Sampling in a constellation

Schlax, M. G., D. B. Chelton and M. H. Freilich, 2001: Sampling errors in wind fields constructed from single and tandem scatterometer datasets. *J. Atmos. Oceanic Tech.*, **18**, 1014--1036.

What about NWP and NWC ?

Ad Stoffelen, Massimo Bonavita, John Eyre, Mitchell Goldberg, Heikki Järvinen, Carmine Serio, Jean-Noël Thépaut, Volker Wulfmeyer, 2006: Atmospheric Sounding and Wind Profiling, Position Paper for **Eumetsat Polar System 2nd Generation**

http://www.eumetsat.int/groups/pps/documents/document/pdf_peps_pp_atmos_sound_wind.pdf

NWP, global and regional

Variable	Application	Units	Accuracy			dx (km)			dt (h)			Delay (h)	
			Thr	Brk	Obj	Thr	Brk	Obj	Thr	Brk	Obj	Thr	Obj
Surface Wind (horizontal component)	NWP global	m/s	3	2	0.5	250	100	15	12	3	1	6	0.5
Surface Wind (horizontal component)	NWP regional, over sea	m/s	3	1.5	0.5	50	30	3	3	3	0.5	3	0.25

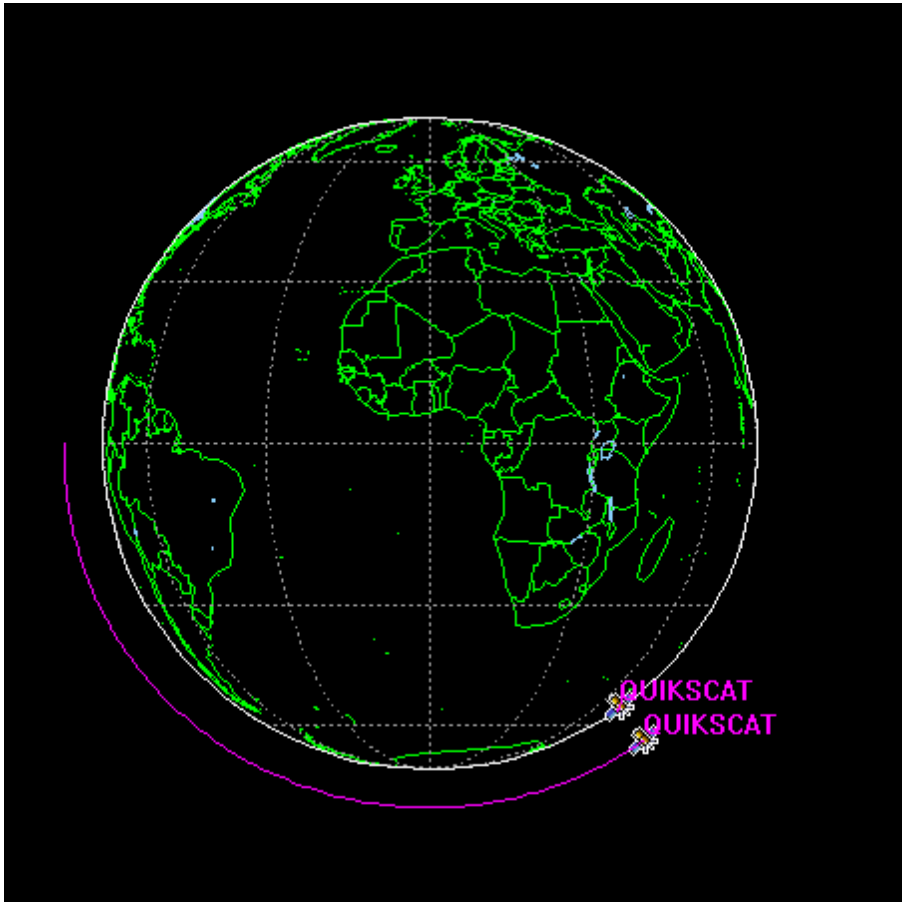
NWC

Variable	Application	Units	Accuracy			dx (km)			dt (h)			Delay (h)	
			Thr	Brk	Obj	Thr	Brk	Obj	Thr	Brk	Obj	Thr	Obj
Sea surface wind vector	Marine dispersion	m/s, deg	2, 10°	2, 10°	1, 5°	5	5	0.1	3	1	0.5	0.5	0.25
Surface wind (component)	Wave/surf models	m/s	2	2	1	50	50	5	6	6	1	0.5	0.25

