Airborne Doppler Wind Lidar: recent results and in-flight visualization using Google Earth

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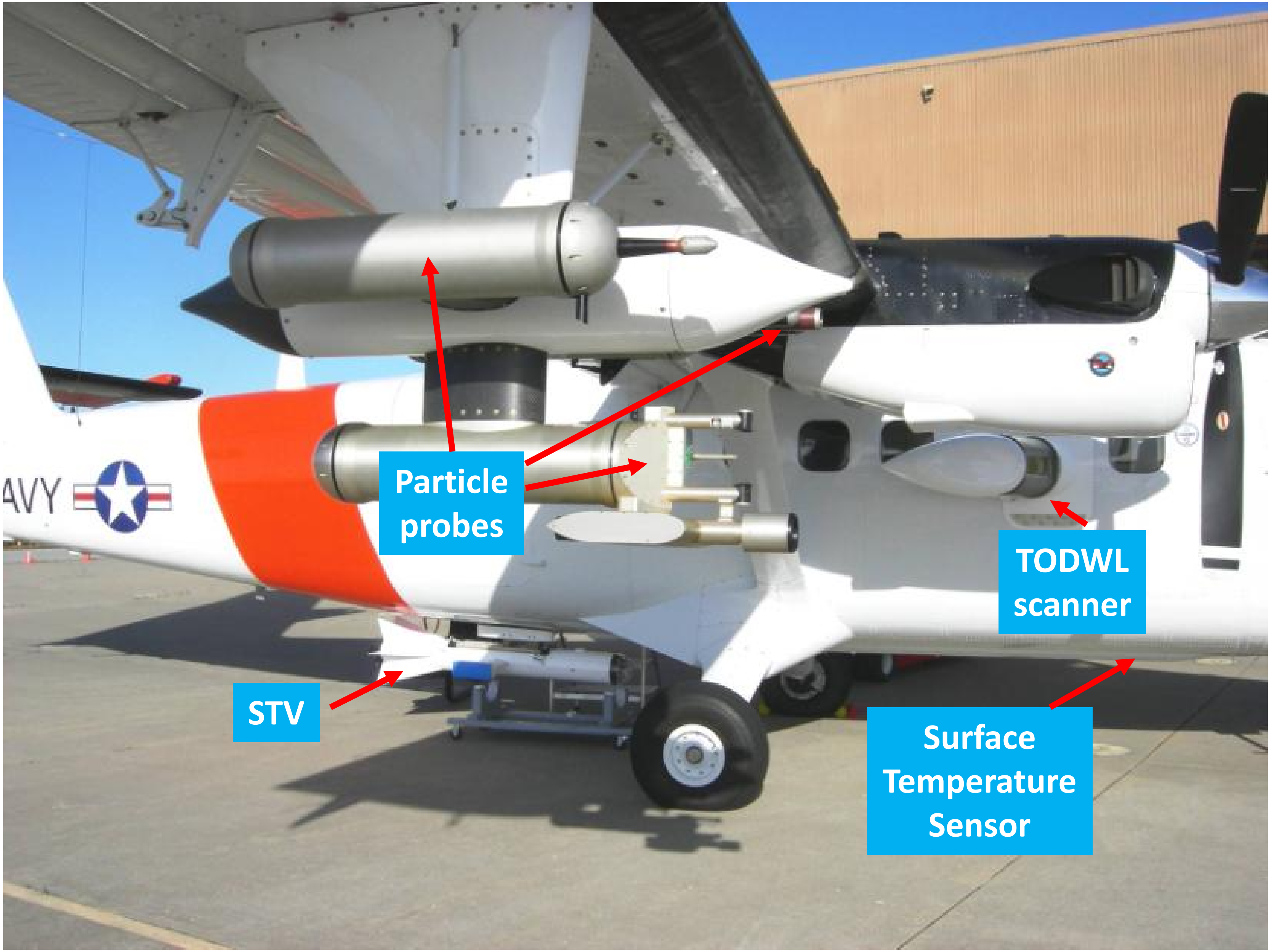
July 8, 2008

WG , Wintergreen, VA.



AVY
Particle probes
TODWL scanner
STV
Surface Temperature Sensor

Overview

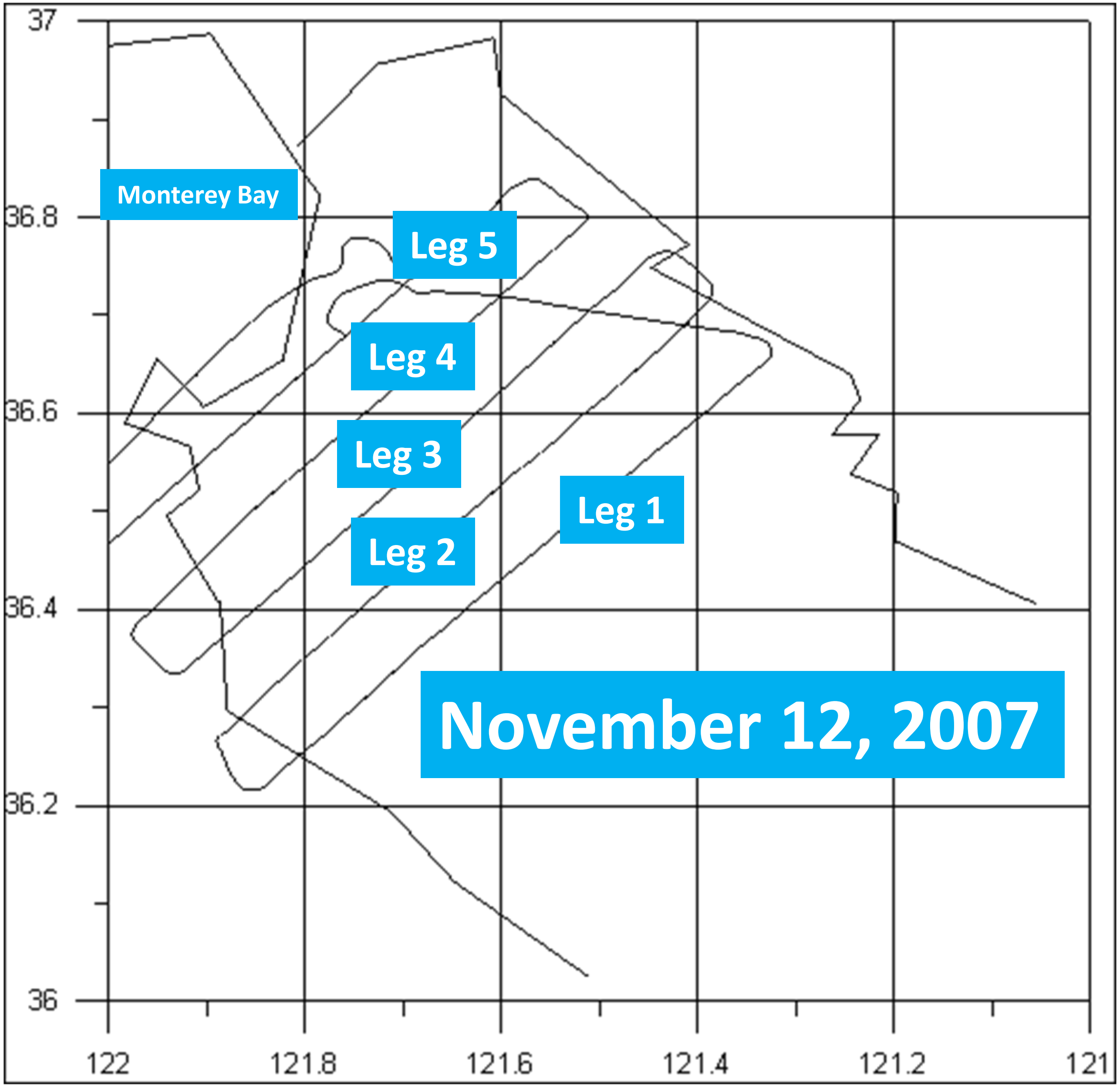
- Update on processing TODWL data from 2007
- Issues related to SkyWalker and space-based DWL data interpretation.
- Use of Google Earth to view airborne DWL data
  - Profiles of u,v,w and SNR obtained with step stare conical scans
  - Forward raster scans

