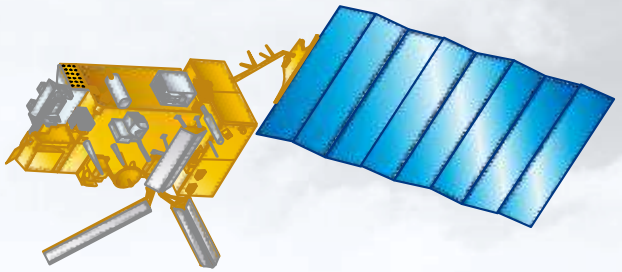
METOP Tandem Phasing

Hans Bonekamp



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METOP Phasing Issue

Phasing:

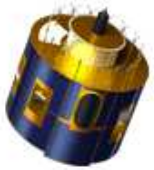
Relative separation in time of the METOP satellites

The phasing translates into a shift of the respective ground tracks of consecutive orbits by the two satellites.

Intro: EUMETSAT Space Segment

Meteosat First Generation

- Meteosat-6
- Meteosat-7



MSG

- Meteosat-8
- Meteosat-9
- Meteosat-10
- Meteosat-11

MTG

EPS

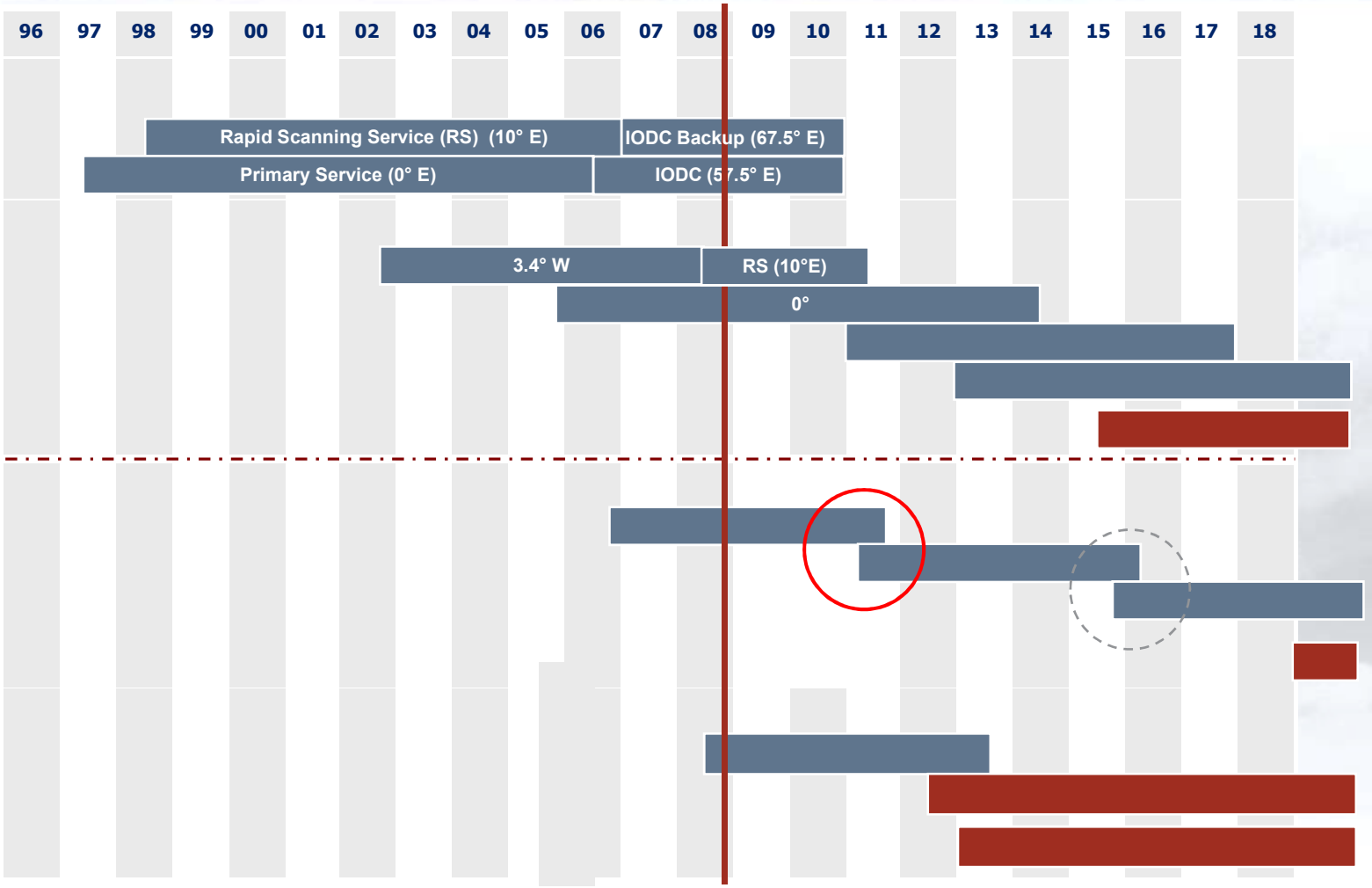
- Metop-A
- Metop-B
- Metop-C

Post-EPS

OSTM

- Jason-2
- Jason-3

GMES Sentinel 3



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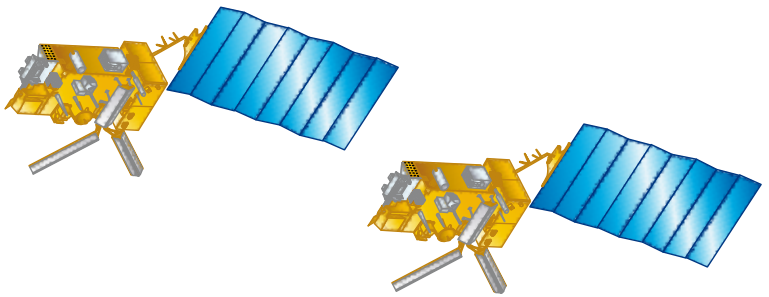
Intro: EPS: METOP-B, METOP-C Launch dates

The baseline launch dates:



METOP-A: October 2006

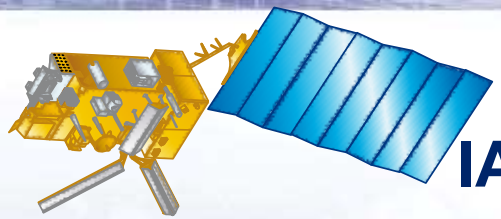
METOP-B: April 2011

METOP-C: October 2015.

