



Planning for LOTOS: A New **L**ower **T**roposphere **O**bserving **S**ystem

Terry Hock

S. Oncley, T. Weckwerth, B. Stephens, W. Brown, A. Rockwell, W.C. Lee, V. Grubišić
National Center for Atmospheric Research
Earth Observing Laboratory

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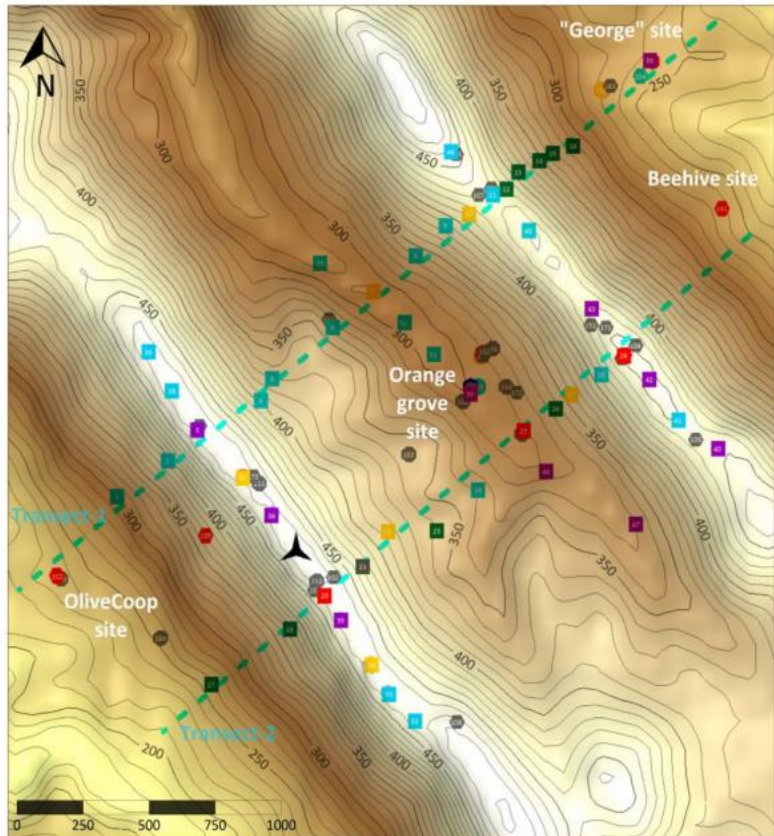
This material is based upon work supported by the National Center for Atmospheric Research, which is a major facility sponsored by the National Science Foundation under Cooperative Agreement No. 1852977.

LOTOS is proposed as a configurable and scalable integrated suite of automated and unattended ground-based in-situ and remote sensors for weather and climate research



LOTOS is designed to provide:

- Quasi-3D sensing of the lower troposphere plus mapping of spatial distribution of properties at the Earth's surface
- Full kinematic and thermodynamic profiling at five nodes
- Multiple observations of exchange processes across the land-surface interface and between BL and the free atmosphere



Remote sensing:
● AERI ● Microwave radiometer ● Profiling Lidar ● Scanning Lidar ● Profiling Radar & RASS ● Profiling Radar
● SODAR & RASS ● Water vapor DIAL ● Scintillometer ● Ceilometer

Meteorological masts:
■ masts [2 m] ■ masts [10 m] ■ masts [20 m] ■ masts [30 m] ■ masts [60 m] ■ masts [100 m]