April/November 2007 TODWL flights

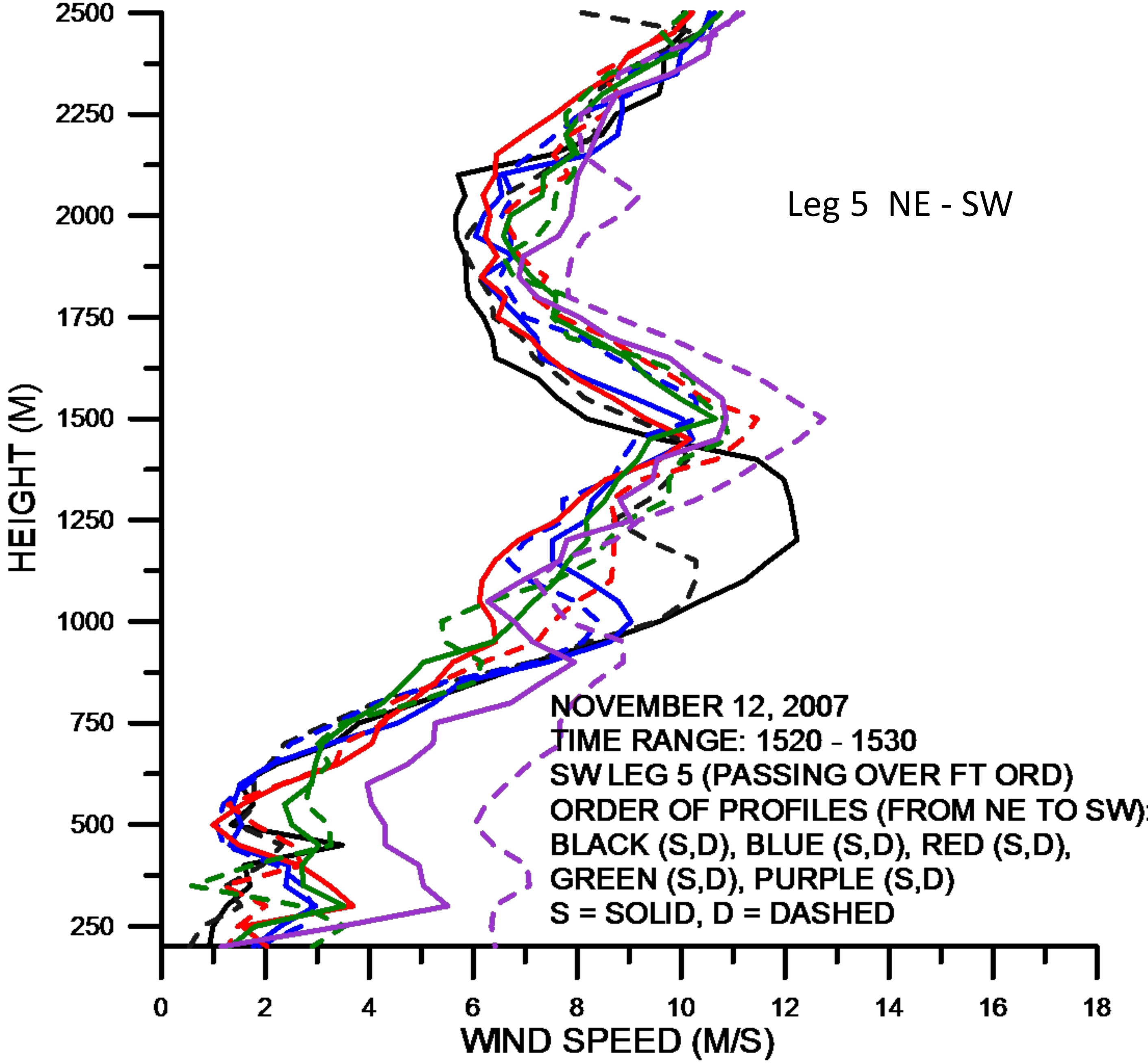
- SkyWalker (autonomous UAV glider operations using onboard DWL)
  - Organized large Eddies
  - Cloud updrafts
  - Mountain waves
  - Shear layers
  - Thermals
- Nocturnal energy

April/November flights (cont)

- ADLAATS (ARO) and I-LIMMS (ONR)
  - Model vs. airborne DWL observations in real-time
  - Autonomous scan mode changes based upon DWL/Model comparisons.
  - Flow visualization needed for development phase
- Survey flights (5 - 6 legs)
- Salinas Valley flows (day and night)
- Ridge circulations (day and night)



Monterey Bay
Leg 5
Leg 4
Leg 3
Leg 2
Leg 1
November 12, 2007
37
36.8
36.6
36.4
36.2
36
122
121.8
121.6
121.4
121.2
121


Leg 5 NE - SW
NOVEMBER 12, 2007
TIME RANGE: 1520 - 1530
SW LEG 5 (PASSING OVER FT ORD)
ORDER OF PROFILES (FROM NE TO SW):
BLACK (S,D), BLUE (S,D), RED (S,D),
GREEN (S,D), PURPLE (S,D)
S = SOLID, D = DASHED
HEIGHT (M)
2500
2250
2000
1750
1500
1250
1000
750
500
250
WIND SPEED (M/S)
0
2
4
6
8
10
12
14
16
18

I-LIMMS[a] SBIR Phase-II Tasks

How was Google Earth selected?