Delays possible if METOP-A health status remains good and if affordable.

EPS: METOP: MULTI MISSION

AVHRR



IASI

HIRS/4

AMSU-A1

MHS

AMSU-A2

GRAS antenna

GOME-2

ASCAT antennas

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EUMETSAT Delegate body meetings

	65th Council	09 Oct 2008 to 09 Oct 2008
→	66th Council	09 Dec 2008 to 10 Dec 2008
	PAC Meetings	**Meeting Dates**
	50th PAC	20 Feb 2008 to 20 Feb 2008
	51st PAC	22 Apr 2008 to 23 Apr 2008
	52nd PAC	20 Oct 2008 to 21 Oct 2008
	STG Meetings	**Meeting Dates**
→	52nd STG	06 May 2008 to 08 May 2008
→	53rd STG	14 Oct 2008 to 16 Oct 2008
	AFG Meetings	**Meeting Dates**
	50th AFG	06 May 2008 to 08 May 2008
	51st AFG	14 Oct 2008 to 16 Oct 2008
	Joint STG/AFG Meetings	**Meeting Dates**
	38th Joint STG/AFG	06 May 2008 to 08 May 2008
	39th Joint STG/AFG	30 Sep 2008 to 30 Sep 2008
	40th Joint STG/AFG	14 Oct 2008 to 16 Oct 2008
	WGP Meetings	**Meeting Dates**
	37th WGP	15 Apr 2008 to 16 Apr 2008
	EACCS Meetings	**Meeting Dates**
	11th EACCS	08 Dec 2008 to 08 Dec 2008
	STG-OPSWG Meetings	**Meeting Dates**
→	24th STG-OPSWG	01 Sep 2008 to 02 Sep 2008
	STG-SWG Meetings	**Meeting Dates**
→	25th STG-SWG	03 Sep 2008 to 04 Sep 2008

Technical and Science issues:

STG-OPSWG: Operations technical group

STG-SWG: science and technical group

STG: science and technical group

Council

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EUMETSAT: Spring 2008

- **24th Science Working Group:**
  - **Action 24.2: SWG delegates to send their input on ideas regarding the use of two METOP satellites in orbit. The minimum and maximum separations of the two spacecraft are 20 and 50 minutes, respectively.**
  - **Deadline for contributions is 30 July 2008.**

- **52nd STG 6-8 May 2008:**
  - **To finalise the actual phasing of METOP-A and METOP-B on their orbit by Autumn 2009 in time for a final iteration with Delegate Bodies, and prior to the conclusion of Launch and LEOP preparation activities. An initial feedback from Delegations is requested by the end of 2008, to allow an intermediate iteration of the document in Spring 2009.**
  - **In the case of an earlier launch date, this schedule would have to be advanced accordingly.**

- **ASCAT SAG Meeting: 19-20 June 2008.**
  - **Recommendation 30.8 SAG makes strong recommendation to optimise orbit of Metop-B to ensure swath coverage fills the gap (i.e. minimises the overlap) between left/right swaths of Metop-A. This should be used as a strong constraint in the orbit trade-off.**

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EUMETSAT: Summer 2008

Paper Preparation of next round of delegate meetings:

"***Recommendation for Metop Satellites Phasing***"

(EUM/STG/53/08/DOC/11)

- Consolidated analyses of the constraints for the selection of the phasing as determined by the inherent capabilities of the existing EPS system

- Including references expressed by the Users

=> Proposed phasing baseline (with an exact value 48.93 minutes)

Paper: Reminder programme baseline

- 14 years of continuous operational observations from the mid-morning orbit, based on a sequence of 3 Metop satellites.

- during the commissioning periods of Metop-B and Metop-C, there will be a temporary overlap with the ongoing operations of the previous satellite, resulting in validation products and services for the newly launched satellite provided in parallel with the operational products and services from the former satellite.

- After successful commissioning, the newer satellite would operationally replace the former one that would anyway be reaching its end of life and would hence need to be de-orbited.

Clearly, wrt the readiness for Metop-B, many different situations had to be analysed:

- longer in-orbit life of Metop-A, with full or partial payload availability and sufficient fuel reserve to delay considerably the time of de-orbiting;
- temporary or permanent degraded performance of Metop-B payload or parts of it, including the possibility of a split mission
- Contingencies on Metop-A requiring an earlier launch of Metop-B.

Paper: selection aspects

- **Constraints given by the existing EPS System:**

  Compatibility with the given space segment, the ground segment and the operational concept.

  Factors: Orbit definition, Ground stations, Links, Data processing and dissemination, Calibration and validation, Split mission, Routine operations, Maintenance. Accommodation of a third Metop satellite

- **Data exploitation by the users**

  Factors: E.g., Revisit intervals, spatial coverage.

METOP ORBIT: Orbit Duration

The orbits for all Metop satellites are essentially the same:

- Mean Local Solar Time (MLST) of the descending node of 9:30,
- the same semi-major axis, inclination, eccentricity and argument of perigee.
- The duration of an orbit is approximately 101.4 min.
- The full repeat cycle is 29 days

A ⇔ B: Phasing Upperbound < half an orbit (~ 51 min.),

Equivalent to about 1400 km at the equator.

Data dump lowerbound

Lowerbound of the phasing originate from the combined time needed

- to set up the CDA for a pass,
- the complete duration of the pass itself and
- the time needed to reset the CDA after the pass.
- Tolerance for each satellite is +/- 2 min. Hence 2 times 2 min

In total, Lowerbound about 28 min.

NOAA has also confirmed that this phasing would be compatible with the potential support by their ground stations for two Metop satellites.

Discrete Phasing

To ensure the same high level of calibration accuracy as it has been achieved for ASCAT on Metop-A, an identical ground track should ideally be implemented for Metop-B to have the same viewing geometry of the ASCAT instrument with respect to the transponders.

