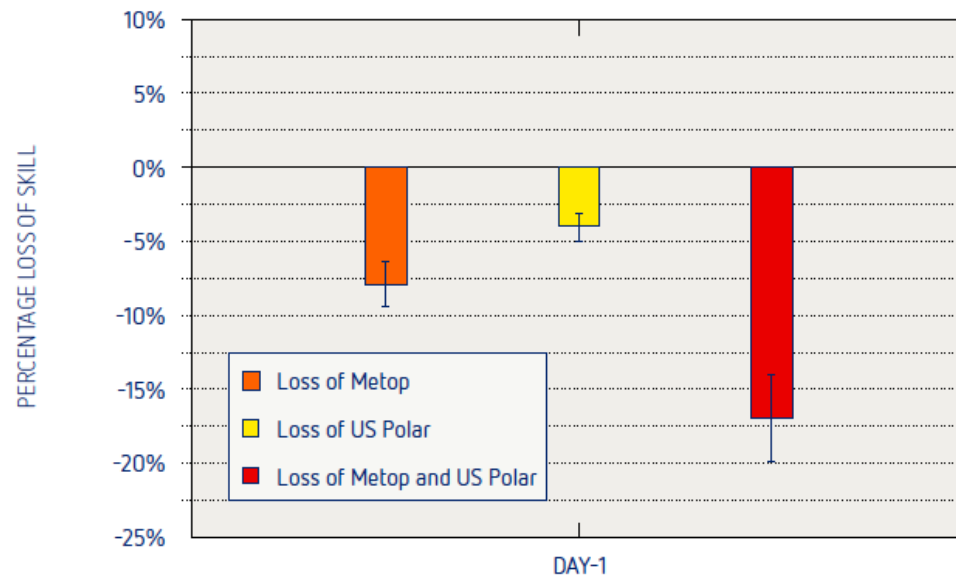
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<Date>

# The benefits of a unique cooperation between EUMETSAT and NOAA: the Joint Polar System



EUROPEAN REGION  
(Loss of skill relative to baseline that includes Metop + US Polar)



$$1 + 1 > 2$$





# Estimated benefits of EPS/Metop-A and EPS-SG

Based of very conservative assumptions (8% contribution) **the likely benefit of Metop-A to the EU is €4.9 Bn/year**

With the same assumption, **the likely benefit of the EPS/Metop-SG programme over the period 2020-2040 is €62.6 Bn**

BENEFIT AREAS	SOCIO-ECONOMIC BENEFIT (over 20 years of EPS/Metop-SG)	
	MINIMUM	LIKELY
Protection of property and infrastructure	€1.45 billion	€6.0 billion
Added value to the European economy	€11.3 billion	€45.2 billion
Private use by European citizens	€3.0 billion	€11.45 billion
<b>TOTAL</b>	<b>€15.7 billion</b>	<b>€62.6 billion</b>

**The benefit to cost ratio of the EPS/Metop-SG programme is between 5 and 20, could be 3 times more with less conservative assumptions**

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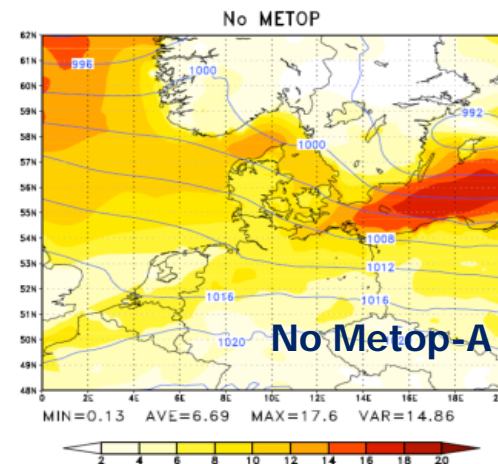
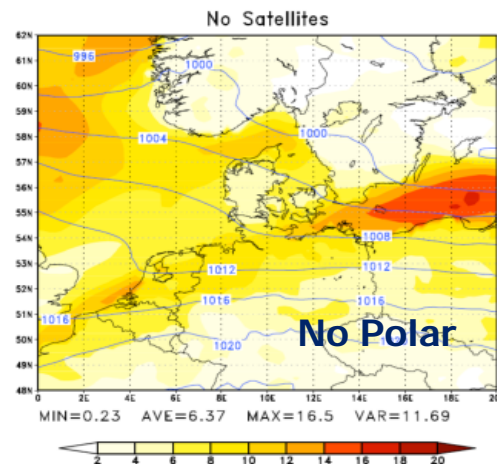
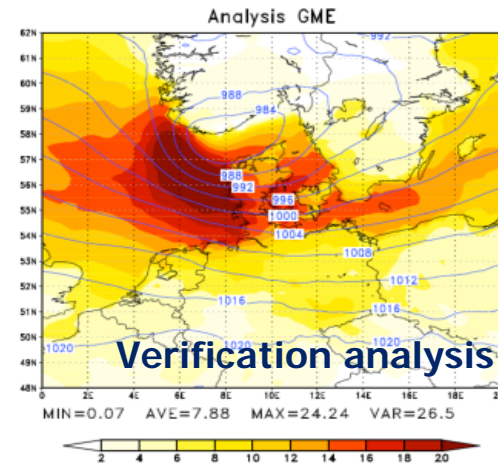
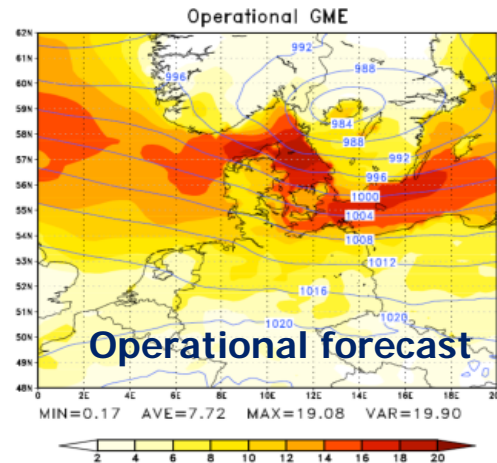
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# Beyond statistics, some cases matter more than others: failing to forecast major storms