1) Optimize in-flight data collection & processing
2) Real-time 4D analysis/visualization from various perspectives, evaluate COTS:
   - IDL
   - GIS (ESRI ArcGIS, GeoTools, …)
   - Voxler (3D)
   - Virtual Globe (Google Earth, …)
   - …

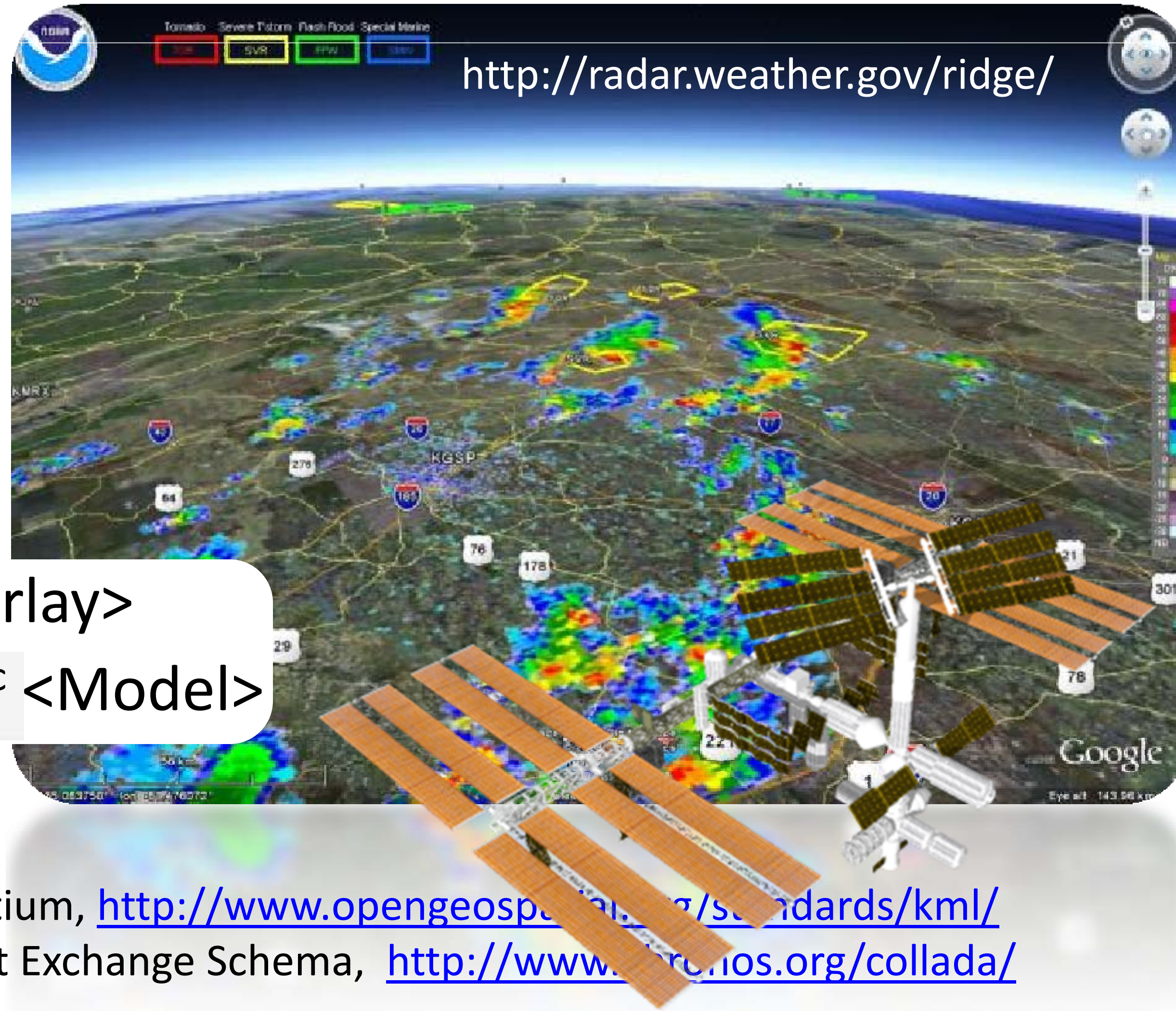
   ✓ ease of use
   ✓ learning curve
   ✓ user adoption
   ✓ functionality
   ✓ licensing & costs
3) Enable non-instrument scientists to operate lidar
4) Merge into system for aircraft operations

[a] In-Flight Lidar Integrated Mission Management System (I-LIMMS)

Google Earth Structures

KML is an OGC Standard[b]

- <Placemark>
  - <Point>
  - <LineString>
  - <Polygon>
- Images:
  - <GroundOverlay>
  - COLLADA[c] <Model>

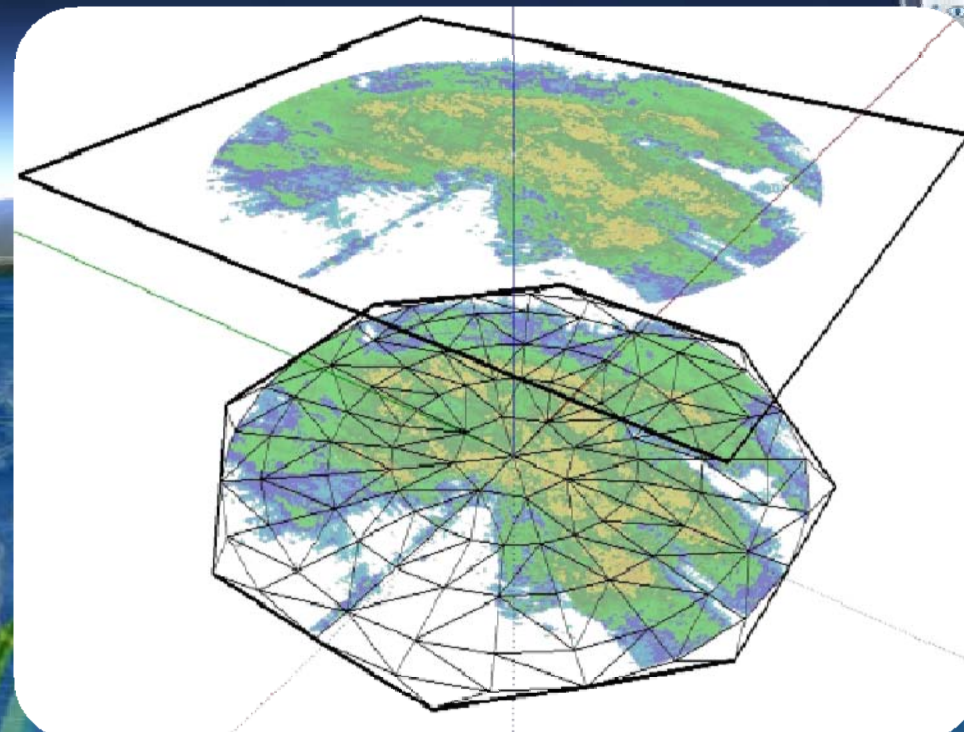


[b] Open Geospatial Consortium, http://www.opengeospatial.org/standards/kml/
[c] Khronos Group, 3D Asset Exchange Schema, http://www.khronos.org/collada/