Revisit Interval (Days Within the 29-Days Cycle)	Phasing (Minutes)
11 / 18	+/- 27.96
13 / 16	+/- 31.46
8 / 21	+/- 34.95
3 / 26	+/- 38.45
2 / 27	+/- 41.94
7 / 22	+/- 45.44
12 / 17	+/- 48.93

Table 1: Phasing values leading to a repetition of the ground track (within the acceptable phasing range)

AVHRR

(scan width of +/- 1447 km, sampling along the whole swath):

Short-term: The scan width ensures that essentially no coverage gaps exist between two subsequent orbits, even close to the equator, when only one Metop is used, i.e. a second Metop is not needed to fill gaps.

Note that the larger the phasing, the larger the longitudinal displacement between the AVHRR swaths for the two satellites, i.e. the covered area is maximised when using the larger phasing.

Long-term: Already one Metop satellite allows to achieve global coverage within about 0.5 days; the second satellite will only increase the frequency of the observations. The selected phasing has no impact.

IASI / HIRS / MHS / AMSU-A

scan widths between +/- 1027 and 1080 km, sampling along the whole swath

Short-term: The scan width is such that with a single Metop gaps between subsequent orbits exist for absolute latitudes less than 45° (exact latitude depending on the considered instrument).

A second Metop will fill the gaps irrespective of the phasing value within the possible range.

As with AVHRR, the covered area is nevertheless maximised when choosing the larger phasing due to the larger longitudinal difference between the two Metop tracks.

Long-term: 100% global coverage is achieved with one Metop after about 1.5 days and with two satellites after days, for any phasing in the range of 28 min. to 49 min.

GOME

(scan width of +/- about 0.5 960 km, sampling along the whole swath):

Short-term: With a single Metop, gaps between subsequent orbits exist for latitudes between +/- 40°. A second Metop will fill the gaps if the phasing value is in the range from 35 min. to 49 min. A phasing of 28 min. would leave some smaller gaps around the equator.

As with AVHRR, the larger phasing would maximise the covered area.

Long-term: 100% global coverage is achieved with one Metop after 2.5 days. With two Metops phased by 28 min, this is achieved within 1 day, but already within about 0.5 days when the phasing is between 35 and 49 min.

Note: the Implementation Group for the Space observation infrastructure for the GMES Atmosphere Core Services recommends to operate GOME-2 in a narrower swath mode in order to improve the resolution and consequently increase the number of cloud-free observations of lower troposphere. With a 49 min phasing GOME-2 could be operated with half of the nominal swath width at +/- 480 km with a 50% improvement in the across track resolution, providing a similar daily coverage as currently with one satellite

occultation measurements of GPS satellites):

the spatial coverage being determined by the relative location of the Metop satellite and the GPS satellites.

For NWP:

Occultations should not be too close in space and time. Phasing should be as large as possible.

For climate

improved data coverage; phasing should be as large as possible,

assessment of the inherent radio occultation accuracy. For issue (1), thethe separation time should be as short as possible, so that the same air parcel is observed from two instruments in the same geometry, using the same GPS satellite

Given the considerations, the largest separation, leading to a phasing of ca. 49 min. is the favoured option.

ASCAT

two swaths of 550 km, starting at 350 km on each side of the Metop ground Track

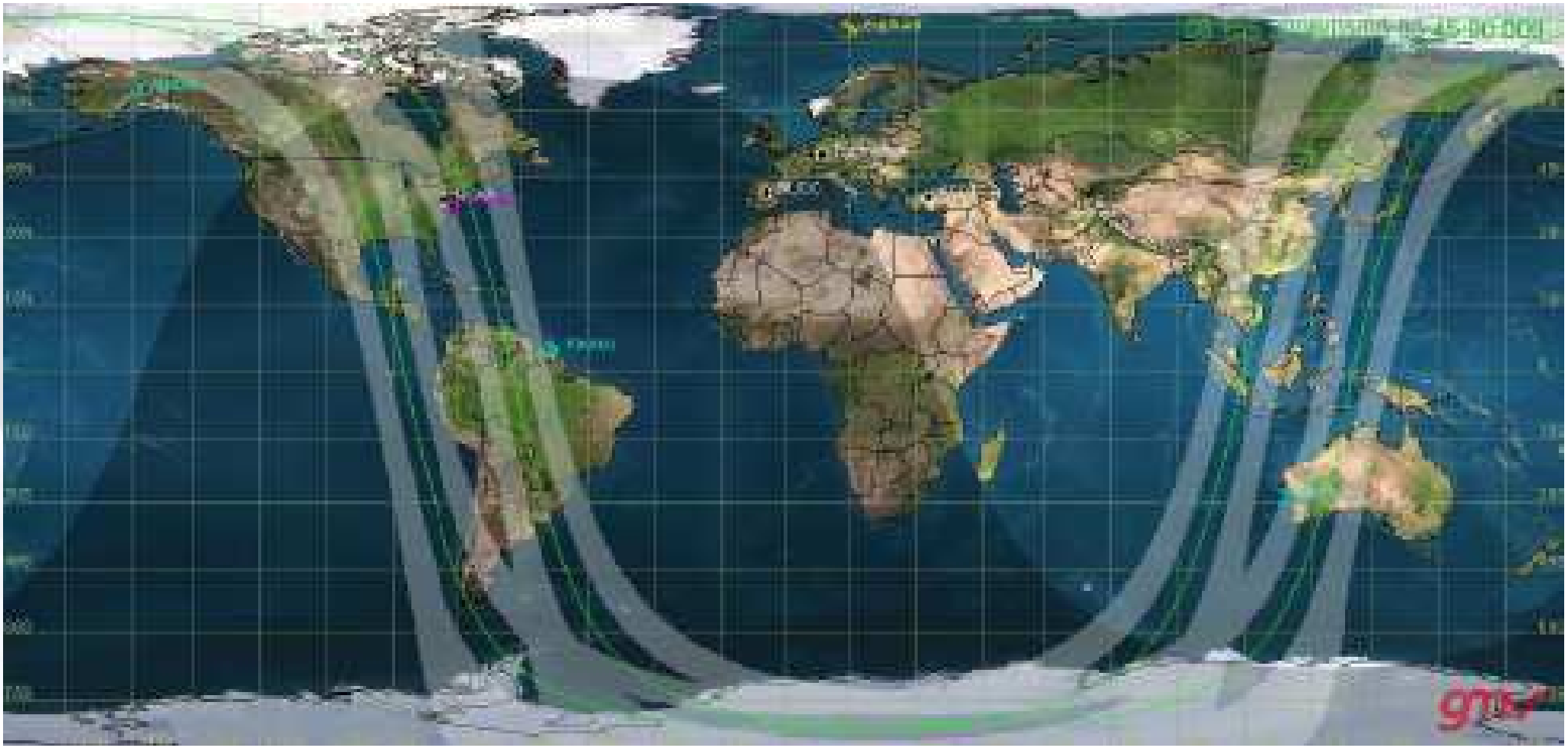
Short-term: The ASCAT spatial sampling leads to gaps of varying size between consecutive orbits at various latitudes when one Metop satellite is used. A second Metop satellite will for any phasing between 28 and 49 min. only partially fill the gaps; with a phasing of 28 min., the coverage of gaps is better in a belt around the equator, with a phasing of 49 min., the coverage of gaps is better at higher latitudes.