> Based on WMO tables

> Stringent time requirement for meteorology

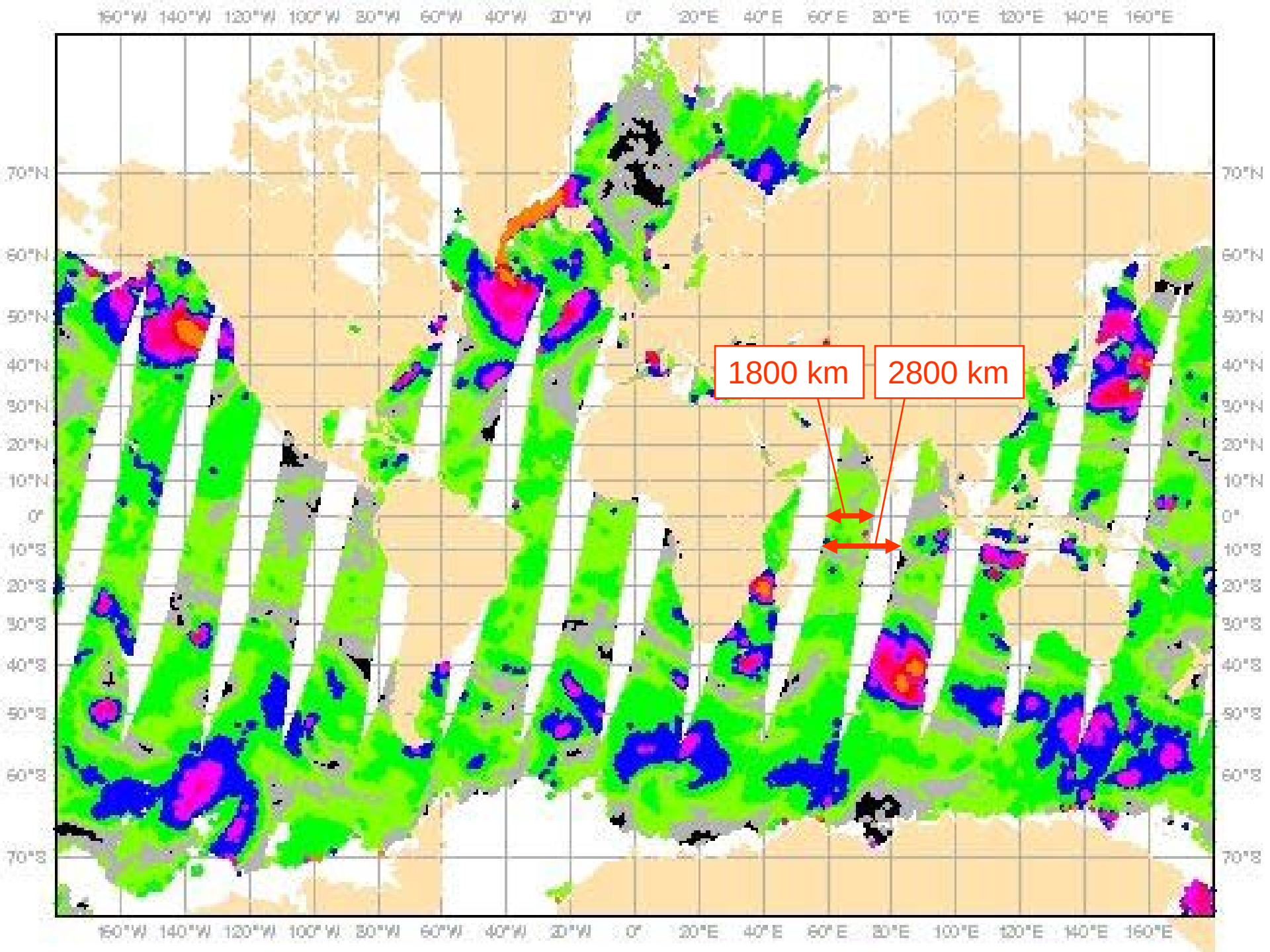
Polar Orbiters



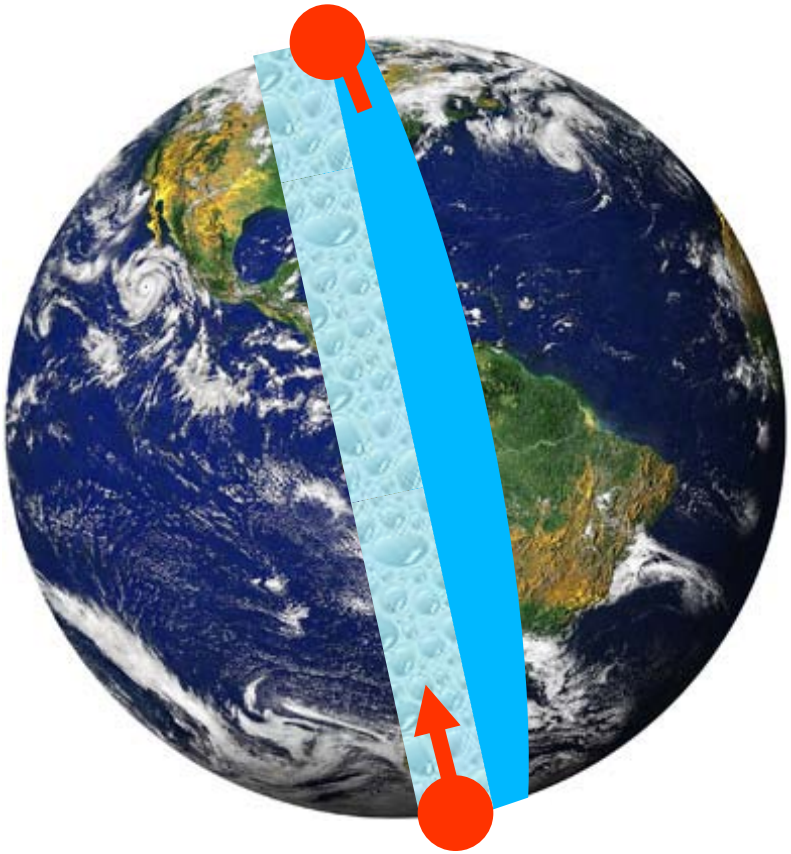
- Polar-orbiting satellites orbit at approximately 800 km above the earth in sun-synchronous orbit and image most areas on the globe twice daily.
  - Sun-synchronous means that the satellite orbit remains fixed with respect to the sun with the earth rotating under the satellite at a cycle per day or at

    0.25 degrees per minute
- One orbit takes ~100 minutes which is an equator separation of ~25 degrees between orbits

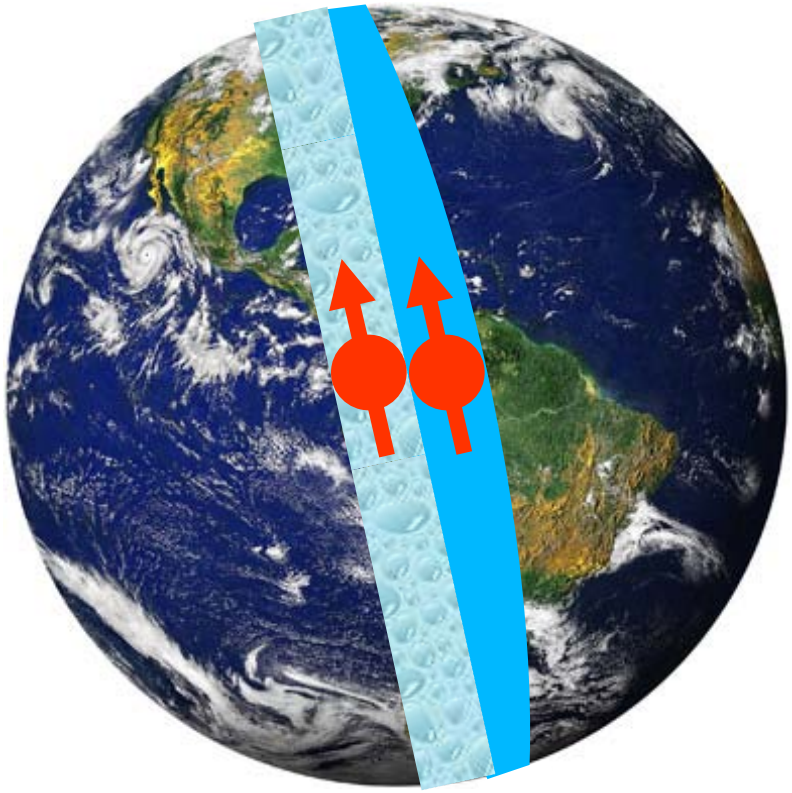
➢ A swath width < 25° (2750 km) leaves gaps


160°W 140°W 120°W 100°W 80°W 60°W 40°W 20°W 0° 20°E 40°E 60°E 80°E 100°E 120°E 140°E 160°E
70°N
60°N
50°N
40°N
30°N
20°N
10°N
0°
10°S
20°S
30°S
40°S
50°S
60°S
70°S
1800 km
2800 km