Sounding sites:
● Radiosonde ● Tethersonde

Other
● Noise Measurement terminal ● Seismometer ▲ Wind turbine

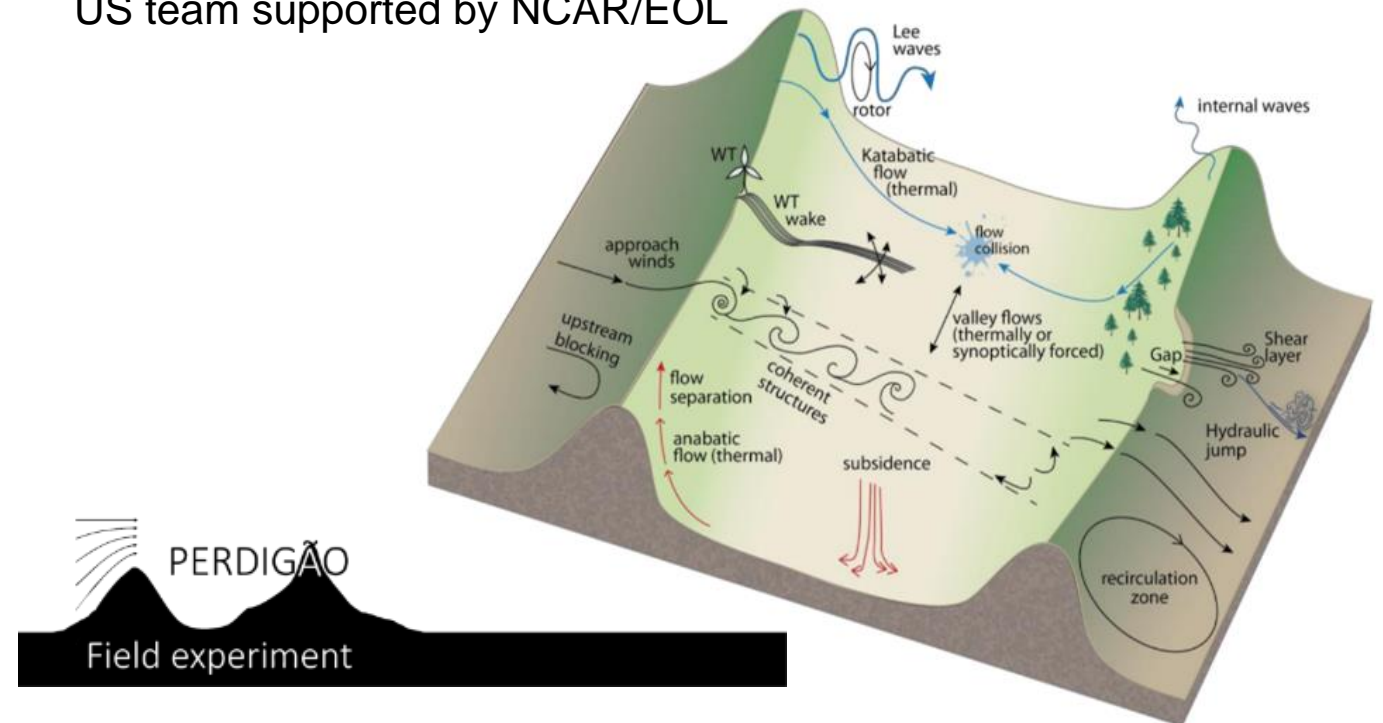
Source: <https://perdigao.fe.up.pt/>

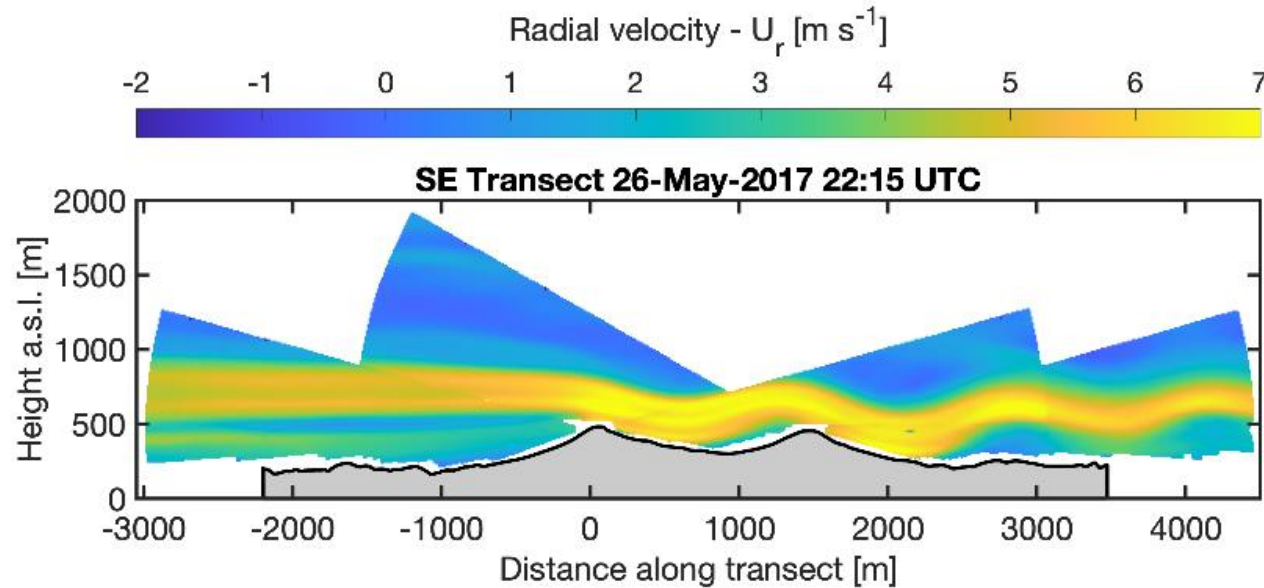
Perdigão

Dec 15, 2016 – June 15, 2017

EU & US collaboration, embedded in the ERANET+ project, focus on BL processes and harvesting of wind energy in complex terrain