COVERAGE:	28 min	49 min
Low Latitudes	80 %	50 %
High Latitudes	85%	95%

Long-term: Full global coverage is achieved with one satellite after 3 days; with two Metops phased by 28 min. it takes about 1.5 days to achieve global coverage, with a phasing of 49 min. it takes about 2.5 days. In the latter case, a quite complete coverage is achieved however already after 1.5 days, with only some relatively small gaps at latitudes between 30°N and 30°S corresponding to about 2.5% in this belt

Note that due to its scan geometry ASCAT always leaves a "hole" at each pole with an area of <0.01%; this is unavoidable, irrespective of the number of satellites and the phasing.

ASCAT Coverage by 2 subsequent orbits per satellite: One METOP



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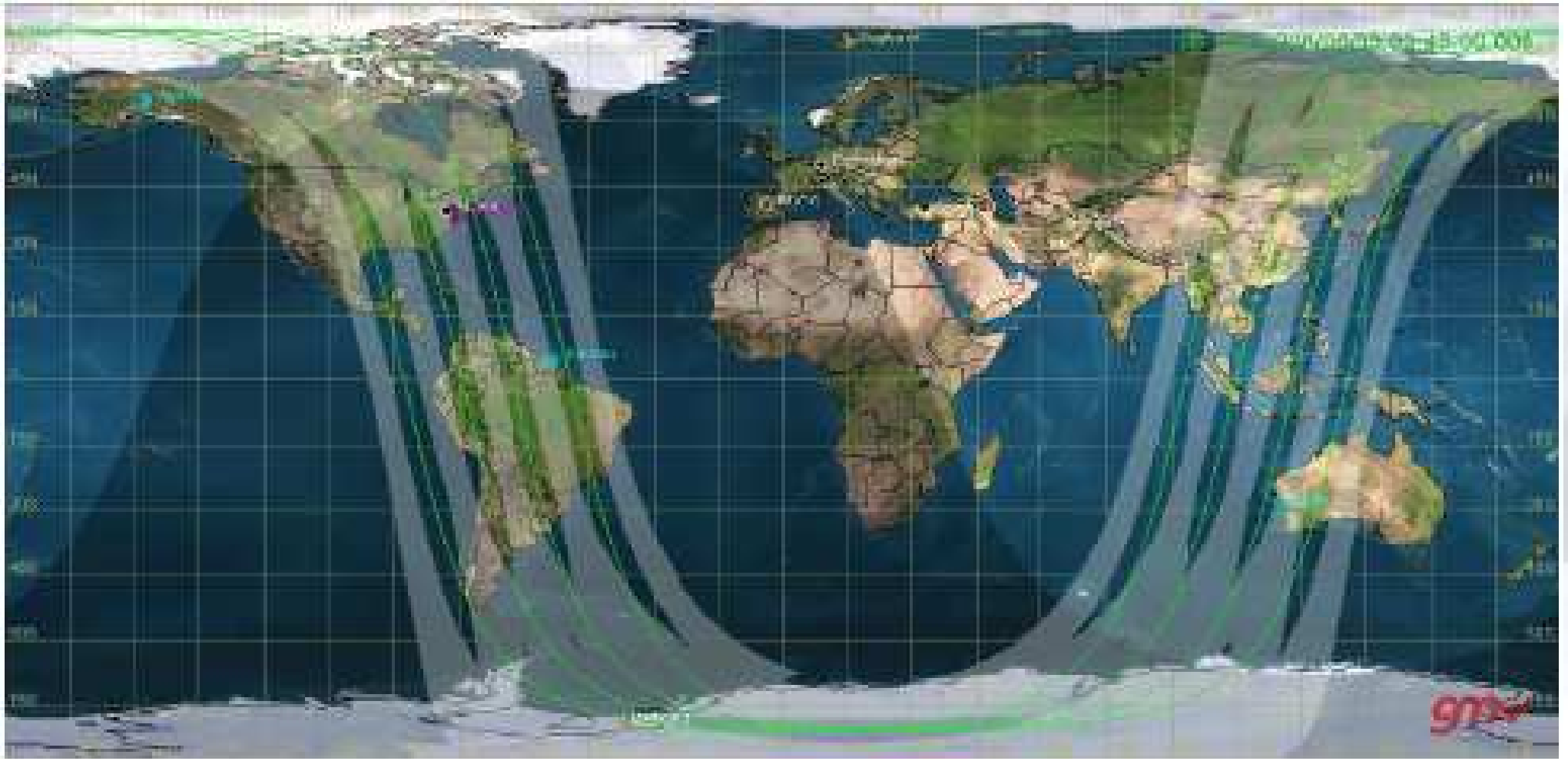
ASCAT Coverage by 2 subsequent orbits per satellite: 49 Minutes



