Update on Hybrid Detection
DWL Study*

G. D. Emmitt
WG on Space-based Lidar Winds
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Study Team

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Outline

• Importance of global wind observations
  – OSE and OSSE results
  – Current wind observing systems
• Accuracy, coverage and resolution
• Role for Doppler wind lidars
  – Direct detection
  – Coherent detection
Primary Current Wind Observing Systems

• Rawinsondes (~ 1-3 m/s)
• Surface stations (~1 m/s)
• ACARS (~1 m/s)
• Scatterometer (~2 m/s)
• Cloud motion (5-7 m/s)
• Water vapor motion (4 -5m/s)
• Assimilating model’s first guess (~2-3 m/s)
Potential new wind observing systems

- Constant level balloons with dropsondes or DWLs
- UAVs for targeted observations
- Higher resolution water vapor winds (GIFTS)
- GPS soundings...derived winds
Data Utility

• Most global wind information results from assimilating direct (t, q, u, v...) observations into numerical models

• 4DVAR data assimilation becoming common

• All observations must “compete” with other observations and model derived “first guesses”

• Consequently the NWP community favors accuracy over coverage if trade is necessary

• Spatial averaging < .1-.5 the model resolution (not necessarily the grid size) ~ 15 - 25 km averaging for today’s global research models
Direct Detection

• Photon counting
  – spectral bins or channels
  – edge filter

• Broad molecular velocity spectrum

• Narrow aerosol velocity spectrum

• Instrument measurement **accuracy** is a function of #photons
Coherent Detection

- Heterodyne...frequency shift detection
- Aerosol (and cloud particle) motions
- Inherently accurate (<1 m/s) for SNR >2-5 dB
- Data coverage is a function of threshold sensitivity (~10-30 coherent photons)
Baseline Systems

• Each concept is considered as SOA and is held to 250 watts for the laser subsystems and flown in a 400 km orbit
• Non-scanning (for ease of comparison) with an along track product resolution of 200 km
• LOSP $\sigma_{\text{Direct}} = 2.43 \text{ m/s at 3.5 km AGL}$
• LOSP $\sigma_{\text{Coherent}} = 0.15 \text{ m/s at 3.5 km AGL}$
• $\beta(90)$ for coherent system $= 1.4 \times 10^{-9} \text{ m}^{-1}\text{sr}^{-1}$
Target Data Product

- An LOSP with a normally distributed error of $\sigma = 1 \text{ m/s}$
- Horizontal resolution: 100 X 100 km
- Vertical resolution: 1 km (worst case)
- Minimum swath width: 1300 km (50% coverage of equatorial band)
- Useful data product obtained 90% of time from 3-4 km layer when intervening cloud fraction is $< 50%$
## Scaled Rayleigh System

<table>
<thead>
<tr>
<th>ORBIT</th>
<th>EAP</th>
<th>PWR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>6.2</td>
<td>.25 KW</td>
</tr>
<tr>
<td>400 KM</td>
<td>2474 (400X)</td>
<td>25 KW*</td>
</tr>
<tr>
<td>833 km</td>
<td>6630 (1060X)</td>
<td>67 KW*</td>
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</tbody>
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* assumes a 2 meter telescope
## Scaled Coherent System

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<td>3.0 KW*</td>
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* assumes a 1 meter telescope
# Hybrid System Data Products

(400 km orbit)

<table>
<thead>
<tr>
<th>Sub-system</th>
<th>Resolution</th>
<th>Soundings*</th>
<th>LOSP $\sigma$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rayleigh</td>
<td>300</td>
<td>266</td>
<td>1.6</td>
</tr>
<tr>
<td>Coherent</td>
<td>100</td>
<td>1864</td>
<td>.71**</td>
</tr>
</tbody>
</table>

* number of LOS soundings per orbit (may involve shot accumulation per sounding)

** $\beta (90) = 5.4 \times 10^{-8} (6.8 \times 10^{-8}) \text{ m}^{-1}\text{sr}^{-1}$