Mon 2011020721 (Sun 06 +45): ff\_10m [m/s] at z0



Winter storm "Nicolas": 45 hour forecasts and operational analysis (best approximation of ground truth) of surface pressure (contour lines) and 10m wind speed (shaded areas – units M/S) for 7 February 2011

Issue <No.>

<Date>

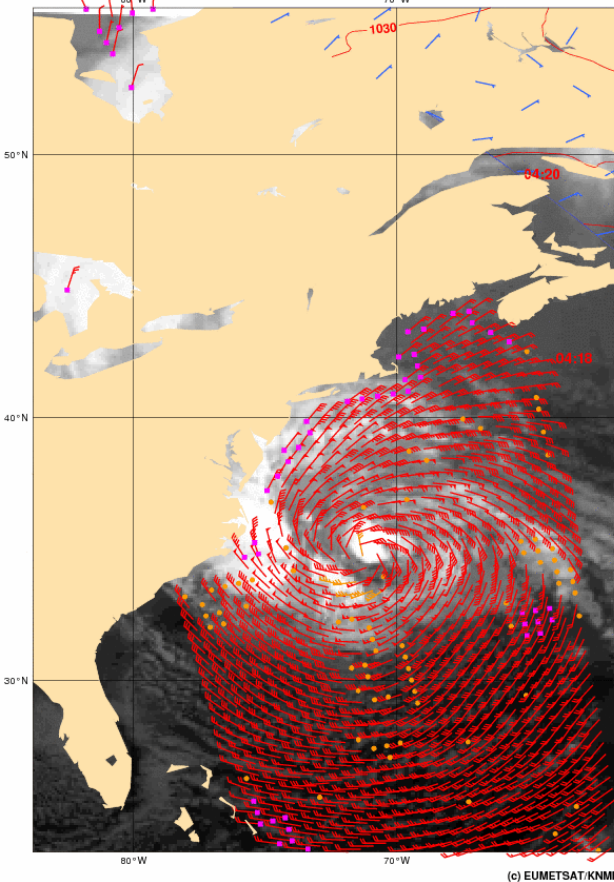


# A recent example/study: preparedness for Sandy



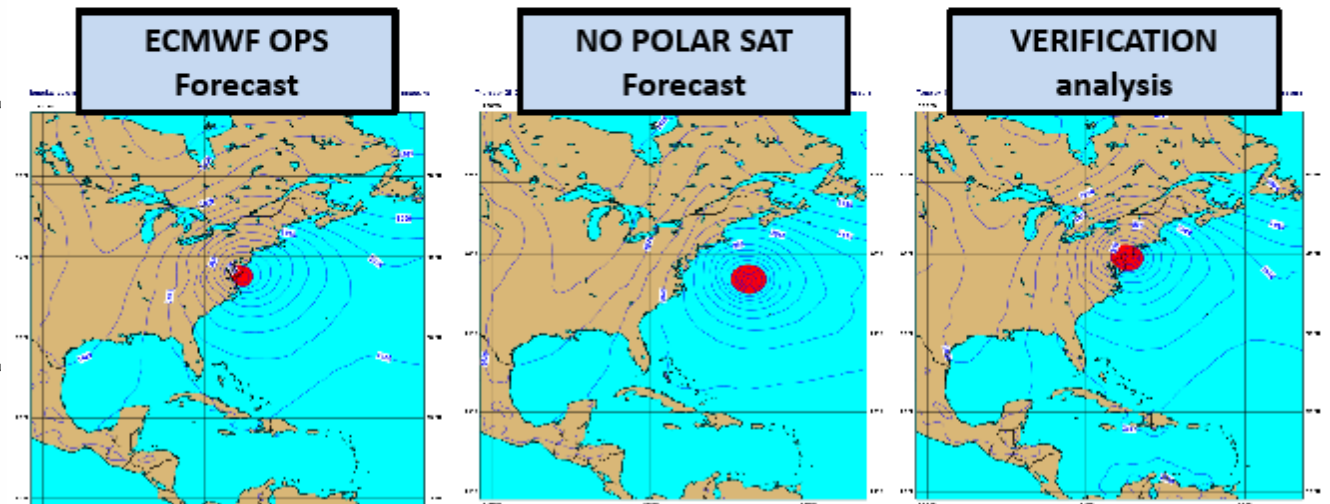
## Forecasts of Hurricane Sandy without polar satellites

OSCAT: 20121029 03:32Z HIRLAM: 2012102900+03 lat lon: 39.52 -72.73 IR: 04:00



(c) EUMETSAT/KNMI

ECMWF forecasts of Mean Sea Level Pressure, 5 days in advance of the 30<sup>th</sup> October 2012 for the landfall of Hurricane Sandy. Forecasts from an assimilation system with no polar satellites fail to predict the landfall of the storm on the US east coast.



**5 day forecast:** Base time 2012-10-25-00z Valid Time: 2012-10-30-00z

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# Conclusion

- The decision to create the Initial Joint Polar System with NOAA incl. a EUMETSAT Polar System (EPS) in 1998 was the right one
- Benefits are clear and acknowledged by all Parties who confirm a long term need
- IASI is a major contributor to this success thanks to the cooperation with CNES and Industry
- It is important to continue and to improve in the areas of
  - weather forecasting
  - knowledge of atmosphere composition.

Noting the growing role of the climate monitoring.

- Long term plans are in place