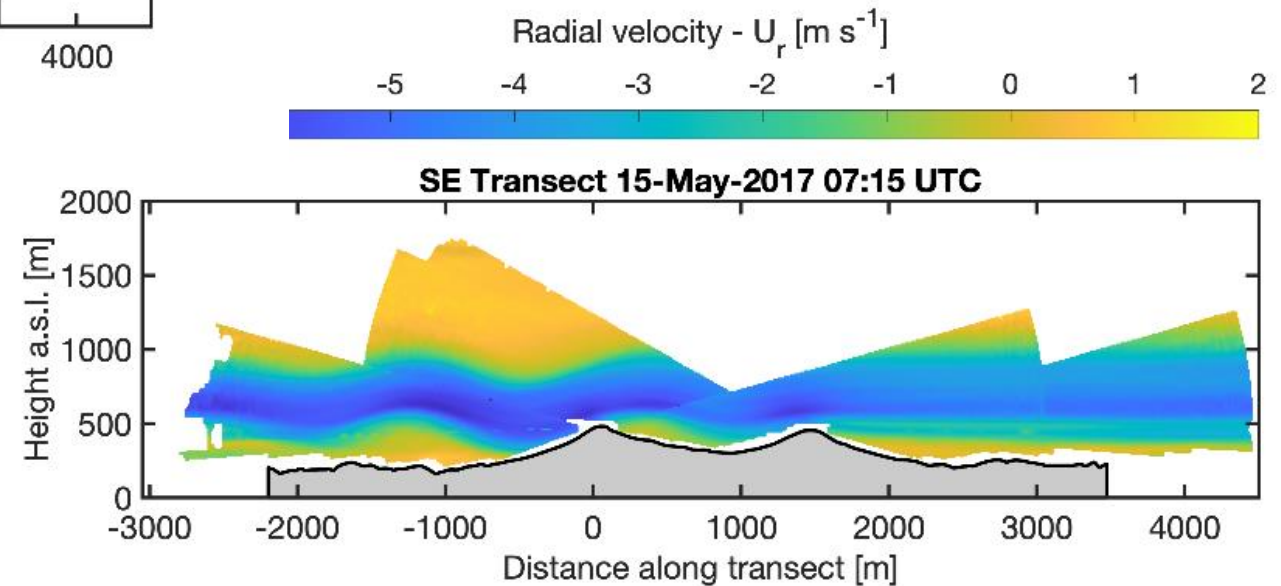
US team supported by NCAR/EOL





Wave Detection from Transect Scans

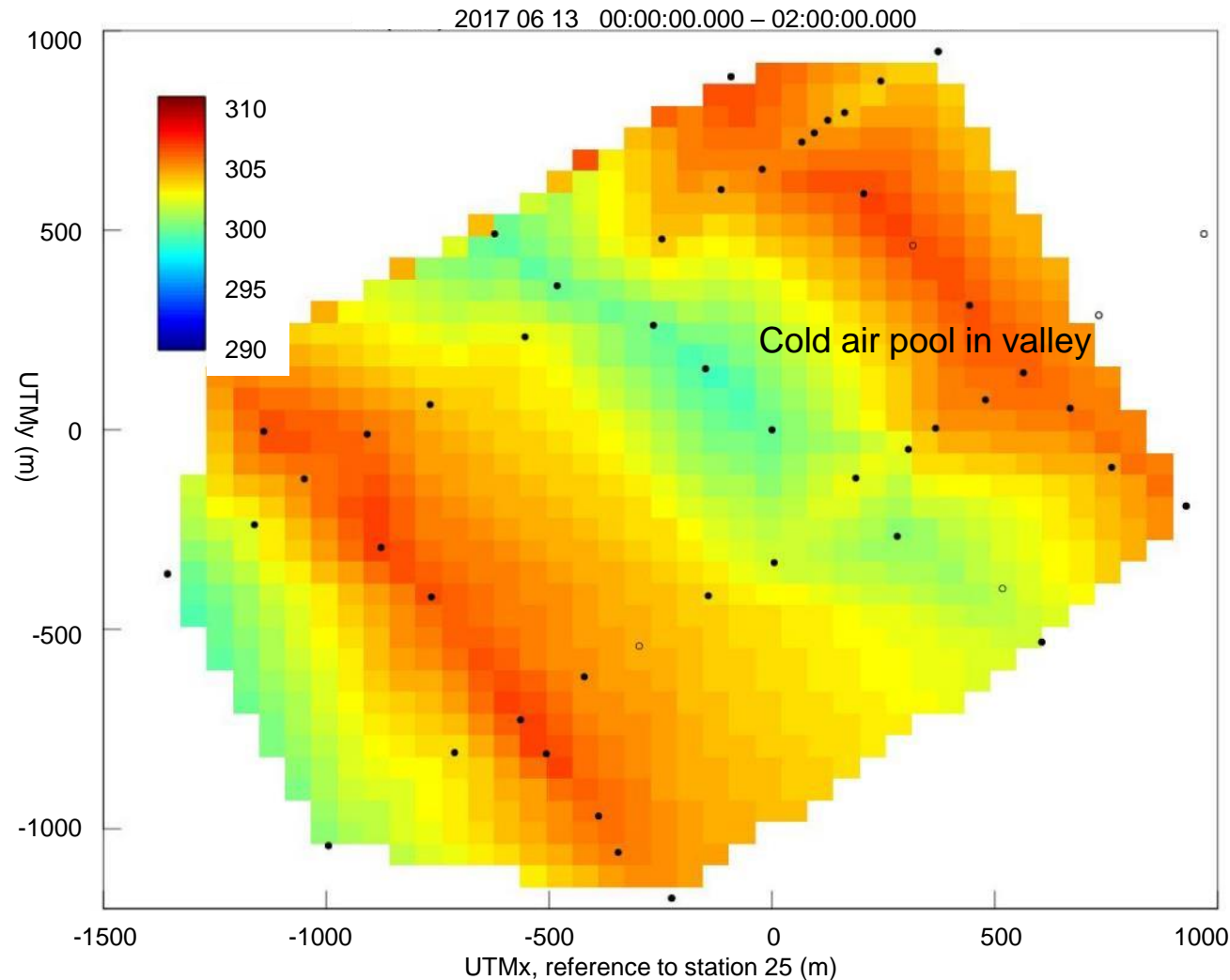
Courtesy Robert Menke (DTU)