Second satellite to fill gaps



1. Same orbital plane or LTAN, synchronized at opposite orbit phase
   - ➢ Revisit after 50 min.

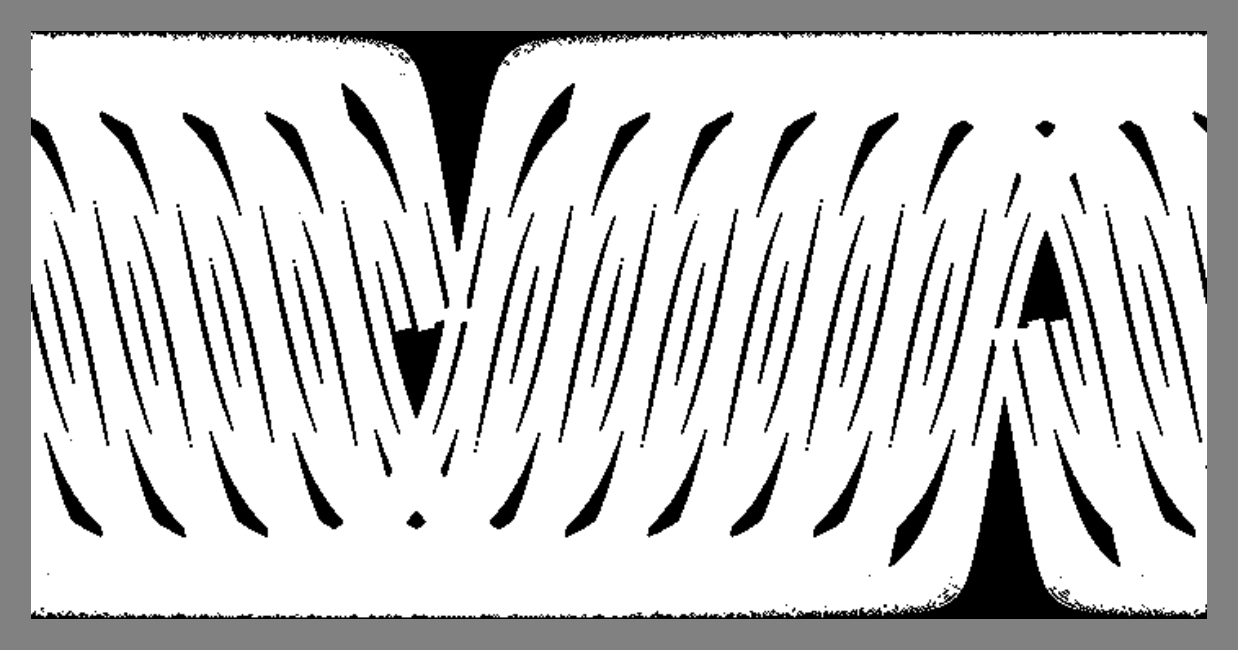


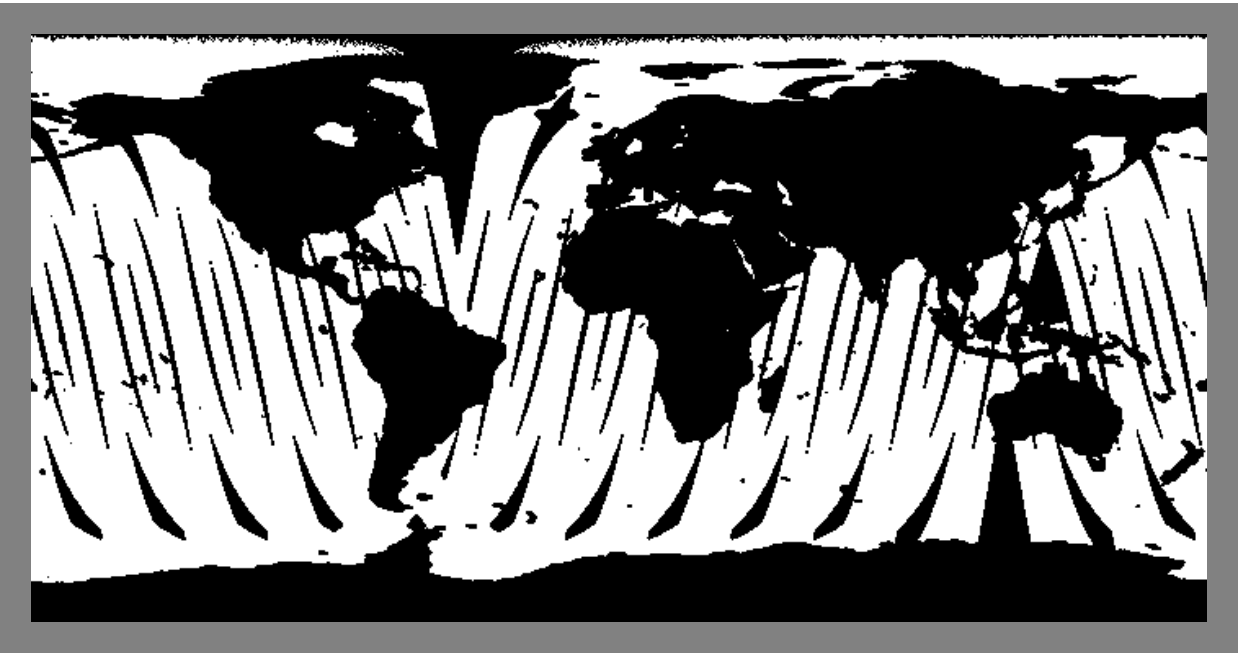
2. Different Local Time of Equator Ascending Node (LTAN)
   - ➢ Simultaneous overlap if synchronized so

ASCAT A/B @ 9:30 LTAN

- Different days have different coverage
- We used it to simulate ASCAT A/B

Orbit	Days	Orbit Phase Shift (min.)	Orbit Phase Shift (min.)	Days	Orbit
170	12	-49	49	17	242
99	7	-45	45	22	313
28	2	-42	42	27	384
369	26	-38	38	3	43
298	21	-35	35	8	114
227	16	-31	31	13	185
156	11	-28	28	18	256
14	1	-21	21	28	398
213	15	-11	10	14	199
0	0	0	0	29	412

