Status of Hybrid DWL Study

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Overview

- Past activities
  - Concept
  - Simulations
  - GTWS comparisons
- Ongoing activities
  - Independent evaluation and comparative cost analyses
  - Technology roadmap being drafted and circulated
- Planned activities
  - Simulated data sets for OSSEs
  - Ground-based demos at LaRC (April 2003)
  - Airborne demonstration (2004)

Notional Hybrid DWL Concept

- First proposed in 1995 as WOS/H (Wind Observing Satellite/Hybrid)
  - Capitalize on the strengths of both technologies
  - Coherent for probing lower troposphere with high velocity accuracy below clouds and in regions of enhanced aerosols
  - Direct for broad coverage of the mid/upper troposphere (+ stratosphere) with modest accuracy
  - Lower cost by reducing investment in “very big” individual lidars; sharing a launch; sharing a platform; sharing pointing control, data collection, mission management and science team, etc.

Science Synergies for the Hybrid DWL Concept

- The hybrid approach will provide full tropospheric wind observations **sooner**, with much of the accuracy, resolution and coverage needed by tomorrows global and regional models
- The molecular DWL sub-system would, in its first mission, provide useful wind observations in cloud free regions of the mid/upper troposphere and lower stratosphere
- The coherent DWL sub-system would immediately meet the science and operational requirements throughout the troposphere in regions of high aerosol backscatter (dust layers, clouds, PBL aerosols)

Synergisms

- The molecular system may provide good first guesses in the coherent system’s weak signal regime, enabling the coherent system to provide a more accurate wind observation than either system alone could make.
- The coherent system could be optimized explicitly for resolving the ageostrophic features (moisture jets, Tropical circulations) of the lower troposphere, while the molecular system could be optimized to produce fewer, but still accurate, observations of the larger divergent features of the mid and upper troposphere

Synergisms

- The more dynamically interesting regions of the troposphere usually involve clouds. The coherent system is best suited to sampling through and below clouds. The molecular system, which is severely compromised by clouds, would provide the winds above and around the generally cloudy areas

IPO funded Hybrid feasibility study

- 1999-2001 Developed “reference systems” which could be used in trade studies.
- Defined a common data product as target
- Scaled each technology to obtain the same data product. (yielded very large systems)
- Defined a hybrid system that would yield the same data products; in some respects better.

Current Hybrid Concept

- Baseline concepts and the hybrid concept have been revised from earlier versions to take advantage of:
  - a set of community data requirements resulting from a collaboration of many individuals and distributed as official draft requirements
  - a series of concept exercises by NASA/GSFC's ISAL and IMDC as part of the GTWS effort

Summary Table of General Mission parameters

Parameter/Consideration	IPO Hybrid
Orbit height (km)	400
Orbit Inclination (degrees)	98
Nadir viewing angle (degrees)	45
Pointing knowledge accuracy (degrees)	50 urad
Lifetime (years)	>2

Summary Table for IPO Hybrid Coherent Detection sub-system

Instrument Parameters	IPO Baseline	IPO Hybrid
Wavelength (nm)	2054	Same
Pulse Energy (Joules)	8	.5
Pulse Duration (Sec)	180.0E-09	same
PRF (Hz)	12	same
Laser Wallplug Efficiency (factor)	.02	same
Shot Integration (Number)	60	same
# Azimuths in Sample Sequence	8	same
Joules per LOS Data Product	480	30
Average Laser Power Required (Watts)	4800	300
Telescope Area (m^2)	.45	.2
Optical transmission 2-way (factor)	.50	same
Detector Quantum Efficiency (factor)	.80	same
Mixing Efficiency (factor)	.40	same
Data Rate / hour (bits)	26.2E+09	same
Mass (kg) Instrument	?	?
Total Inst. Average Power (watts)	5251	600

