Sampling in a constellation


What about NWP and NWC?


### NWP, global and regional

<table>
<thead>
<tr>
<th>Variable</th>
<th>Application</th>
<th>Units</th>
<th>Accuracy</th>
<th>dx (km)</th>
<th>dt (h)</th>
<th>Delay (h)</th>
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<tbody>
<tr>
<td>Surface Wind (horizontal component)</td>
<td>NWP global</td>
<td>m/s</td>
<td>3</td>
<td>250</td>
<td>12</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>NWP regional, over sea</td>
<td>m/s</td>
<td>3</td>
<td>50</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Sea surface wind vector</td>
<td>Marine dispersion</td>
<td>m/s,  deg</td>
<td>2, 10°, 2, 10°</td>
<td>5</td>
<td>3</td>
<td>0.5</td>
</tr>
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<td>Surface wind (component)</td>
<td>Wave/surf models</td>
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> Based on WMO tables
> Stringent time requirement for meteorology

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2nd PEPS UC, 3-4 February 2009
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
Contract final milestones are scheduled for May 2014 but...

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

<table>
<thead>
<tr>
<th>Orbit</th>
<th>Days</th>
<th>Orbit Phase Shift (min.)</th>
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<th>Days</th>
<th>Orbit</th>
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<tbody>
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<td>170</td>
<td>12</td>
<td>-49</td>
<td>49</td>
<td>17</td>
<td>242</td>
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<td>99</td>
<td>7</td>
<td>-45</td>
<td>45</td>
<td>22</td>
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<td>28</td>
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<td>-42</td>
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<td>-38</td>
<td>38</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>29</td>
<td>412</td>
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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 minutes
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
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> 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
"Bulges" of relatively poor sampling occur in the low latitude band 10°-20° for OSCAT and SCATSAT, and in the higher latitude band 20°-35° for QuikSCAT and SeaWinds.
Time-Length 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.
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 170°E to 170°W.

The solid and dotted lines in each panel are, respectively, the mean and standard deviation of the relative errors* of 2° x 2° 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