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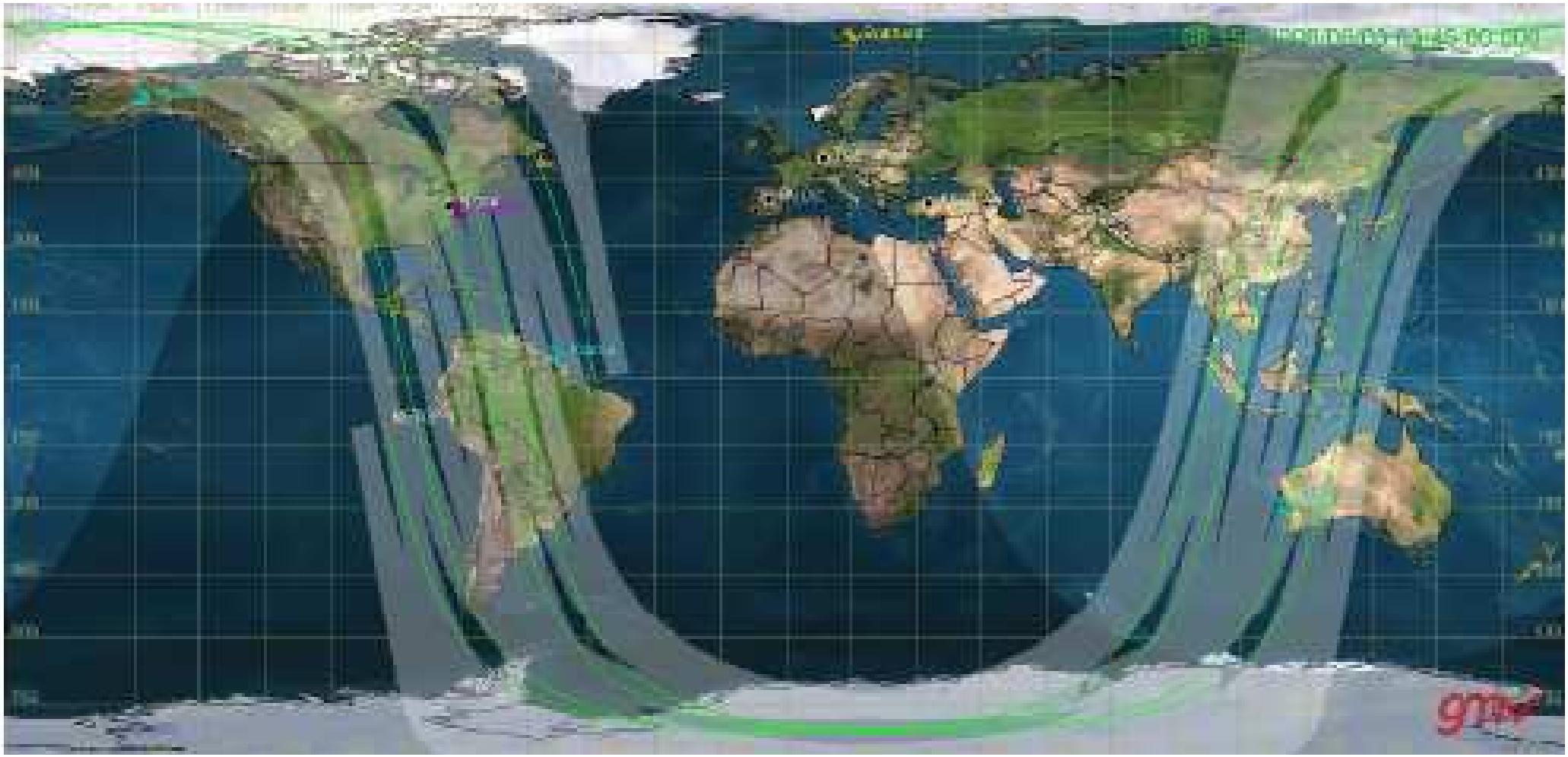
ASCAT Coverage by 2 subsequent orbits per satellite: 28 Minutes



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Feedback by users

Since the last OPSWG meeting in Spring 2008

- Météo-France: maximum separation
- ECMWF: maximum separation
- ITSC-16 (NWP Sub-Group): maximum separation
- ASCAT SAG: maximisation of coverage by ASCAT

(ITSC = International TOVS Study Conference; SAG = Science Advisory Group)

- **The feedback received by the Users so far shows a preference for the larger phasing in view of the use of Metop data for NWP, with the desire to maximise the spatial coverage by the relevant instruments. In addition, NWP users (e.g., ECMWF) have indicated that the optimisation of sounding data coverage should have priority over the ASCAT coverage optimisation.**

- **This optimisation of the ASCAT coverage would be best fulfilled by a phasing value closer to the minimum of 28 min. However, as discussed above, the differences in global longer term coverage by ASCAT for the minimum phasing and the maximum phasing are quite small.**

- **NOAA as recipient of Metop data and products has not expressed a specific preference for a phasing value. They have confirmed that the maximum phasing between the two satellites would be acceptable to them, but stated that their processing system could also handle a smaller phasing in the discussed range.**

EUMETSAT: Autumn 2008

OPS WG: ***02 September 2008***

Recommendation 08/24/03: STG-OPSWG recommends to STG the endorsement of the proposed phasing baseline (with an exact value 48.93 minutes), which is in line with the identified constraints and with the preferences expressed by the Users as a basis for the definition of the Metop-B launch and LEOP services.

SWG: ***03 September 2008***

STG: ***16 October 2008***

Noted the recommendations for the phasing of the Metop Satellites, as described in EUM/STG/53/08/DOC/11, in particular, the consolidated analyses of the constraints and the operational impact for the selection of the phasing as determined by the inherent capabilities of the existing EPS system.

Noted the preferences expressed by the Users for the larger phasing value equivalent to approximately half an orbit and the endorsement of the recommended phasing by the OPSWG and the SWG in September 2008;