3D radar problem solved

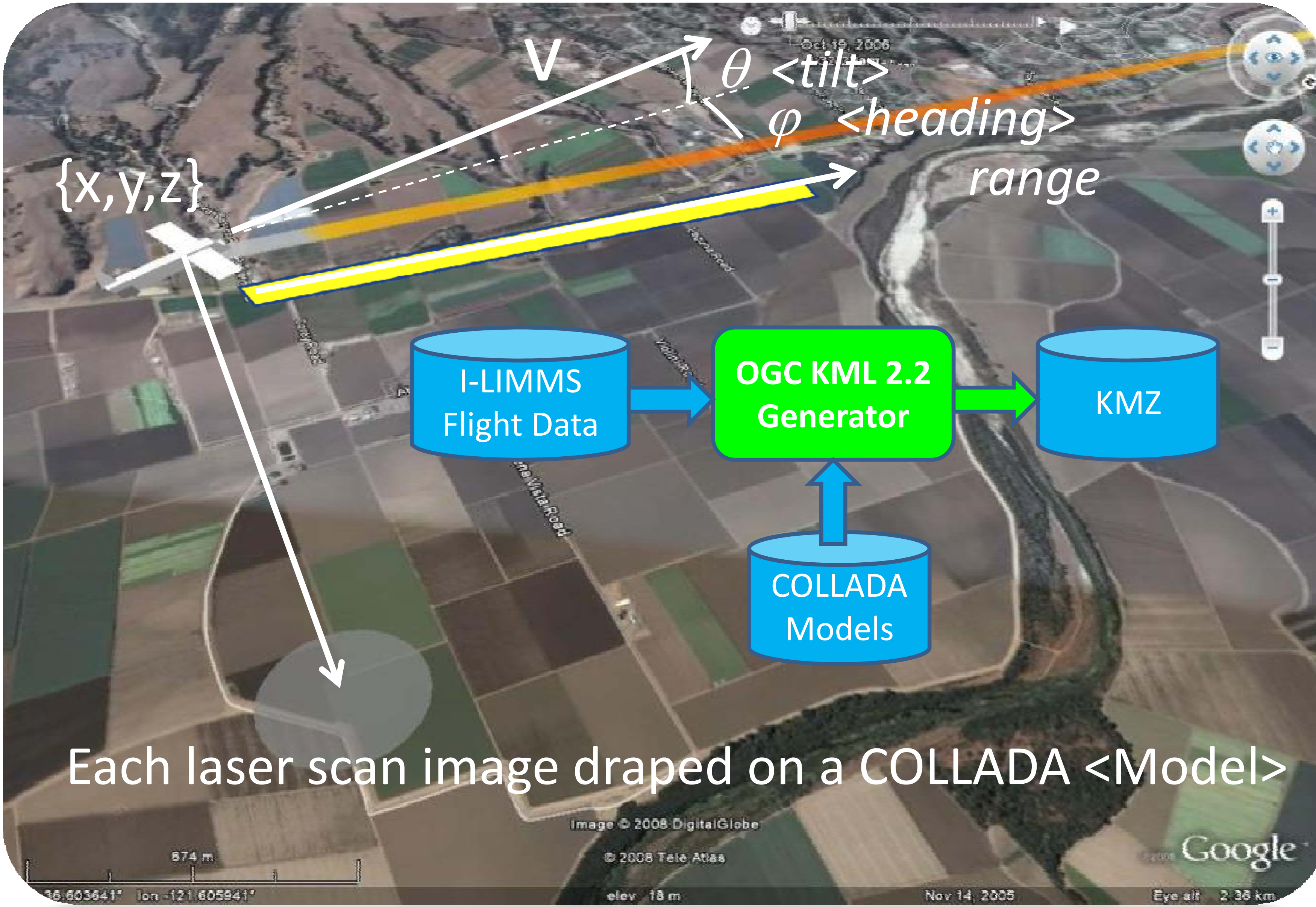
COLLADA <Model> Approach [d]

- KTAX Occultation
- COLLADA model on Google Earth

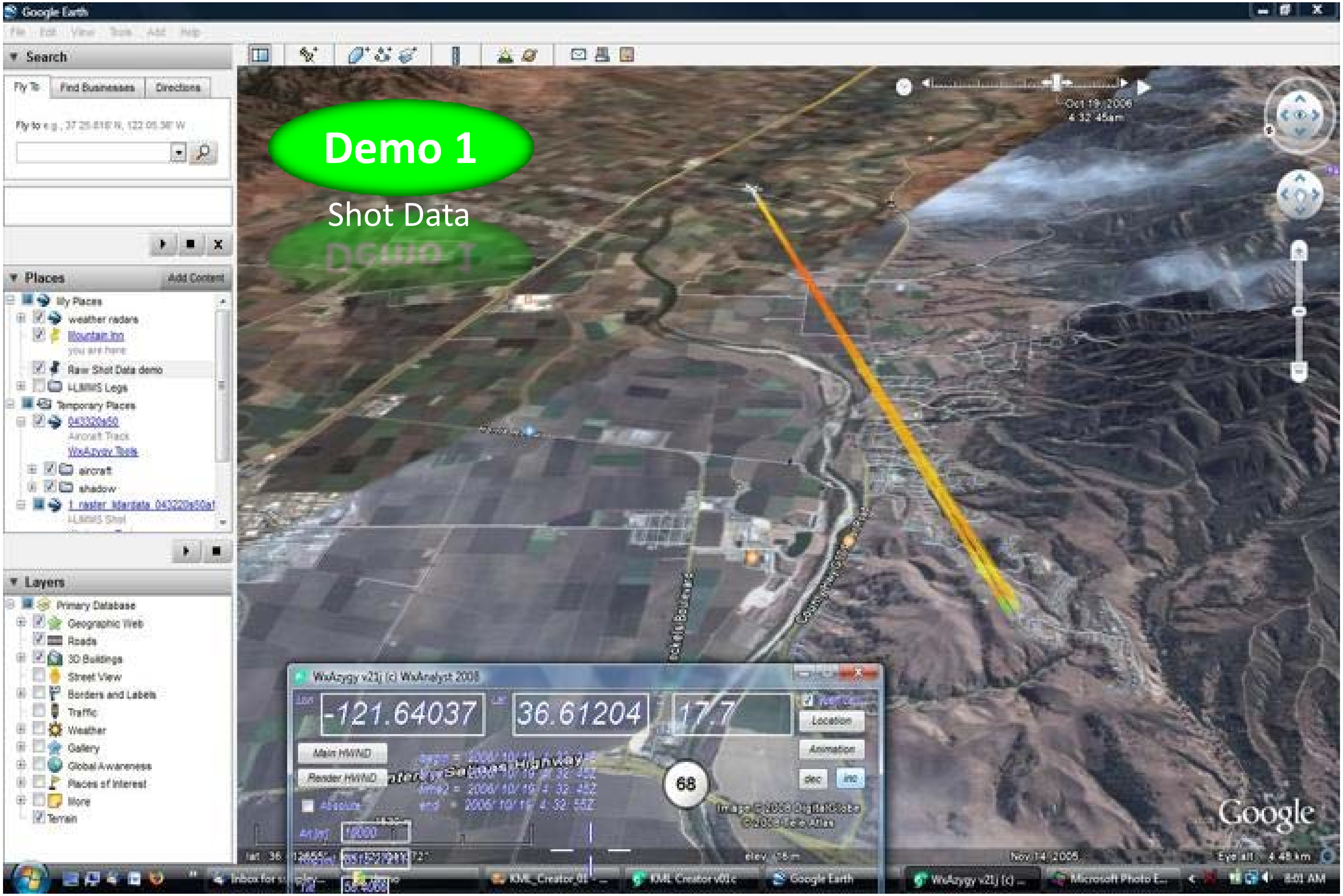


[d] Shipley, S.T., R.M. Steadham and D.S. Berkowitz (2007) Comparison of Virtual Globe technologies for depiction of radar beam propagation effects and impacts, Fall AGU.