LOTOS Surface Characterization

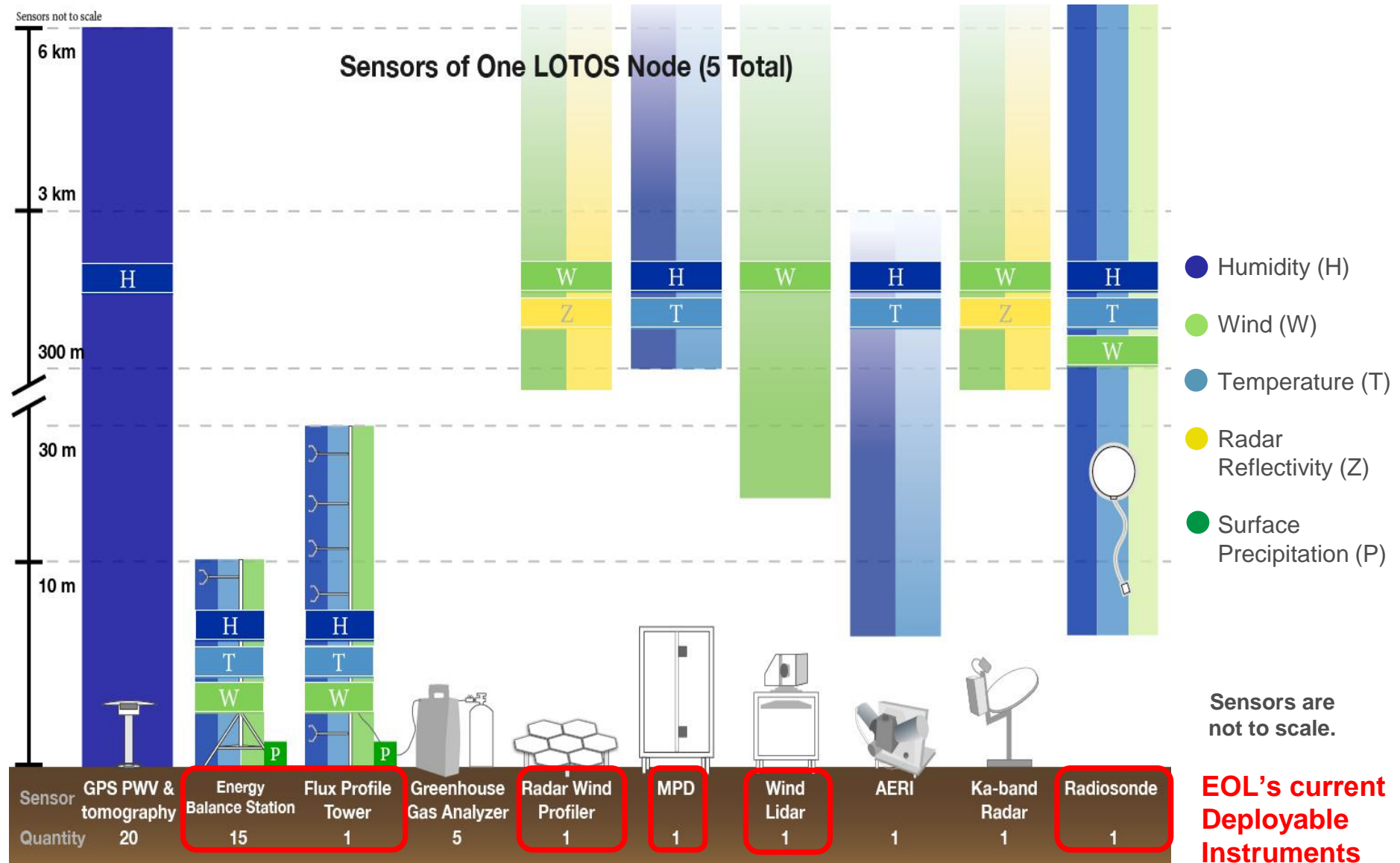
ISFS Composite from
Perdigão

Potential temperature field from 47-site ISFS network in Portugal



LOTOS Node Components

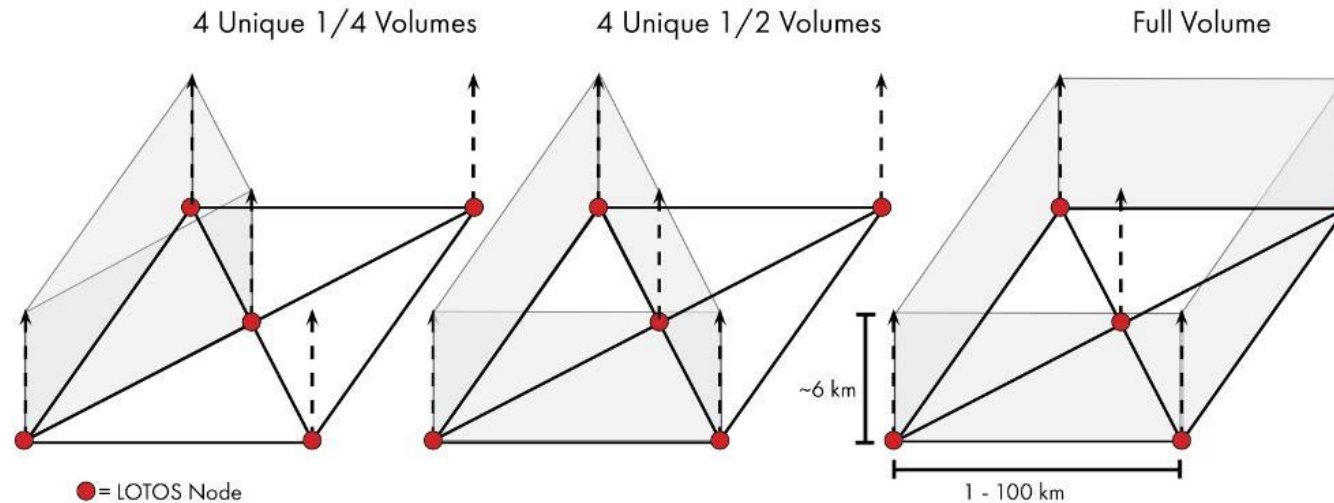
Complementary In-situ and Remote Sensors



Vertical measurement ranges of the LOTOS sensors at each of the five nodes.

LOTOS: Why 5 Nodes?

Control Volumes of 5 Nodes



Examples of various control volumes, as indicated by shading, that can be used with for determining mass and momentum budgets of different volumes.