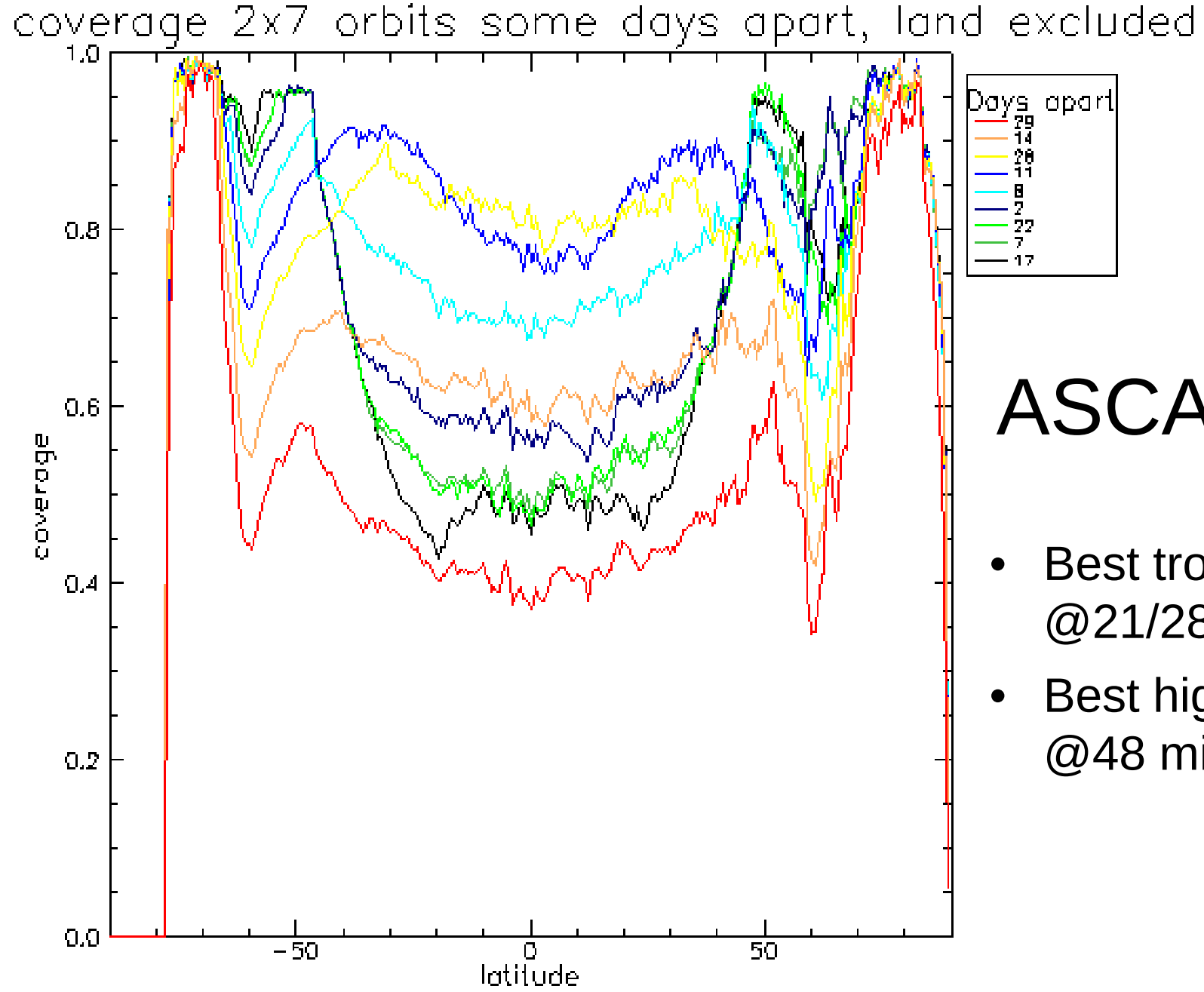




ASCAT A/B

ASCAT coverage for 2x 7 orbits, 11 days apart. 11 days minus 28 minutes apart.

- Tropical coverage may be optimized
- However, high-latitude coverage has still gaps



ASCAT A/B

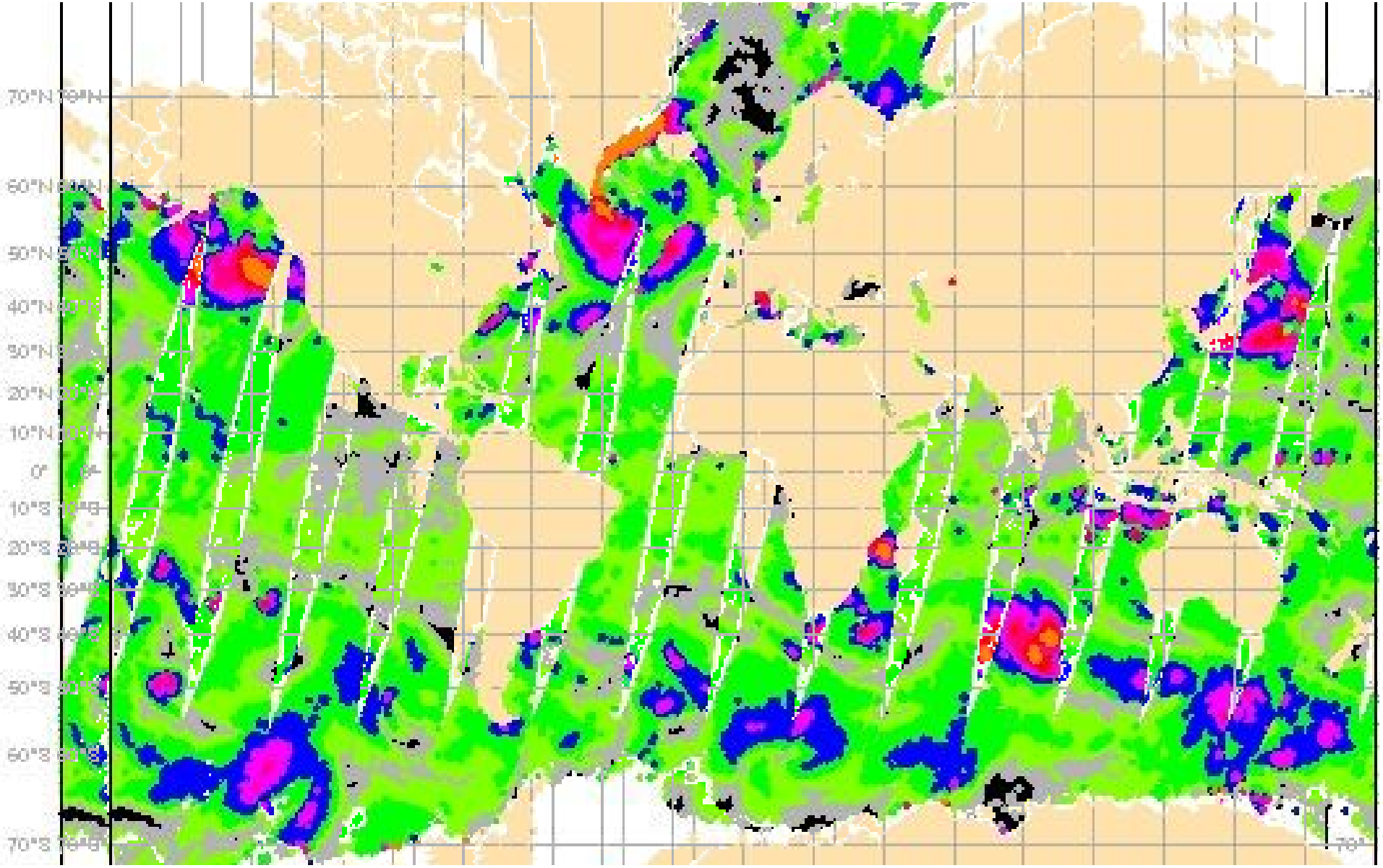
- Best tropical @21/28 minutes
- Best high-latitude @48 miutes

Optimized constellation?