Summary

- **Multi-Mission issue**

- **Paper Conclusion:**

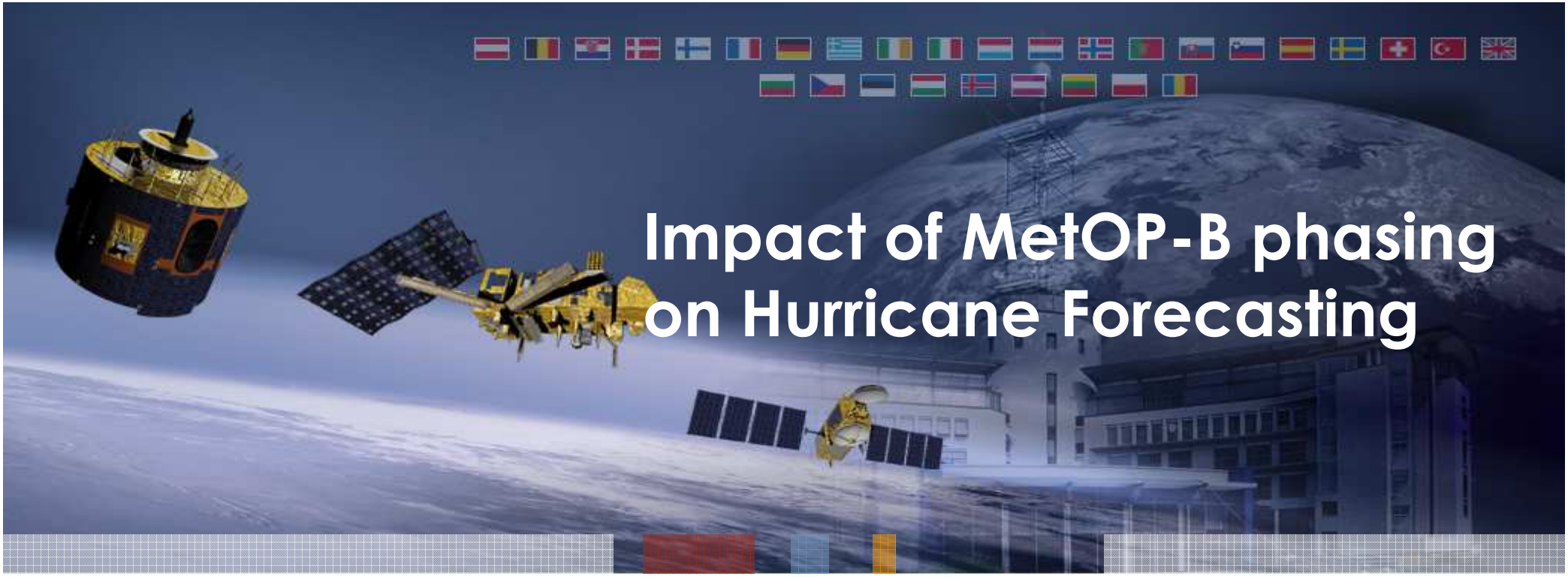
"With the feedback from the Users being quite homogeneous and compatible with the operational preference by EUMETSAT for the phasing, the baseline for the phasing of 48.93 minutes is proposed"

- Endorsed by OPSWG, (SWG)

- **STG53 Unanimously** (**Italy** in writing) recommended to Council, as **uncontroversial**, the endorsement of the proposed phasing baseline (with an exact value of 48.93 minutes), which is in line with the identified constraints and with the preferences expressed by the Users as

a basis for the definition of the Metop-B launch and LEOP services.

Endorsement of baseline expected from 66th Council, 9-10 December 2008



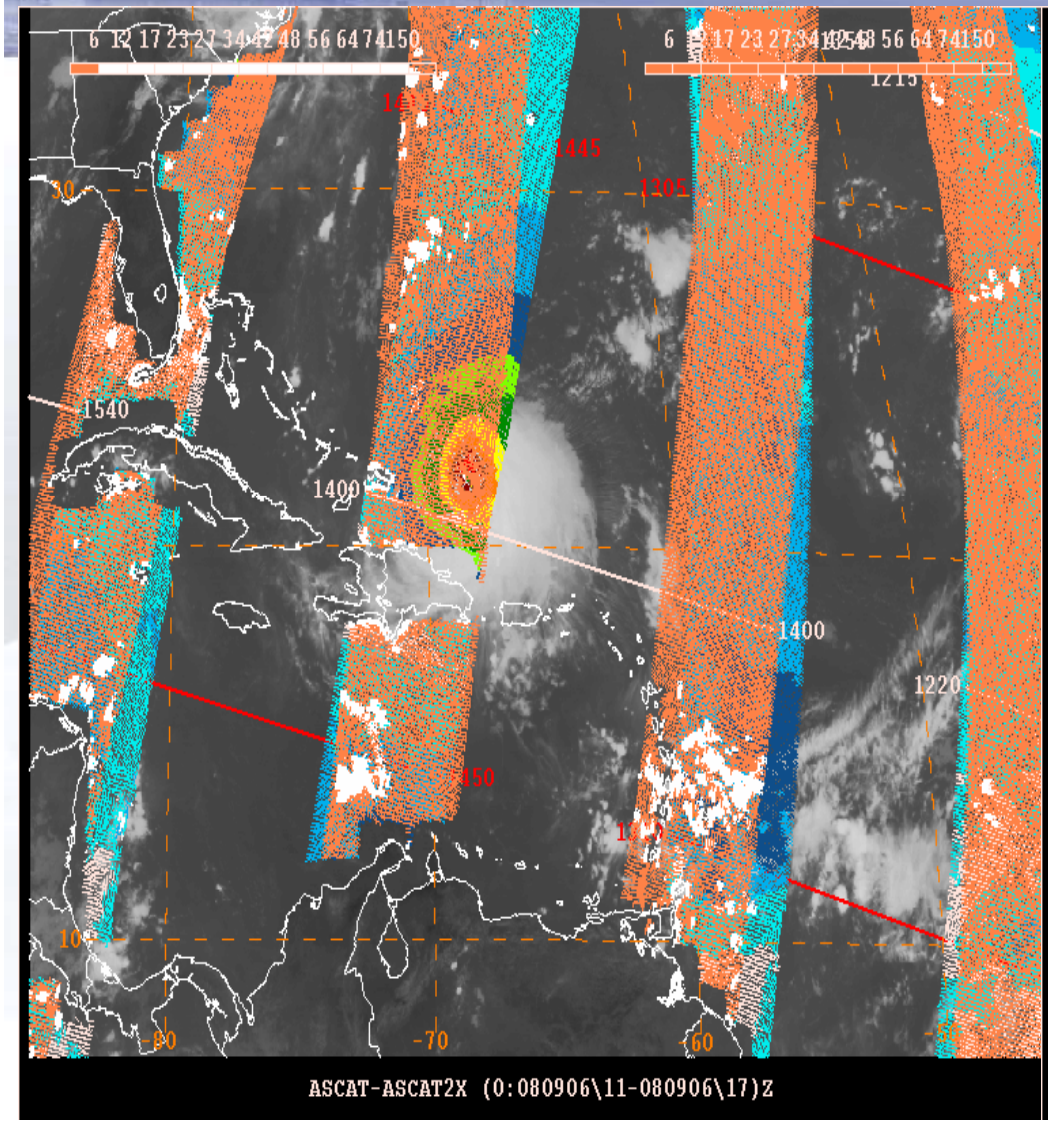
Impact of MetOP-B phasing on Hurricane Forecasting