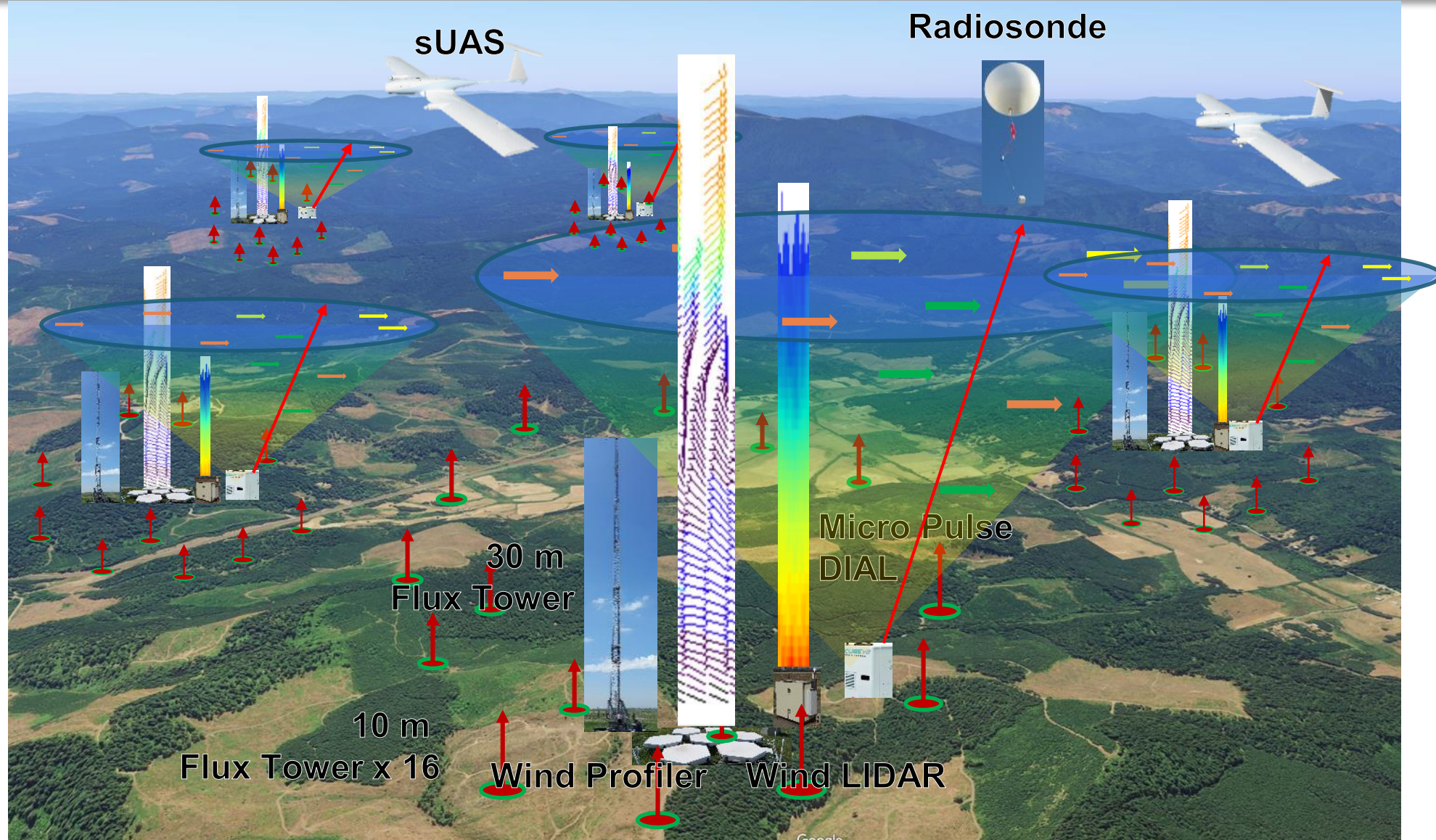
3-Nodes minimum: A key measurement to determine entrainment velocity, w_e is the convergence or divergence of the air within the volume from the surface to the top of the PBL.

3-nodes involves determining small differences between larger wind speeds and thus has large relative uncertainties.

4-Nodes: A fourth profile enables checking the convergence calculation with four sub-volumes.

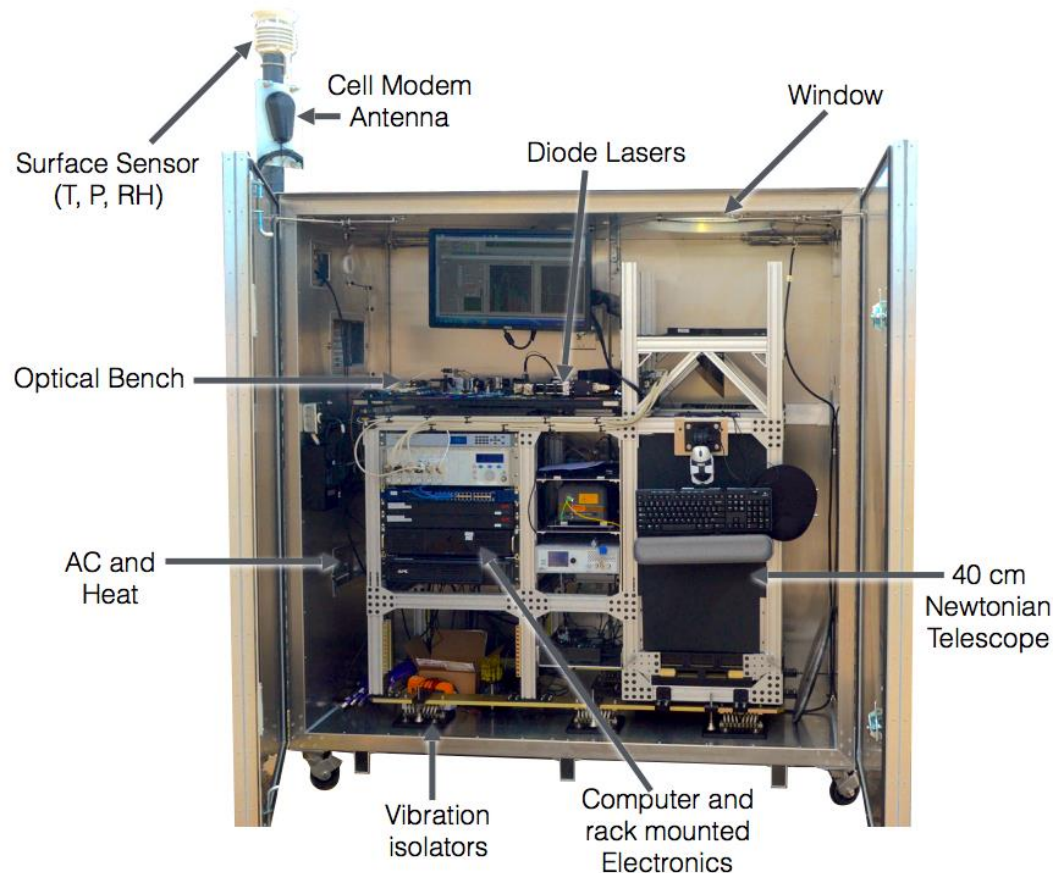
5-Nodes: Eight sub-volumes are possible with a total of five profiles.