- OSCAT at 12 LTAN
- Add ScatSat at 6 LTAN or 12 LTAN
- HY2A at 6 LTAN
- MetOp A/B at 9:30 LTAN
- Meteor ?

- ➢ Satellite orbit phase synchronization is needed to fill spatial gaps
- ➢ What about temporal gaps?

- Good coverage, provided satellites are synchronized



- Revisit time 2nd satellite can be set for temporal coverage

NWP, global and regional

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NWC

Variable	Application	Units	Accuracy			dx (km)			dt (h)			Delay (h)	
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Sea surface wind vector	Marine dispersion	m/s, deg	2, 10°	2, 10°	1, 5°	5	5	0.1	3	1	0.5	0.5	0.25
Surface wind (component)	Wave/surf models	m/s	2	2	1	50	50	5	6	3	1	0.5	0.25

> Based on WMO tables

> Stringent time requirement for meteorology

Conclusions

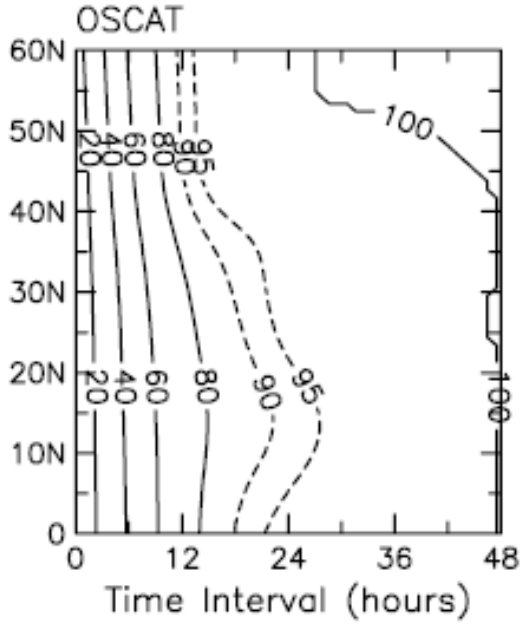
- Weather is transient; short scales are the fastest
- It makes little sense to enhance spatial resolution without enhancing temporal sampling
- Sampling should deliver independent observations in the time-space domain

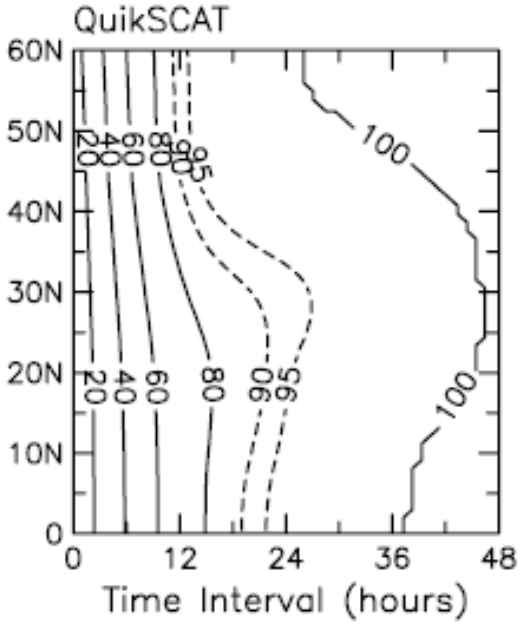
➢ Separate samples by 3-6 hours; do not fly at identical LTAN if possible

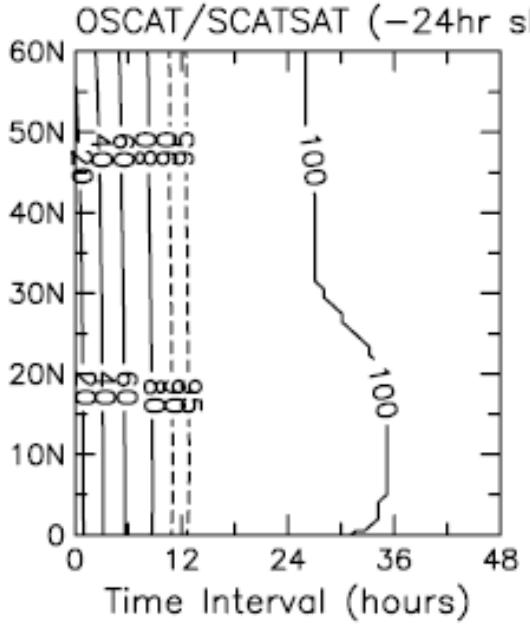
Percent Coverage as a Function of Latitude and Time Interval

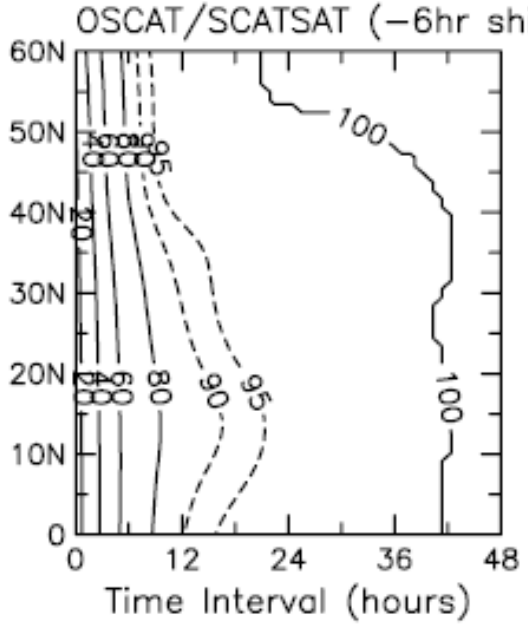
1800km swaths

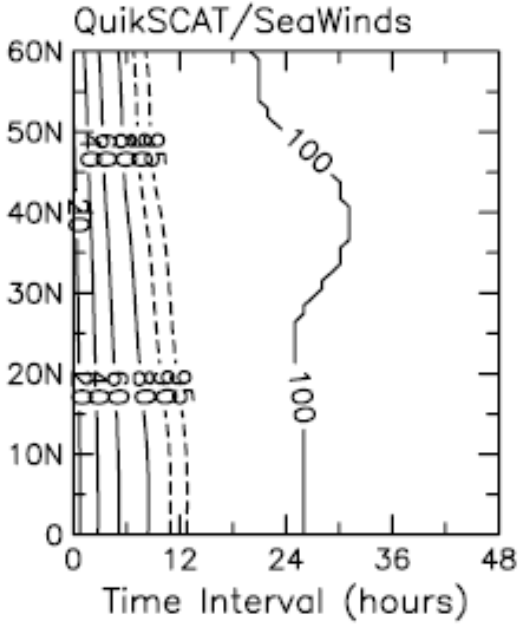
"Bulges" of relatively poor sampling occur in the low latitude band 10º-20º for OSCAT and SCATSAT, and in the higher latitude band 20º-35º for QuikSCAT and SeaWinds.