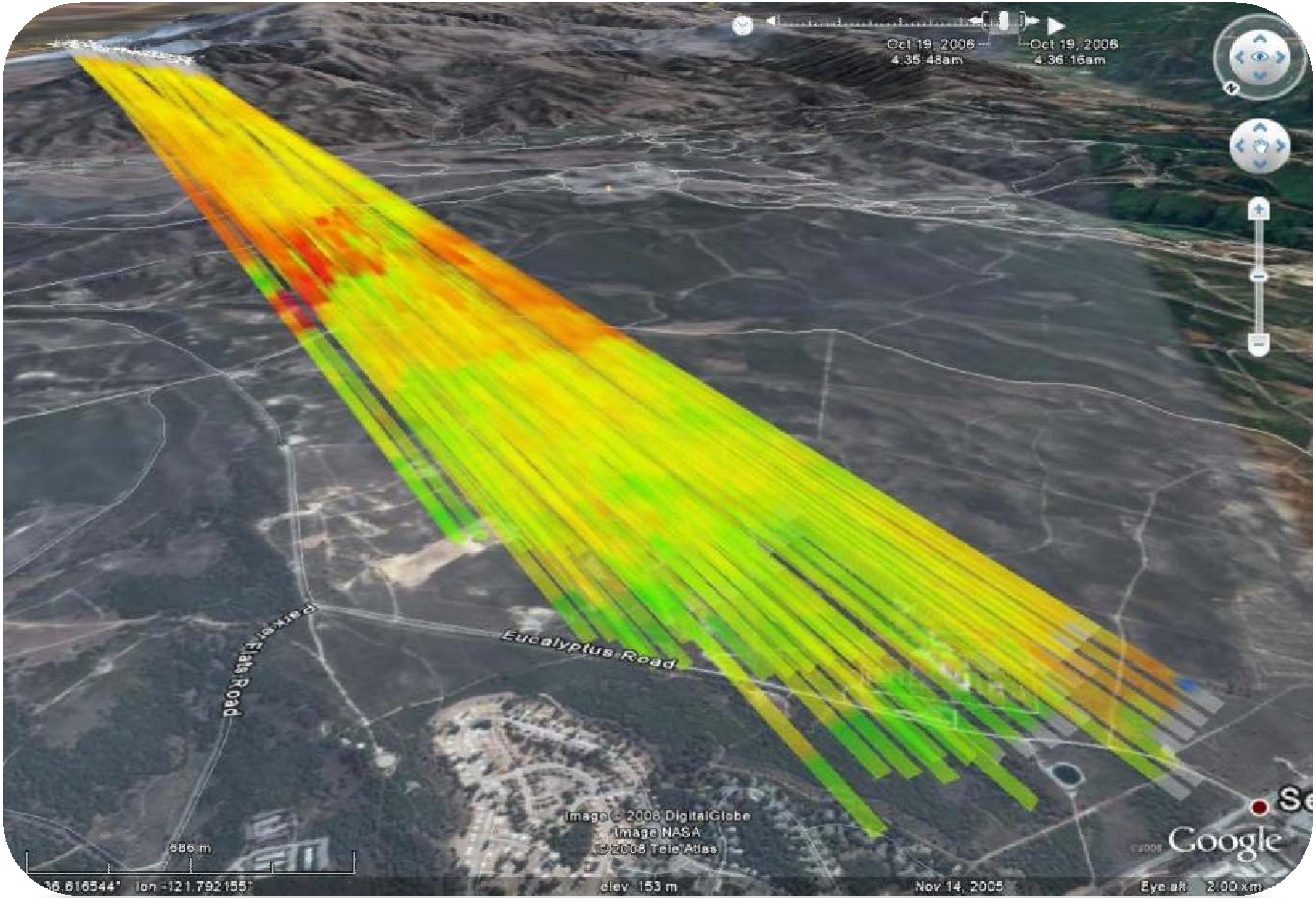
Airborne Lidar in Google Earth



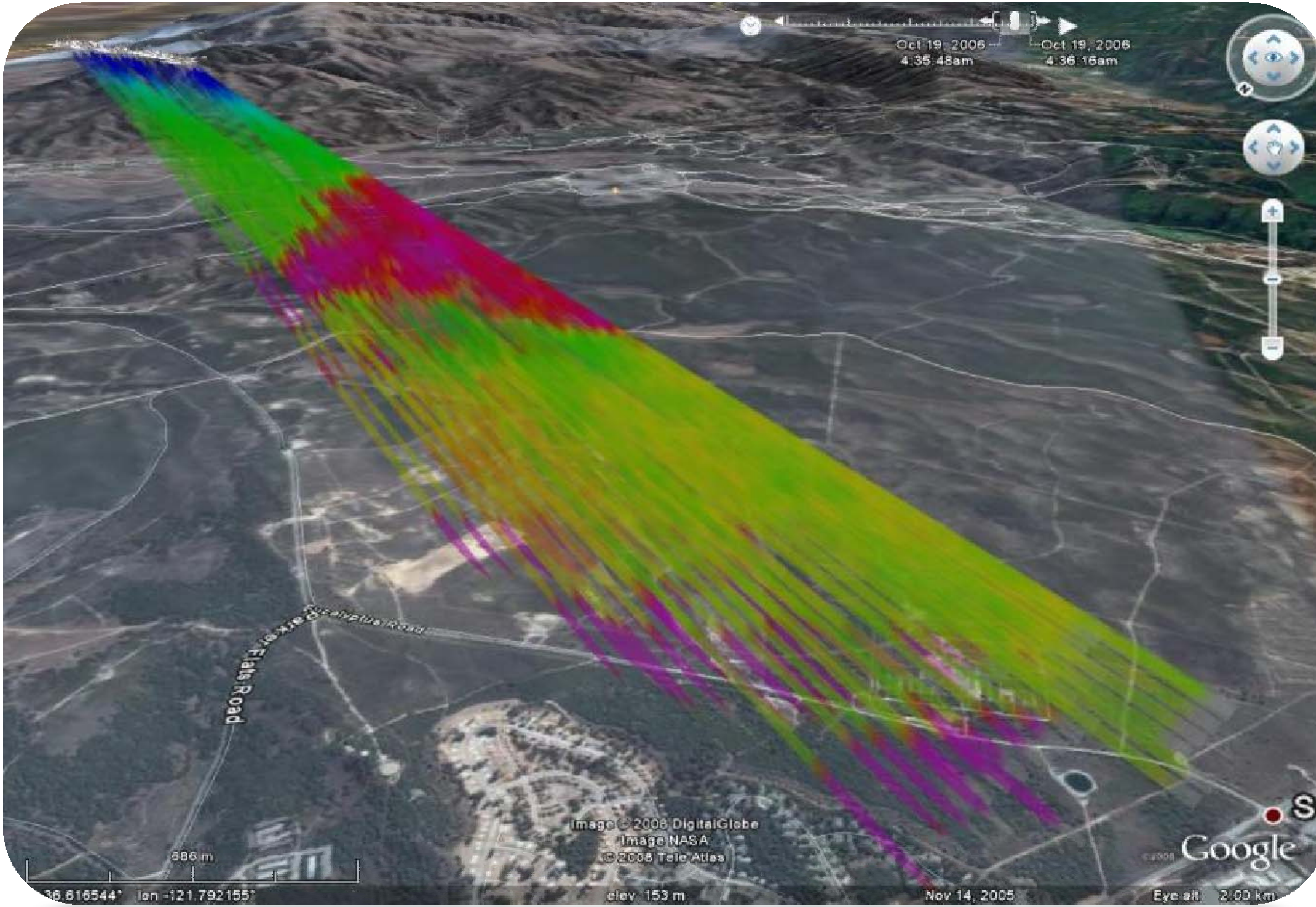
Airborne lidar scan animation



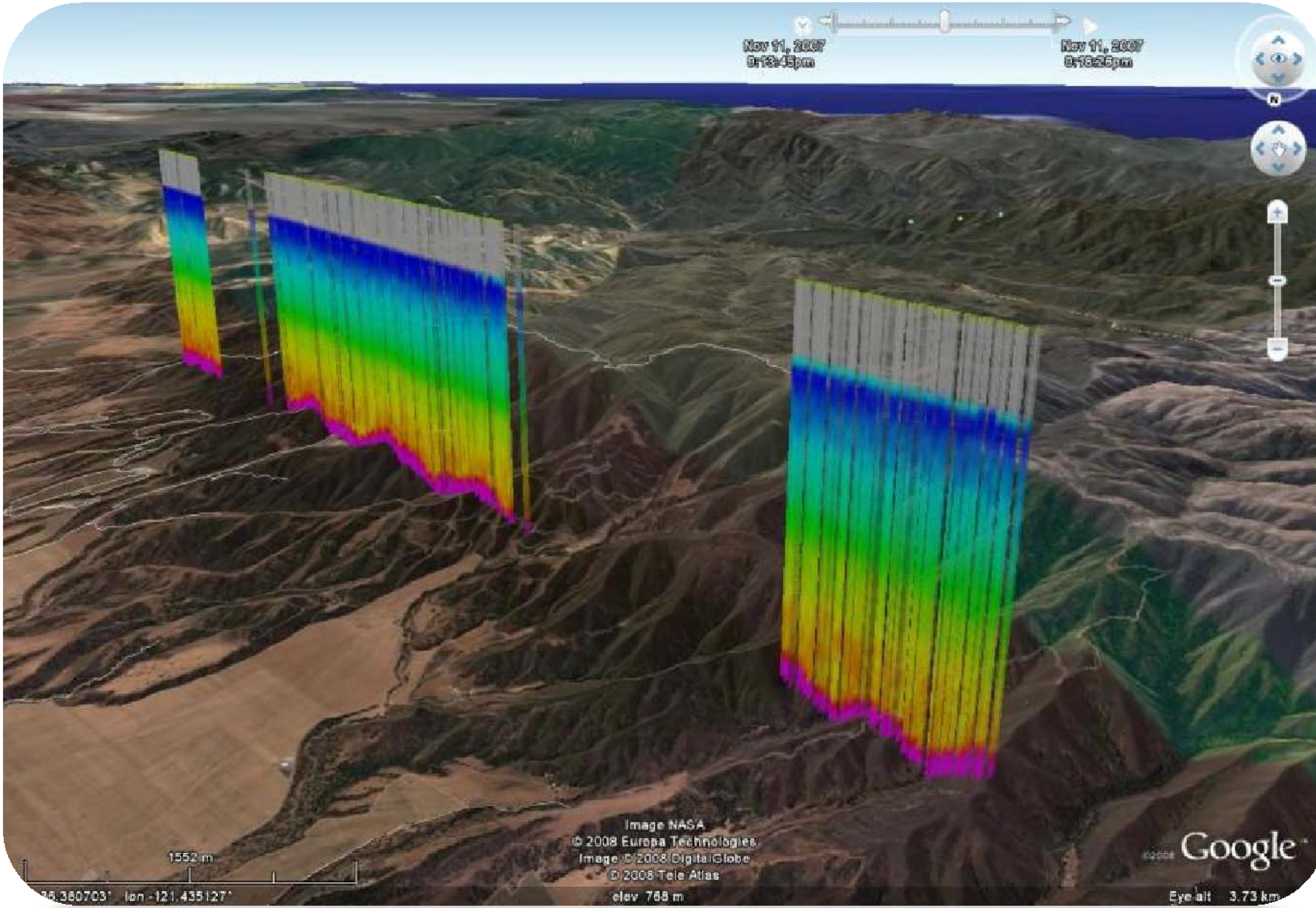
Radial Wind Speed (VLOS)