LOTOS: Future of Complex Terrain Observations



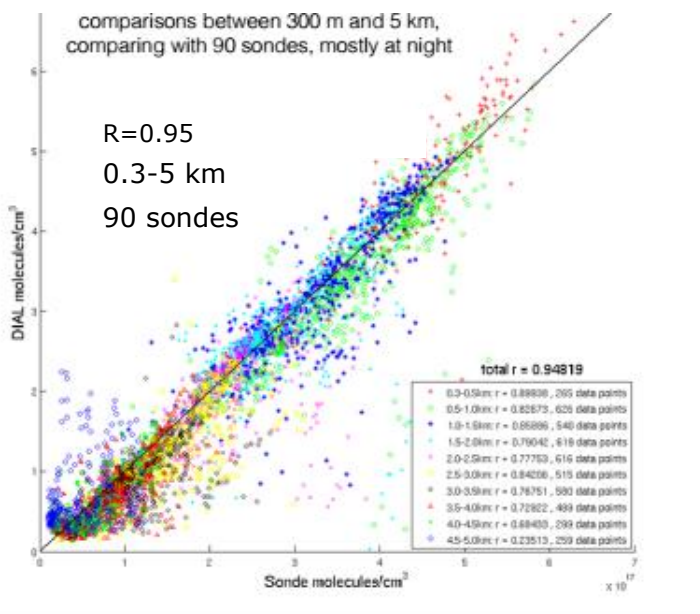
LOTOS Profiling: Water Vapor & Temperature

MPD Development

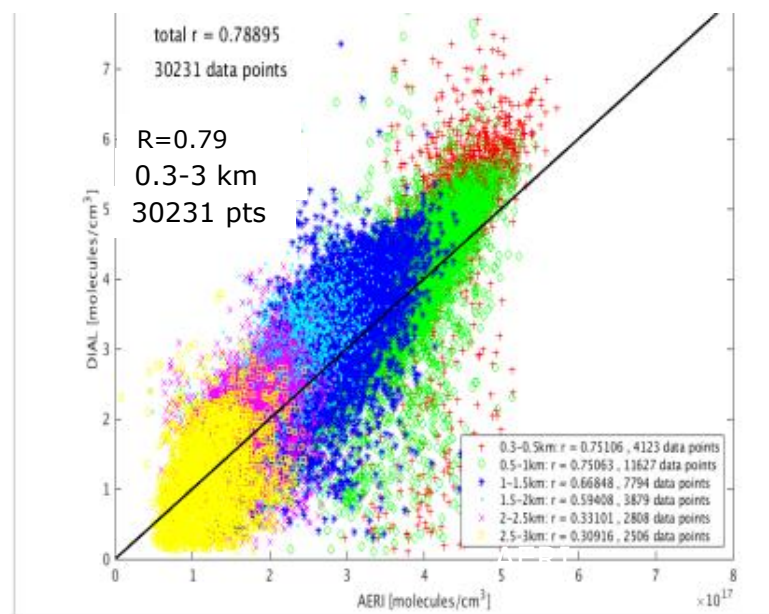


- Two tunable wavelengths (Near IR: 828 nm)
- Water Vapor Micro-Pulse DIAL (MPD) for measuring vertical profiles of water vapor up to 3-5 km AGL
- Network of five MPDs current testing in U.S. Southern Great Plains
- Calibrated aerosol addition via HSRL (780 nm)
- Efforts toward temperature MPD (770 nm)
- Low power eye safe