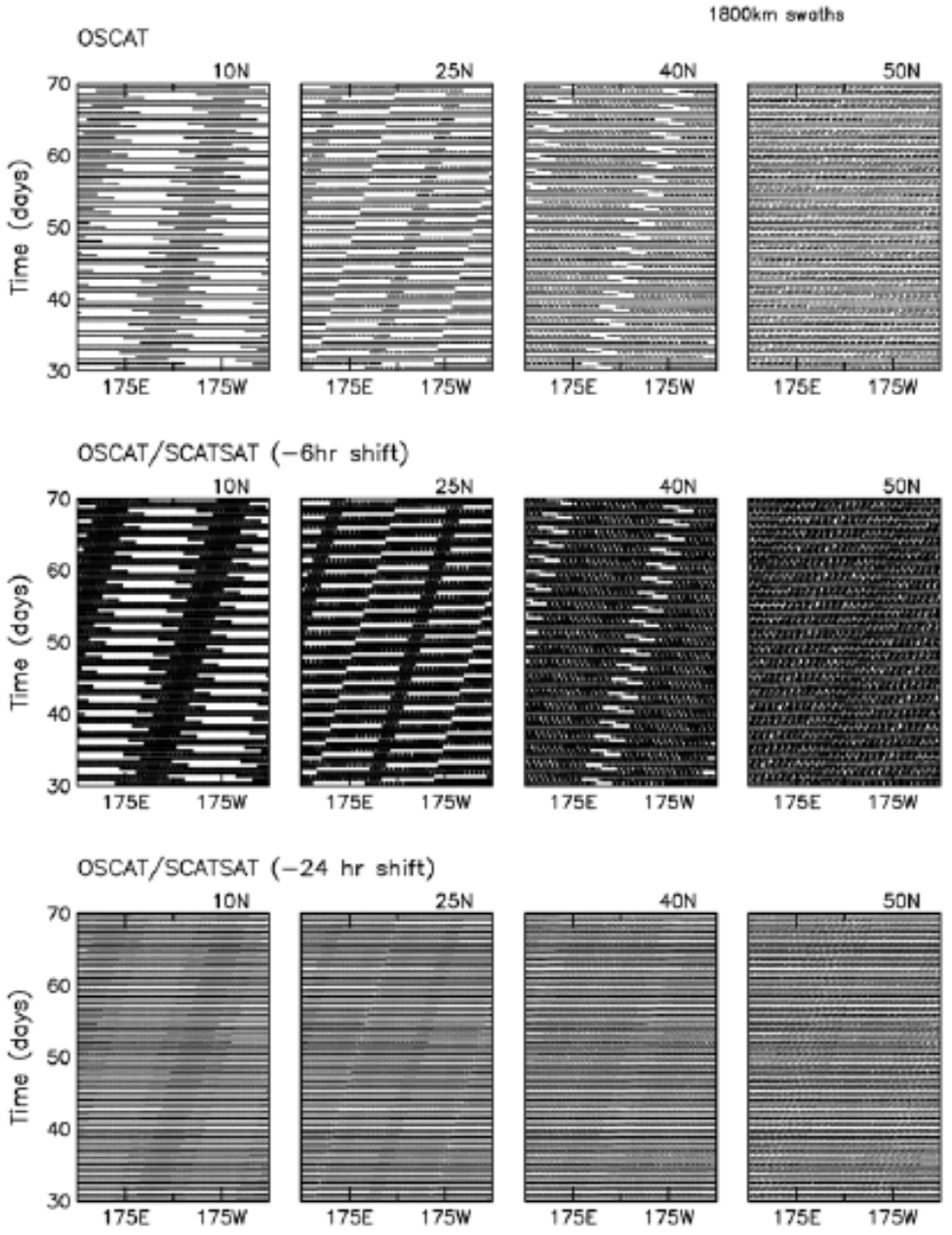


Time-Longitude Distributions of Measurements Along Selected Latitudes for OSCAT and SCATSAT Over a 40-Day Period

Each panel shows the measurement times as a function of longitude along the latitude specified in the panel title.

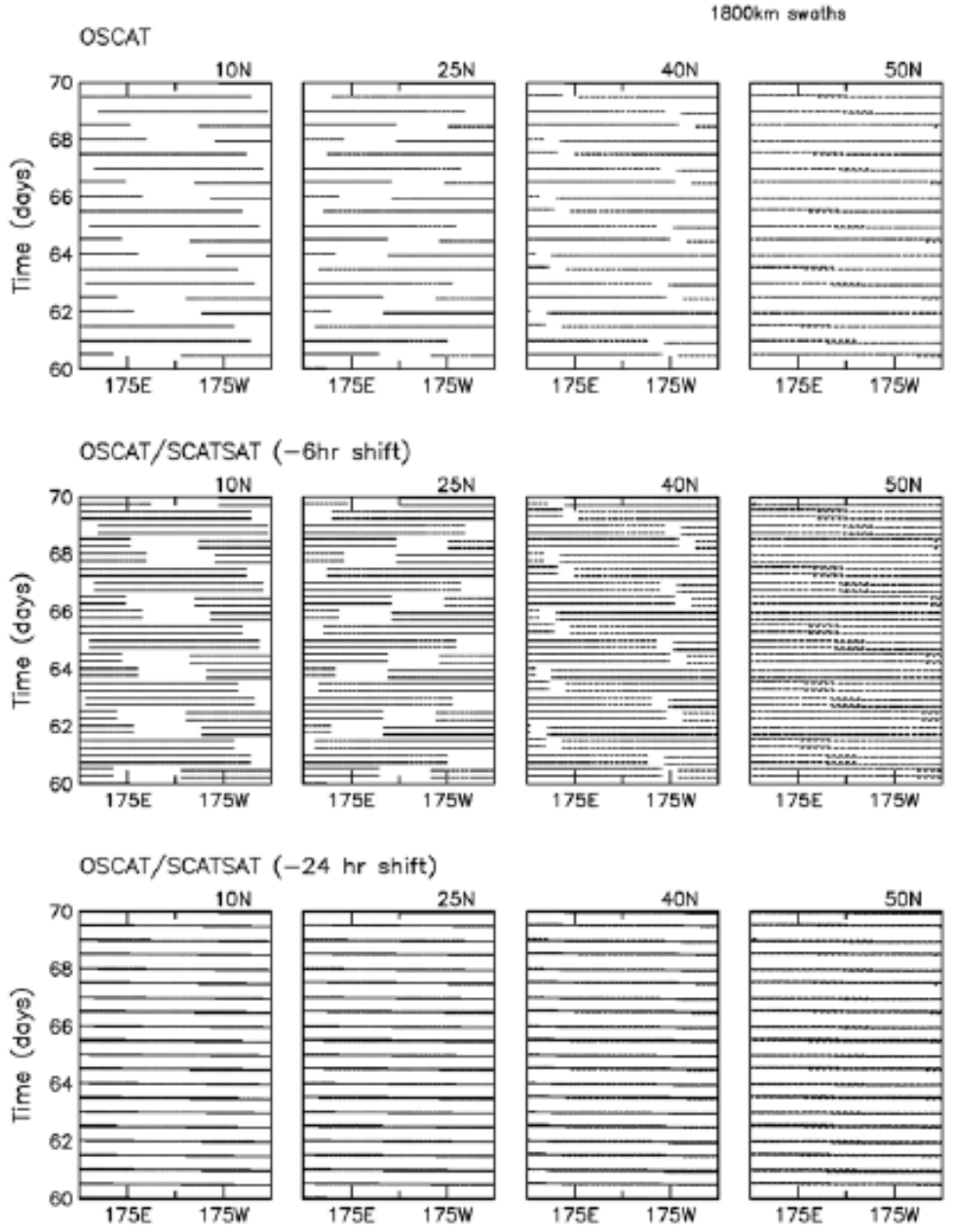
Note the very slow eastward drift of the alternating bands of dense and sparse sampling for both OSCAT alone (top row) and for OSCAT plus SCATSAT with the 6-hour offset (middle row). The sparsely sampled time periods are therefore long in duration.