Zorana Jelenak, Paul S Chang, Qi Zhu and Khalil Ahmed

NOAA/NESDIS/StAR

EUMETSAT

IKE 09/06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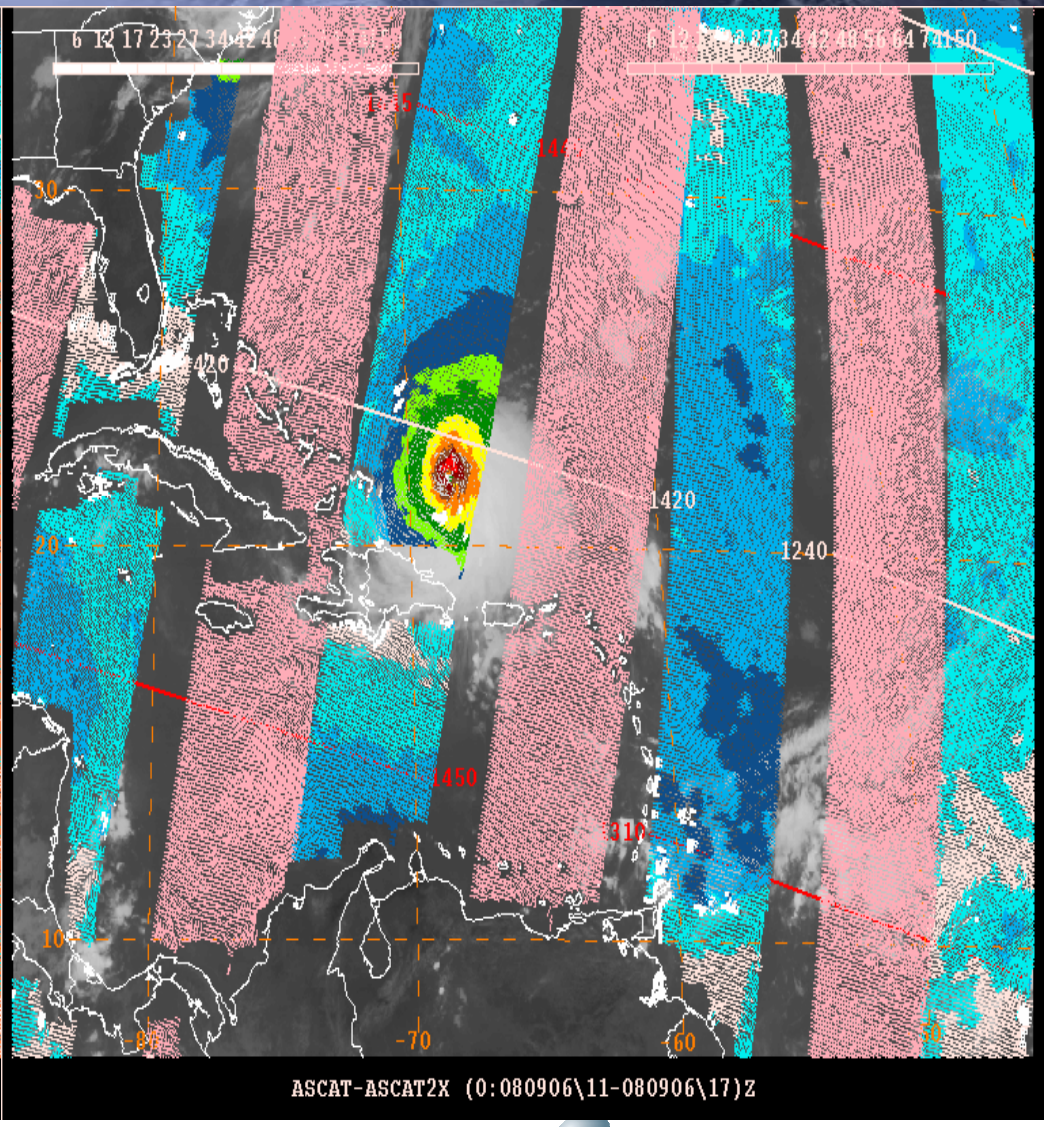
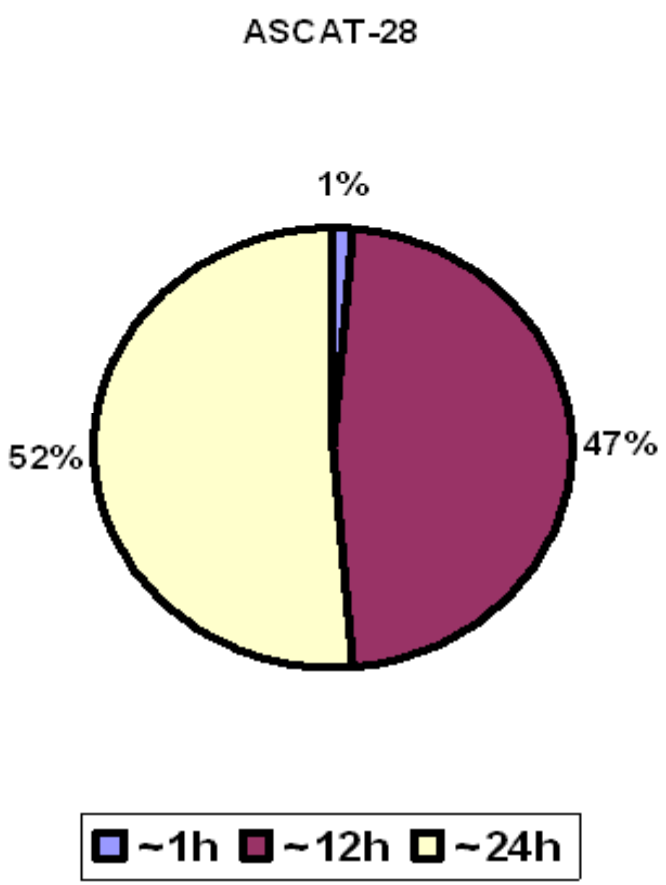
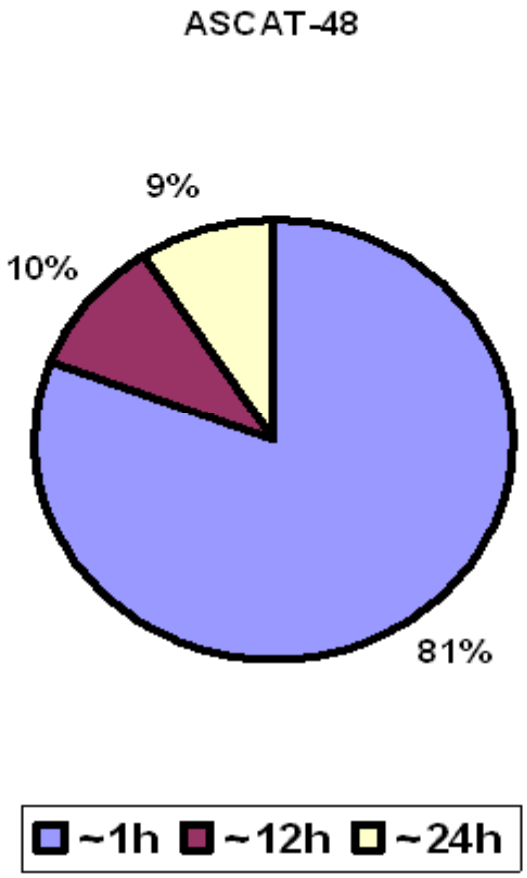