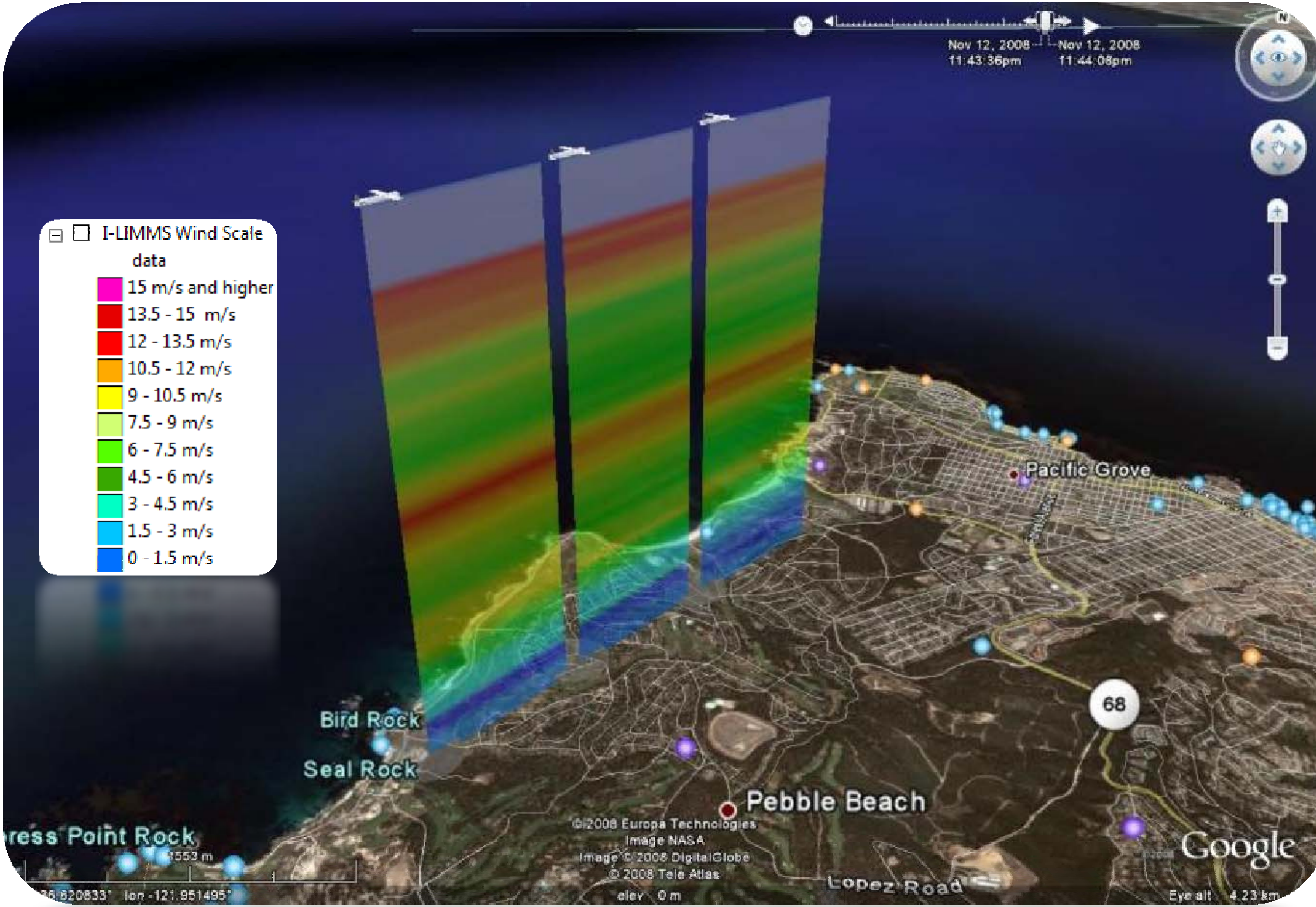
Backscatter (SNR)