The sampling pattern is far superior for OSCAT plus SCATSAT with the 24-hour offset (bottom row).

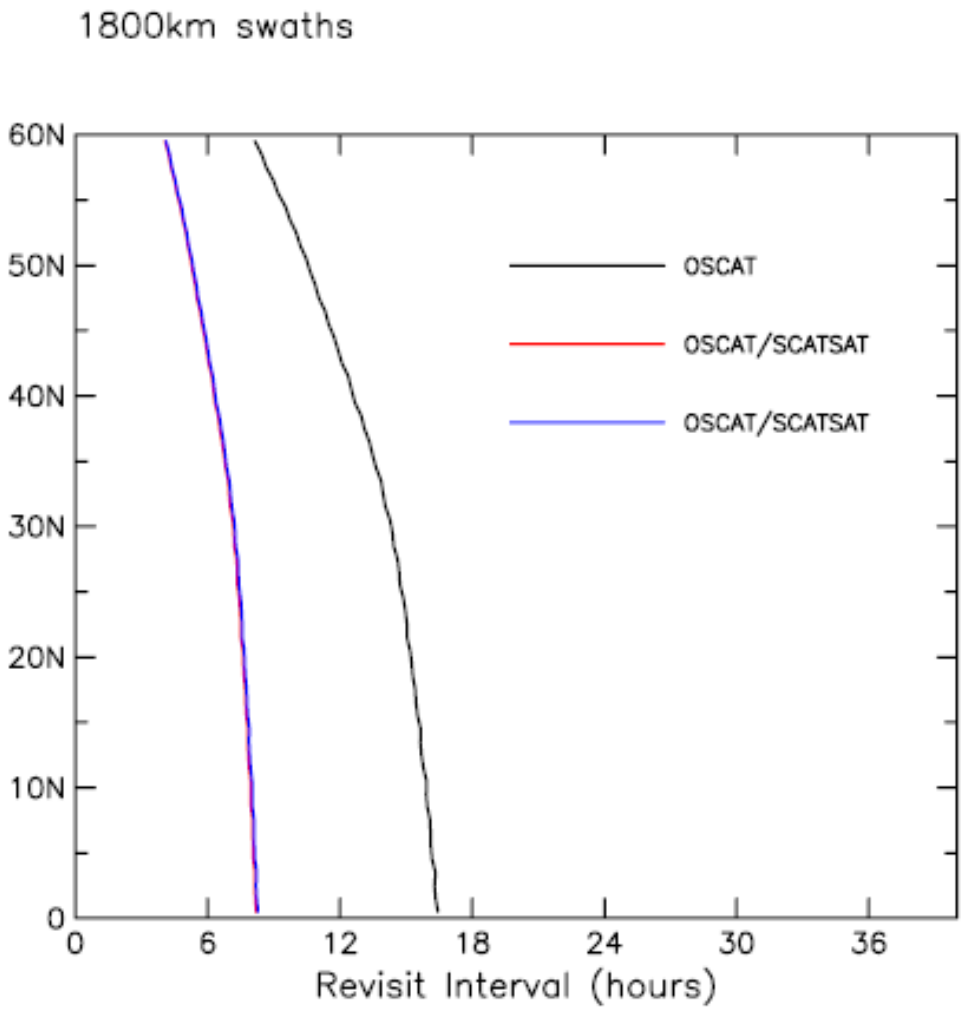


Time-Longitude Distributions of Measurements Along Selected Latitudes for OSCAT and SCATSAT Over a 10-Day Period

The intervals between samples are seen more clearly in this version of the plot that shows only a 10-day period.