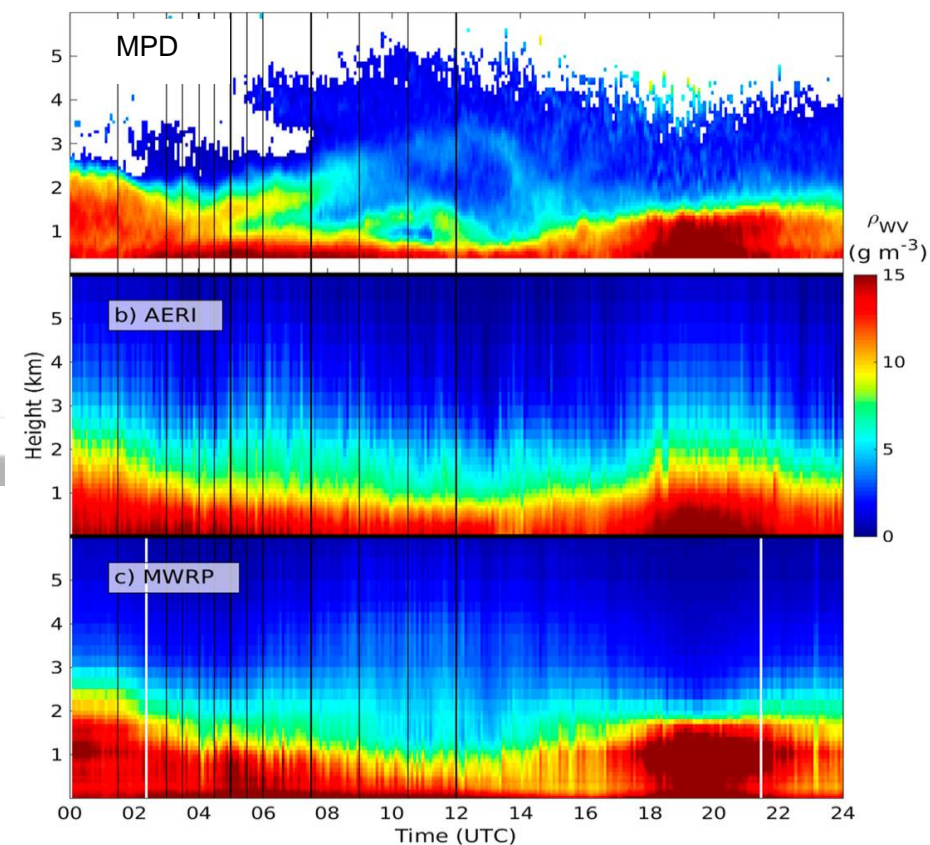
Radiosonde-MPD



AERI-MPD



Weckwerth, Weber, Turner and Spuler, 2016, *J. Atmos. Oceanic Technol.*

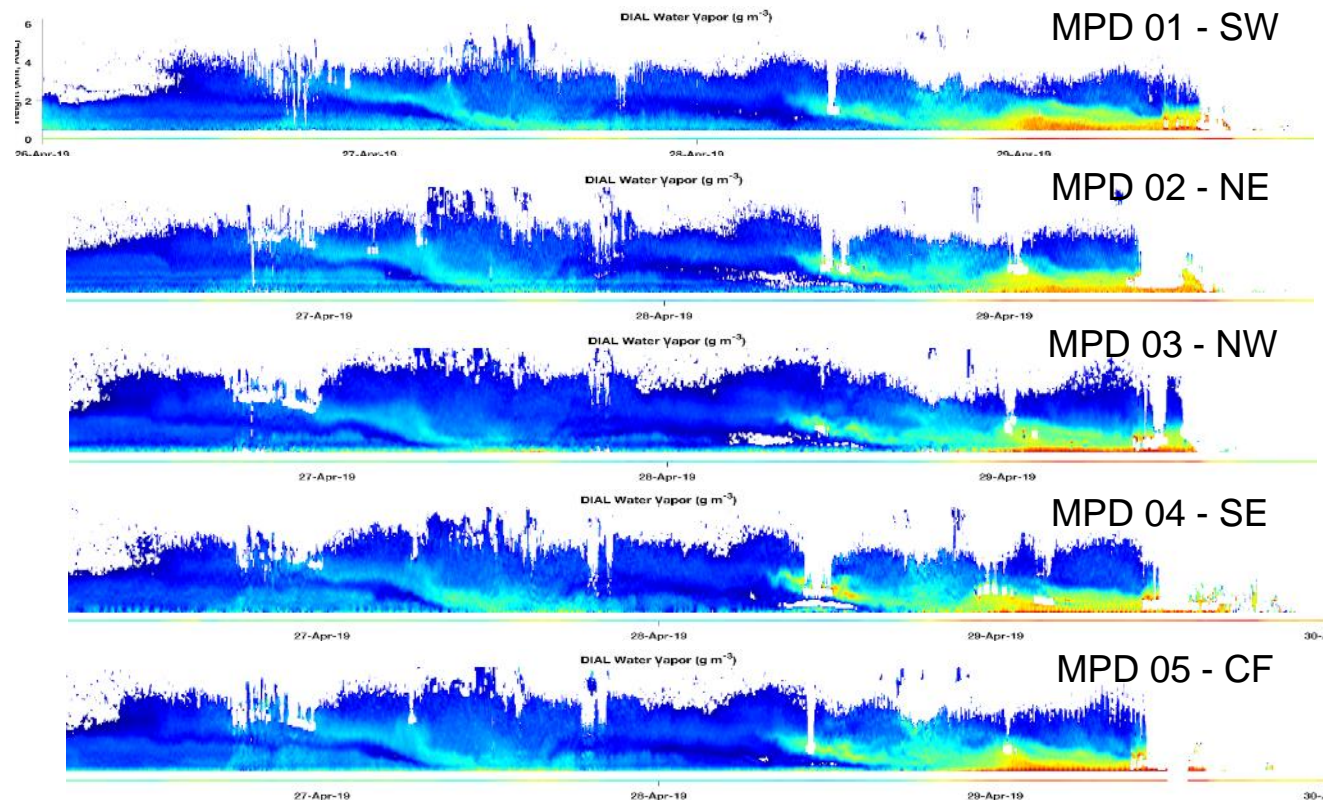


- Excellent comparisons with radiosondes, MWRP, AERI and GPS receivers providing PWV
- Elevated layers of moisture observed by MPD but not by passive remote sensing systems

LOTOS Profiling: MPD

Network of Five MPDs
at DOE/ARM/SGP

- Water vapor concentration at 150 m vertical and 5 min temporal resolution
- From 300 m to 3-5 km (or cloud base) in day, night and cloudy conditions



- 26-30 April 2019
- Consistent WV pattern
- Descending moist layer
- Development of CBL



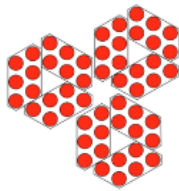
- MPD Network Demonstration at DOE/ARM/SGP sites
- 22 April – 19 July 2019

Courtesy Scott Spuler (EOL)