Summary Table for IPO Hybrid Direct Detection sub-system

Instrument Parameters	IPO Baseline	IPO1 Hyb	IPO2 Hyb
Wavelength (nm)	355	same	same
Pulse Energy (Joules)	1	.2	.2
Pulse Duration (Sec)	20.0E-09	same	same
PRF (Hz)	125	60	30
Laser Wallplug Efficiency (factor)	.016	same	same
Shot Integration (Number)	633	300	600
Joules per LOS Data Product	635	60	60
# Azimuths in Sample Sequence	8	8	4
Average Laser Power Required (Watts)	7812	750	375
Telescope Area (m^2)	1.23	.78	.5
Optical transmission 2-way (factor)	.034	same	same
Detector Quantum Efficiency (factor)	.80	.80	.80
Data Rate / hour (bits)	.88E+09	.44E+09	.44E-09
Mass (kg) Instrument	?	?	?
Total Average Power (watts)	**8112**	**1050**	**675**
Size (m)	3 x 1.5 x 1.5		

Combined IPO Hybrid Doppler Wind Lidar

Instrument Parameters	IPO1 H(DD,CD)	IPO2 H(DD,CD)
Average Laser Power Required (Watts)	750 + 300 = 1050	375 + 300 = 675
Effective Telescope Area (m^2)	.78 .2	.5 .2
Data Rate / hour (bits)	26 E+09	26 E+09
Mass (kg) Instrument		
Total Average Inst. Power (Watts)[1]	1050 +600 = 1650	675 + 600 = 1275

1. Includes lidar, thermal control, data system, scanner motors. No shared subsystems such as power distribution unit or data system.

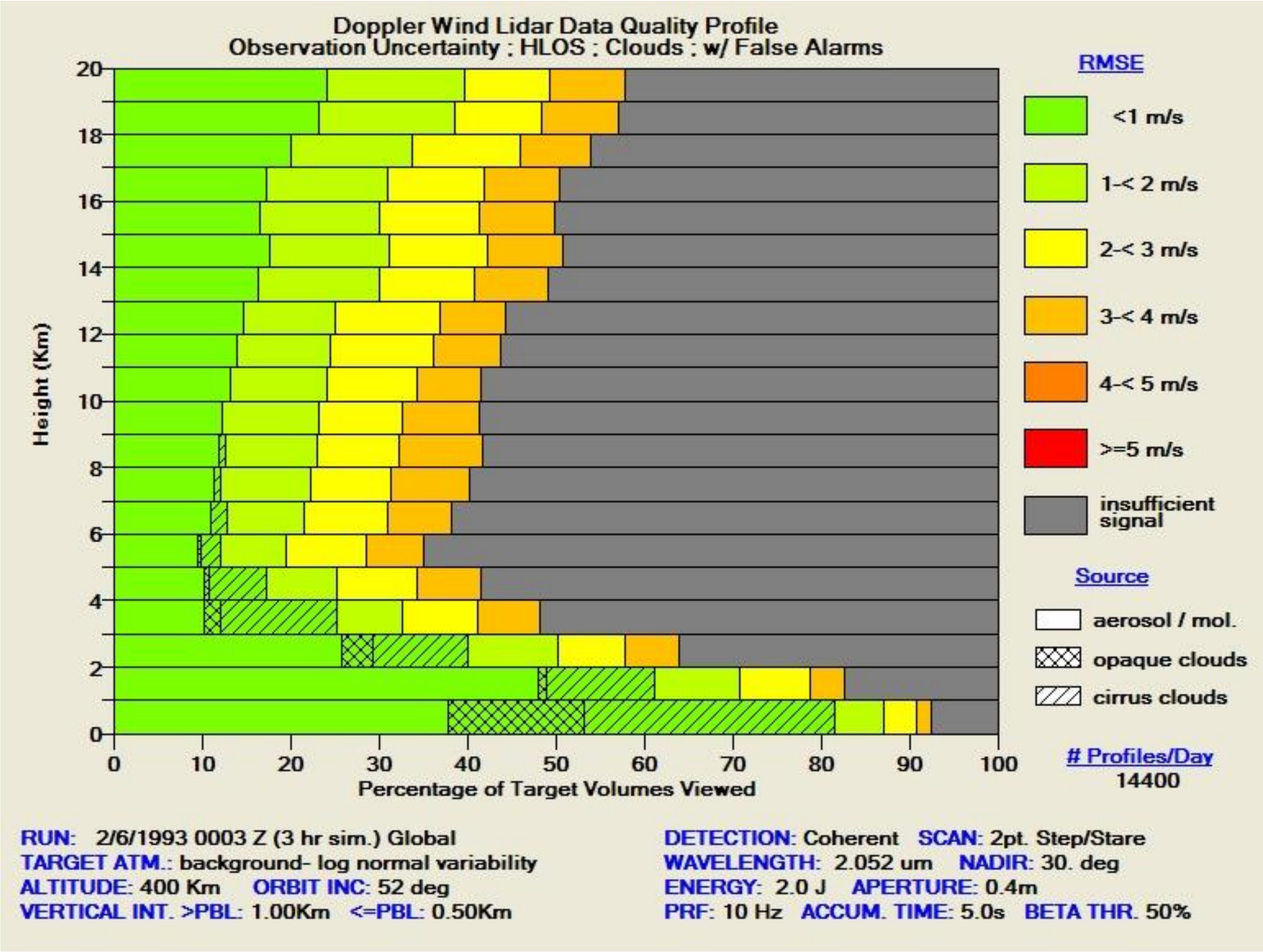
NASA/NOAA Draft Data Requirements 10/16/01