Quality Test – Location & Height

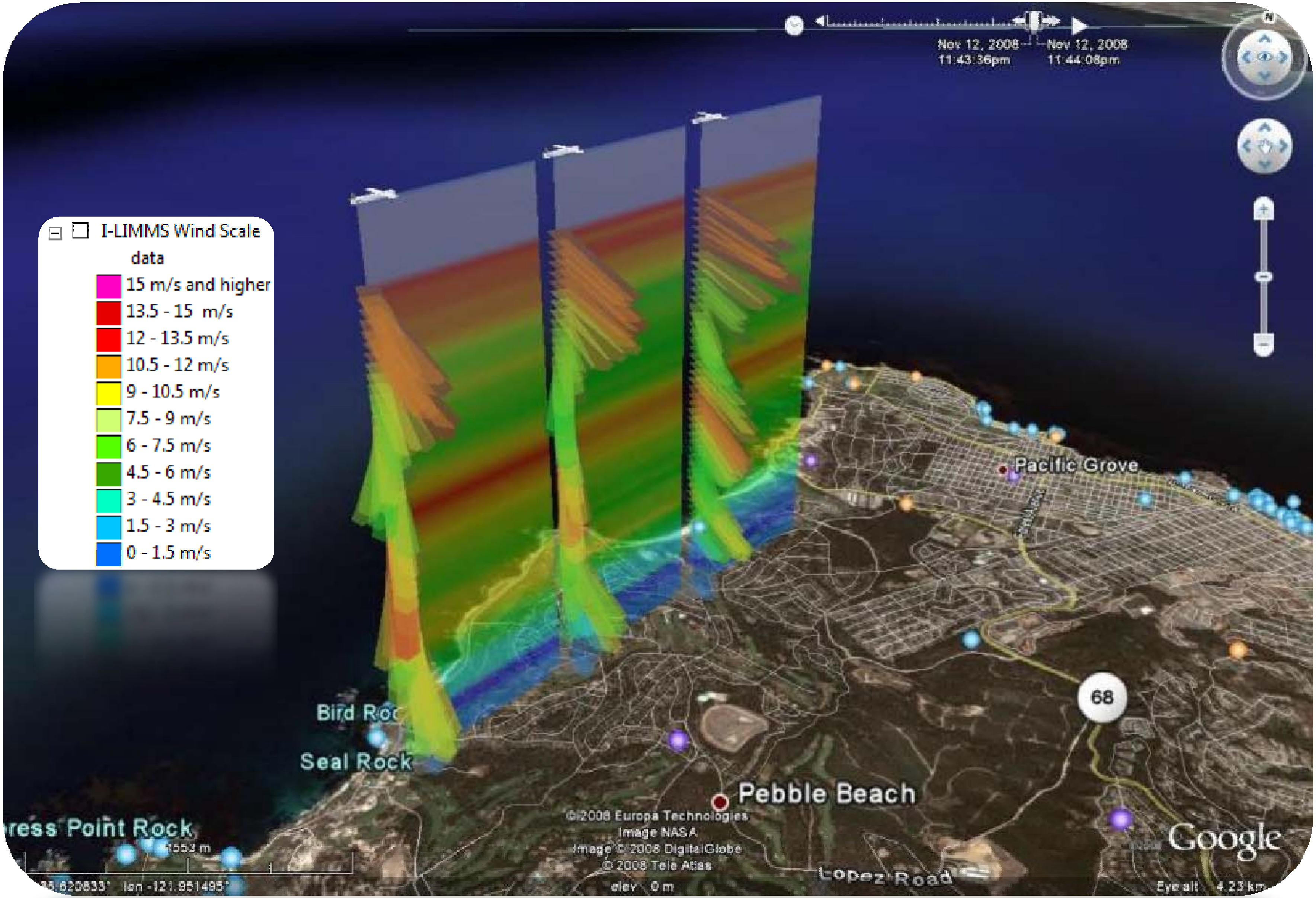


Wind Speed as Cross Section



Wind Speed & Direction as <Polygon>