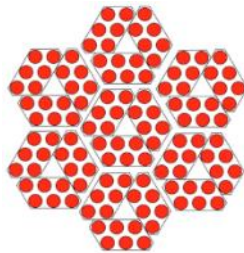
LOTOS Vertical Profiling: Wind

449 Modular Wind Profiler

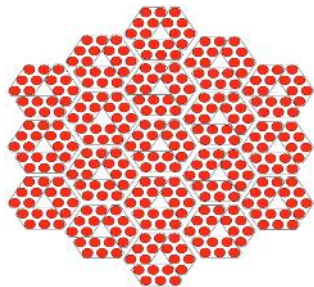
- NCAR/EOL developed radar wind profiler
- Operates at 449 MHz (other frequency options are also proposed)
- Spaced antenna for rapid wind measurement
- Modular design enables scalability and flexibility



Boundary Layer Configuration
3 antenna modules
Range: 150 m – 4 km
Resolution: 30 - 100 m

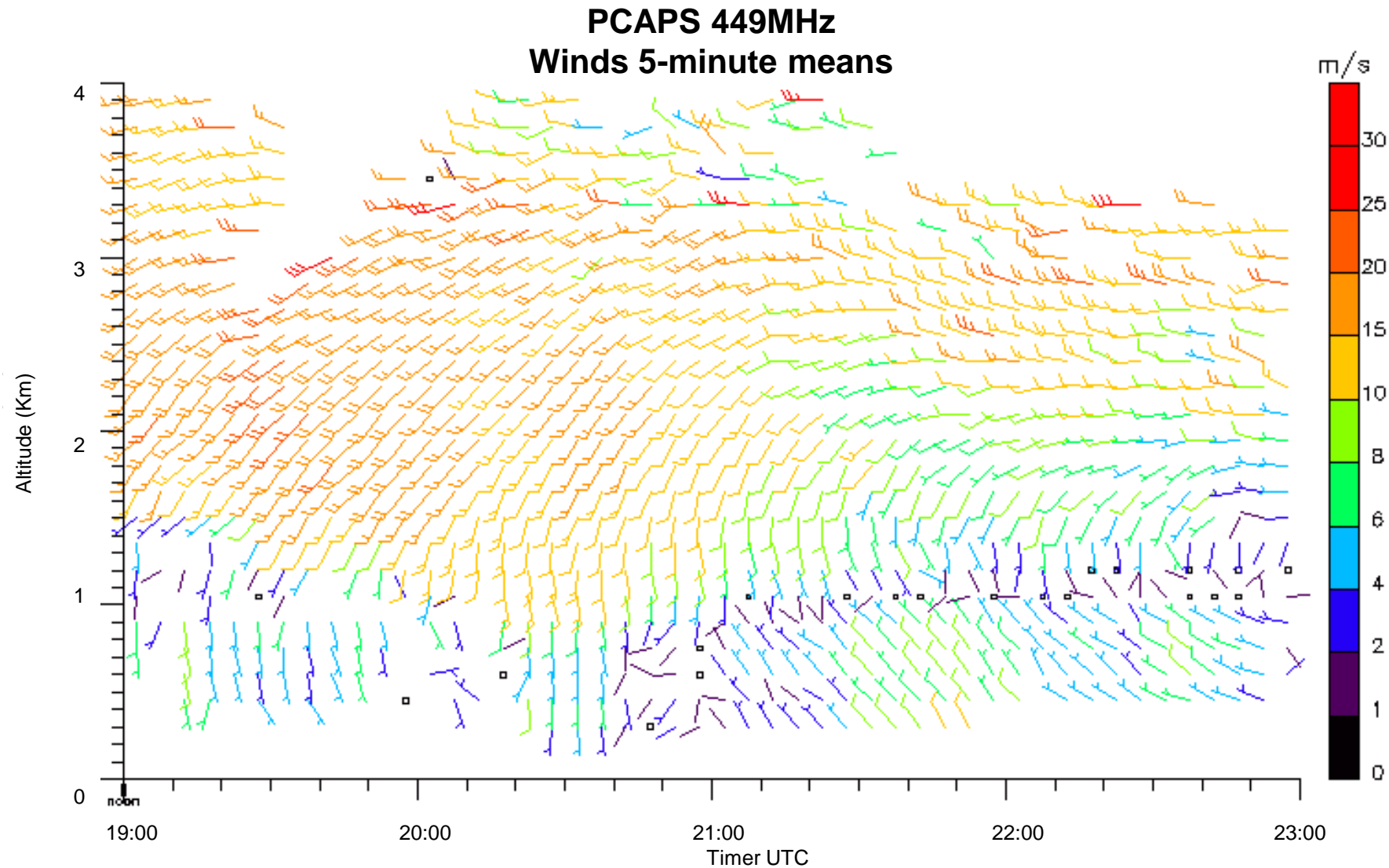


Mid Troposphere Configuration
7 antenna modules
Range: 200 m – 7 km
Resolution: 50 - 200 m



Full Troposphere Configuration
19 antenna modules





LOTOS PI
Terry Hock
ISF Manager
hock@ucar.edu

Co - Science PIs:

Dr. Steve Oncley – Leads the Integrated Surface Flux System

Dr. Tammy Weckwerth – Leads the MPD Science, GPS WP, AERI-I

Science/Technical Team:

Dr. Britt Stephens – Surface Chemistry

Dr. Bill Brown – Wind Profiling/Ceilometer/Sounding Systems

Dr. Scott Spuler – MicroPulse DIAL

Dr. Mike Dixon – Software Engineer

Gary Granger – Software Engineer

Management

Dr. Vanda Grubišić – NCAR Associate Director & Director of EOL

Dr. Wen-Chau Lee – RSF Manager