ISAL

	Threshold	Objective
Depth of regard (km)	0- 20	0-30
Vertical TSV resolution (km) Top of DOR to tropopause Tropopause to boundary layer top Within boundary layer	 Not required 1 .5	 2 .5 .25
Height assignment accuracy (km)	.1	.1
Horizontal TSV dimension (km) (maximum for averaging)	100	25
Horizontal location accuracy (km)	.5	.5
Horizontal resolution (km) (distance between TSVs)	350	100
Minimum X-track regard (km) (# in ( ) is # of TSVs)	±400 (4)	±625 (12)
Number LOS perspectives in TSV (angular separation > 30 and < 150)	2	2
Accuracy(1σ) of LOSH (m/s) Above boundary layer Within boundary layer (number in ( ) is σ_s within TSV)	 3(1.2) 3(1.2)	 2(1.4) 1(1)
Horizontal component bias (m/s)	.1	.05
Maximum horizontal speed (m/s) Above boundary layer Within boundary layer	 75 50	 100 50
Temporal resolution (hours) (revisit period)	12	6
Data product latency (hours)	2.75	2.75

http://nais.msfc.nasa.gov/cgi-bin/EPS/synopsis.cgi?acqid=99220

JEM/CDL


Doppler Wind Lidar Data Quality Profile
Observation Uncertainty ; HLOS ; Clouds ; w/ False Alarms
Height (Km)
Percentage of Target Volumes Viewed
RMSE
<1 m/s
1-< 2 m/s
2-< 3 m/s
3-< 4 m/s
4-< 5 m/s
>=5 m/s
insufficient signal
Source
aerosol / mol.
opaque clouds
cirrus clouds
Profiles/Day
14400
RUN: 2/6/1993 0003 Z (3 hr sim.) Global
TARGET ATM.: background- log normal variability
ALTITUDE: 400 Km ORBIT INC: 52 deg
VERTICAL INT. >PBL: 1.00Km <=PBL: 0.50Km
DETECTION: Coherent SCAN: 2pt. Step/Stare
WAVELENGTH: 2.052 um NADIR: 30. deg
ENERGY: 2.0 J APERTURE: 0.4m
PRF: 10 Hz ACCUM. TIME: 5.0s BETA THR. 50%

Scaling TODWL*

Scaling TODWL Observations to Space-based Concepts

Parameter	TODWL	IPO Hybrid	IPO baseline
Energy/pulse (J)	.005	.500	8
PRF (Hz)	80	12	12
Aperture (m)	.1	.5	.75
System eff (%)	3	14	14
Relative perf (X)		4666	163000
Range Equiv perf (km)		6	1

* ONR/IPO **T**win **O**tter **D**oppler **W**ind **L**idar

Current and Planned Activities

- Cost study at JPL funded by IPO (expected to be completed by Spring 2003)
- Hybrid OSSE funded by IPO (expected to be completed at NASA/DAO by Spring 2003)
- Developing technology roadmap for hybrid system (draft being circulated)

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