Mean Revisit Interval



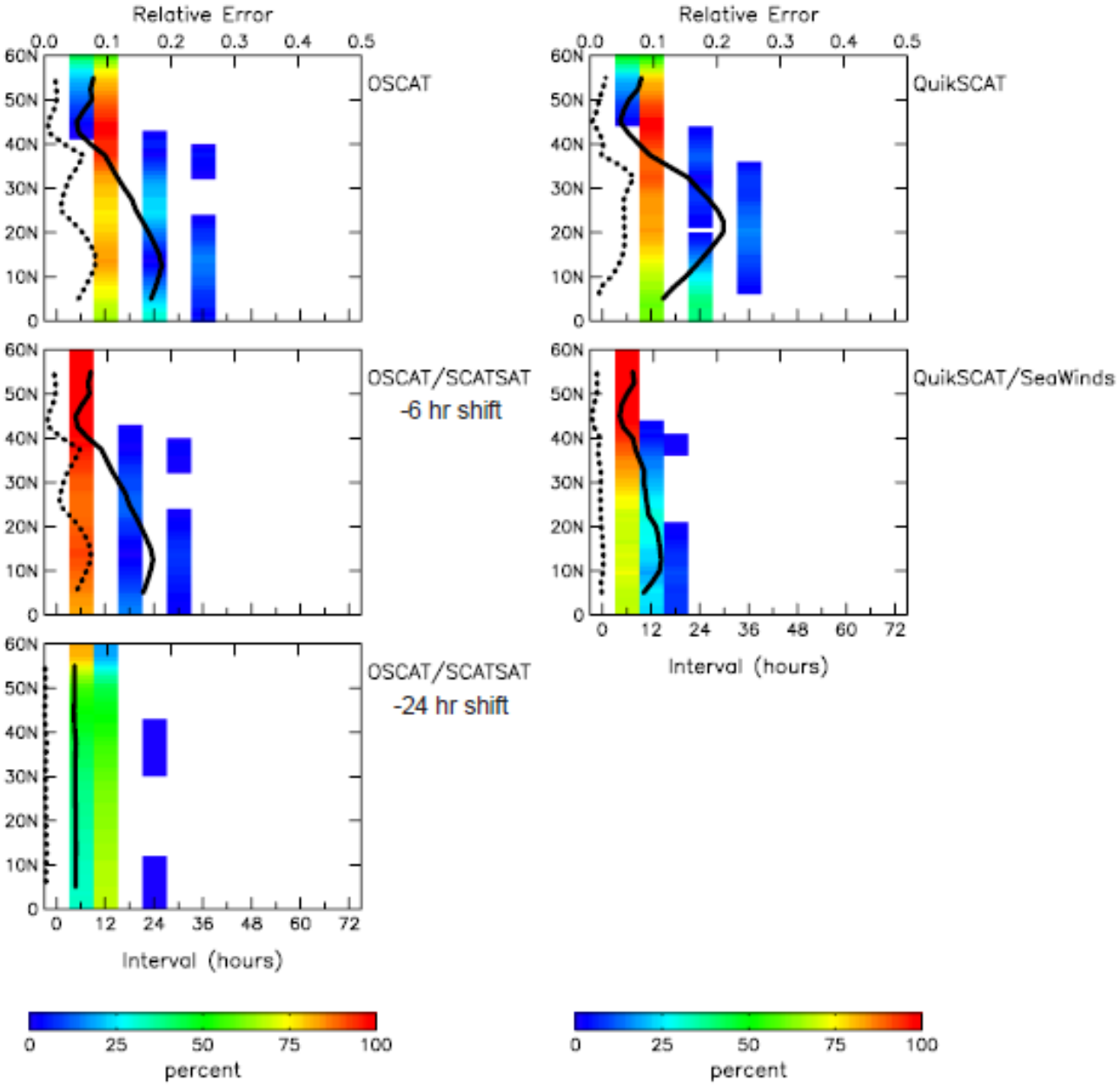
The almost identical latitudinal dependence of the mean revisit interval for the two very different tandem OSCAT/SCATSAT configurations considered here shows why mean revisit interval can be a misleading characterization of the sampling. This is because orbits with very different histograms of revisit interval (see next slide) can have the same mean.

Latitudinal Dependence of Histograms of Revisit Intervals
for OSCAT/SCATSAT and QuikSCAT/SeaWinds

These figures show the histogram of revisit intervals at each latitude over the longitude range 170ºE to 170ºW.

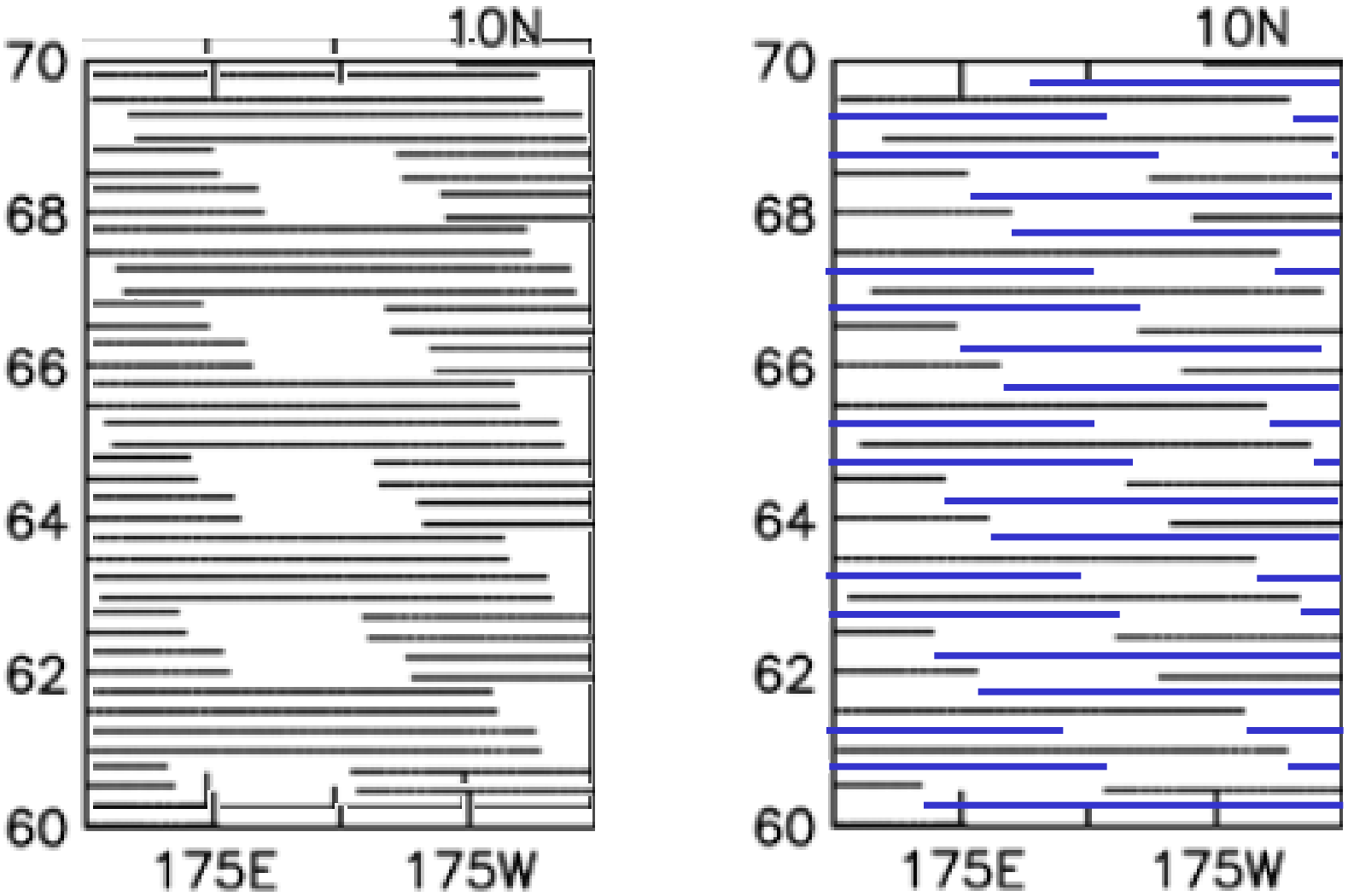
The solid and dotted lines in each panel are, respectively, the mean and standard deviation of the relative errors* of 2º x 2º x 4-day smoothed wind component fields at each latitude (see the scale at the top of each column of figures).The latitude of largest mean error is seen to coincide with the latitude of broadest distribution of revisit interval.

*Relative error is defined to be the square root of the variance of the mapping error normalized by the variance of the wind.



6 hour time shift

- Move satellite 2 to fill gaps of satellite 1



Compare 6 and 24 hour shifts

- 6-hour shift has better time coverage