ASCAT-ASCAT2X (0:080906\11-080906\17)Z

Time Differences Between ASCAT and ASCAT-28 or -48 During 2008 Atlantic Hurricane Season TC Observations





52% of time ASCAT-28 would observe storms during days when ASCAT didn't observe them **vs 9%** of time that such observations would be made by ASCAT-48

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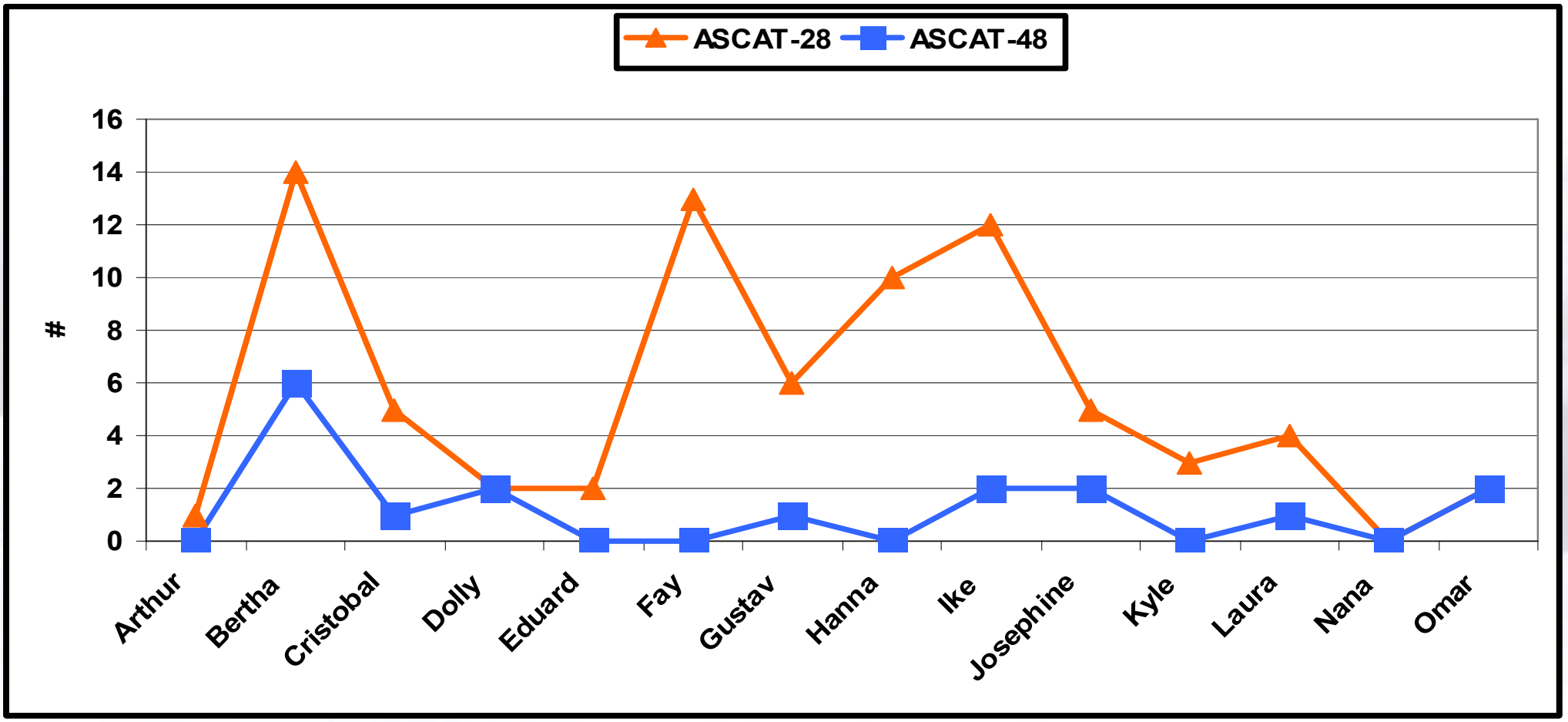
Number Of Forecasting Cycles for which New Measurements would be Available from ASCAT-28 or ASCAT-48 During 2008 Atlantic Hurricane Season



ASCAT-28 would contribute to total of 79 new forecasting cycles

ASCAT-48 would contribute to total of 17 new forecasting cycles

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North Atlantic and Pacific Daily Ocean Coverage

ASCAT = 75.3%
ASCAT+ASCAT28 = 95.9%
ASCAT+ASCAT48 = 86.4%