Assessing the Expected Performance and Data Utility of an Adaptively Targeted, Scanning, Hybrid Technology DWL for Space

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Contributions

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• B. Gentry (NASA, GSFC)
• M. Masutani and many others (NOAA, NCEP)
• Mission Definition Team
  – Chaired by M. Hardesty
Outline

• Background
  – LAWS
  – SPARCLE
  – GTWS
    • ISAL/IMDC
  – ADM
  – OSSEs (NCEP and NASA)

• Current concept for DWL mission
  – Hybrid (95)
  – Hybrid (06)

• Recent NASA studies (11 – 15 September 06)
  – Hybrid, 100% duty, 4 azimuths

• Next Steps
Background

• **LAWS**
  – Coherent 9 micron (CO2), single shot, continuous scanning (too big, too costly, too soon)

• **SPARCLE**
  – Coherent 2 micron, demonstration class on US Shuttle, scanning: (over-budget ($15M) cancellation)

• **GTWS**
  – Technology Neutral Data Buy
  – NASA engineering study of individual detection techniques (Direct and Coherent): (very large systems required to provide full tropospheric soundings of the full horizontal wind components, too big, too costly, far ahead of SOTA for both technologies)

• **ADM**
  – Direct detection of aerosol and molecular backscatter, non-scanning along the terminator. Confirmation of system size required for single as well as multiple perspective when one technology is used.
OSSEs persist in showing the advantage of bi-perspective, full tropospheric soundings of the horizontal wind vector in both hemispheres.

OSSEs show analyses and forecasts for the Tropics best served by multiple perspectives.

OSSEs also demonstrate value of both lower and upper tropospheric winds, especially near tropical cyclones. Clouds are the primary issue in coverage.

Adaptive targeting has merit but is still being evaluated as a mission enabler.
Current DWL concept

- Hybrid first suggested in 1995
  - Use molecular (355nm) direct detection for cloud free portions of upper troposphere and lower stratosphere. Getting accurate winds from aerosols drives direct detection to being very resource demanding. (8 - 20X savings)
  - Use aerosol coherent detection for cloudy regions and lower troposphere. Getting sufficient signal from cloudfree/aerosol sparse regions drives the coherent design very large (50-200X savings)
• NASA and NOAA are now considering hybrid approach for their first DWL operational precursor mission.

• Basic philosophy: obtain useful (high impact potential) observations of tropospheric vector wind profiles at the expense of global coverage (if required for an affordable first mission)

• Process data for lower stratospheric winds (up to 25km)
Recent concept evaluations

• Instrument Synthesis & Analysis Laboratory (ISAL) at GSFC
  – Direct molecular at .355 microns
  – Coherent aerosol at 2.06 microns
  – Shared telescopes (4): .5 meters diameter
  – 10 - 12 second integration (1 second sub integration)
  – Baseline at 100% duty cycle
    • Descope option for < 100%
Instrument unique parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Coherent</th>
<th>Direct</th>
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</thead>
<tbody>
<tr>
<td>Energy per pulse</td>
<td>.25 J @2 µm</td>
<td>.8 – 1 J</td>
</tr>
<tr>
<td></td>
<td></td>
<td>.36 - .45 @.355 µm</td>
</tr>
<tr>
<td>PRF</td>
<td>5 Hz</td>
<td>100 Hz</td>
</tr>
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### Common parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orbit altitude and inclination</td>
<td>400km</td>
</tr>
<tr>
<td>Nadir angle</td>
<td>45 degrees</td>
</tr>
<tr>
<td>Aperture diameter</td>
<td>0.5 meters shared</td>
</tr>
<tr>
<td>Azimuths</td>
<td>4 (two orthogonal pairs)</td>
</tr>
<tr>
<td>Dwell times</td>
<td>10 – 12 seconds</td>
</tr>
</tbody>
</table>
Performance profiles

- Uses Doppler Lidar Simulation Model developed with funding from NASA, NOAA, DoD and SWA.
- Global distribution of HLOS wind components meeting various quality thresholds using ECMWF T213 Nature Run with modified clouds and sub-grid-scale wind variance.
Molecular: 0.8/0.36J, 100Hz, 0.5m, clouds
Molecular: 1/.45J, 100Hz, .5m, clouds
Aerosol: .25J, 5Hz, .5m w/clouds
(Background aerosols)
Aerosol: .25J, 5Hz, .5m no clouds
(Background aerosols)
Aerosol: .25J, 5Hz, .5m w/clouds
(Enhanced aerosols)
Aerosol: .25J, 5Hz, .5m no clouds
(Enhanced aerosols)
Performance in Tropics

• The following performance plots are for 2 complete orbits and thus 4 latitudinal band crossings. Might be considered an example of coverage for a current NWP update cycle.

• The best that the coherent might do would be under enhanced aerosol conditions.

• The best that the direct molecular could do would be under background aerosol conditions.
Next steps

• Integrated Mission Design Center (IMDC) at GSFC
  – First week in October 2006
  – Total mission feasibility and preliminary cost estimates

• OSSEs
  – Adaptive targeting
  – Synergistic observations with CMV and Ocean Vector Winds
  – Tropical storm intensity and track forecast impacts (full life cycle).

• Airborne studies
  – Data for use in DAS development (cloud effects, data quality flags, etc)

• Use CALIPSO data to update cloud statistics derived from LITE and GLAS
Example of vertical AT coverage

With background aerosol distribution

Red: < 3 m/s error
Blue: < 1.5 m/s error

With convectively pumped aerosol distribution
GLAS cloud Statistics

• General cloud statistics
  – ~80% of pulses intercepted cloud (half of these also had surface return)
  – ~70 - 80% of pulses had surface returns over land
  – ~30-40% of shots intercepted very thin cloud over thick layers over land
  – Tropics are the challenge for mid and upper tropospheric observations… much high cirrus.

• Recently a NASA report was delivered that addresses contiguous CFLOS opportunities to various levels of the atmosphere. Important to instrument concepts that require shot integration to perform accurately.