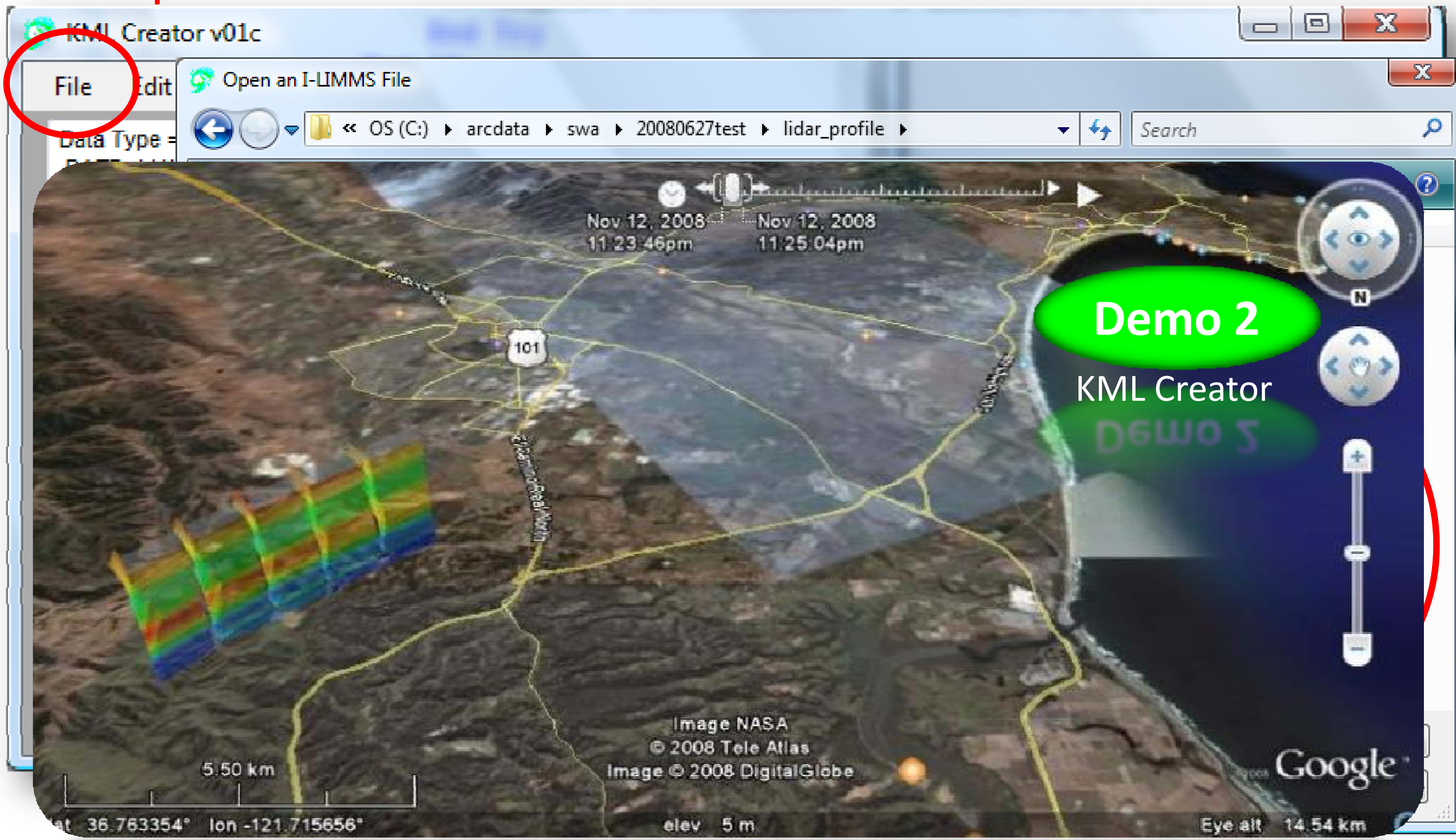
Wind Speed & Direction



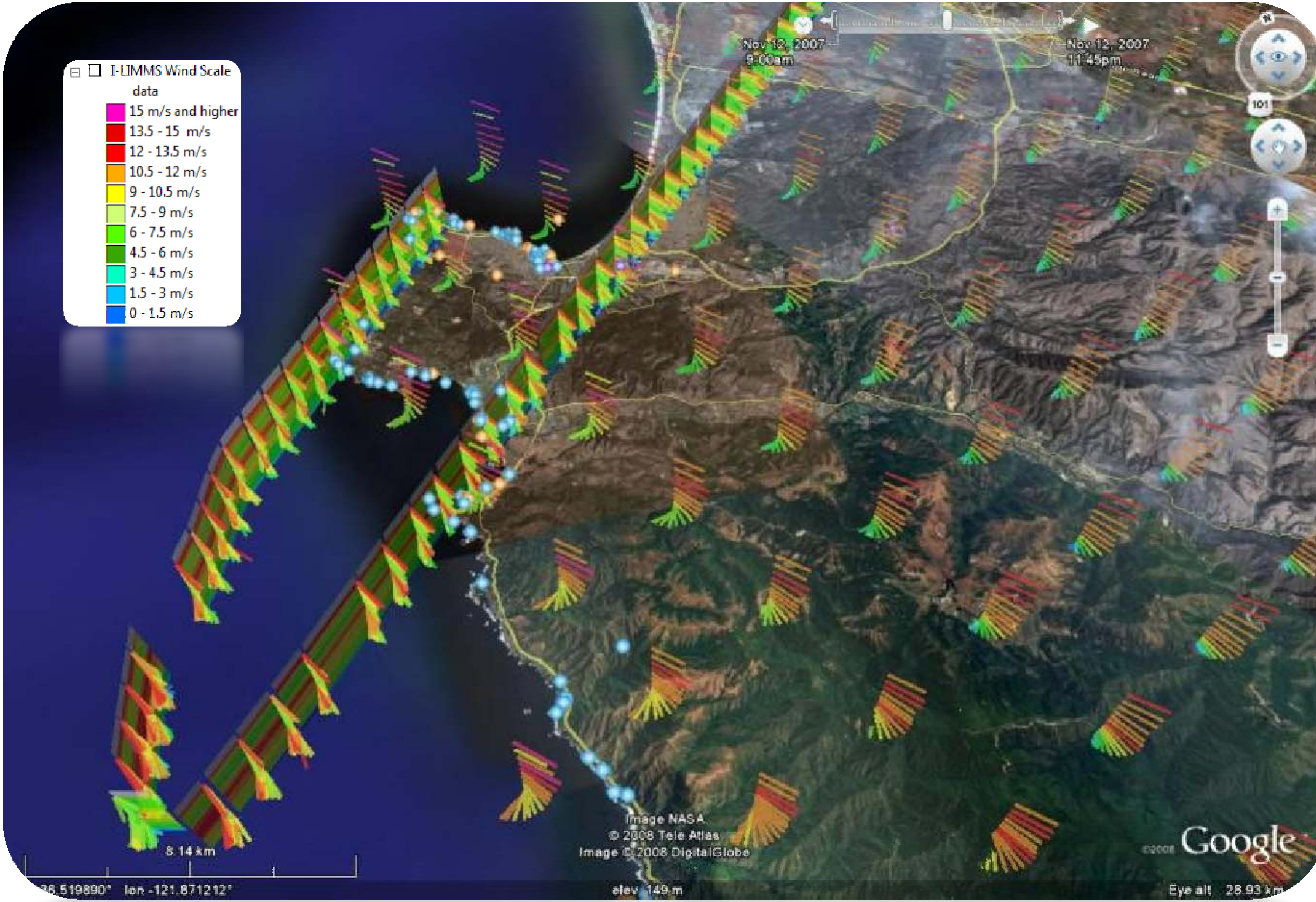
KML Creator

generates KMZ "on-the-fly"

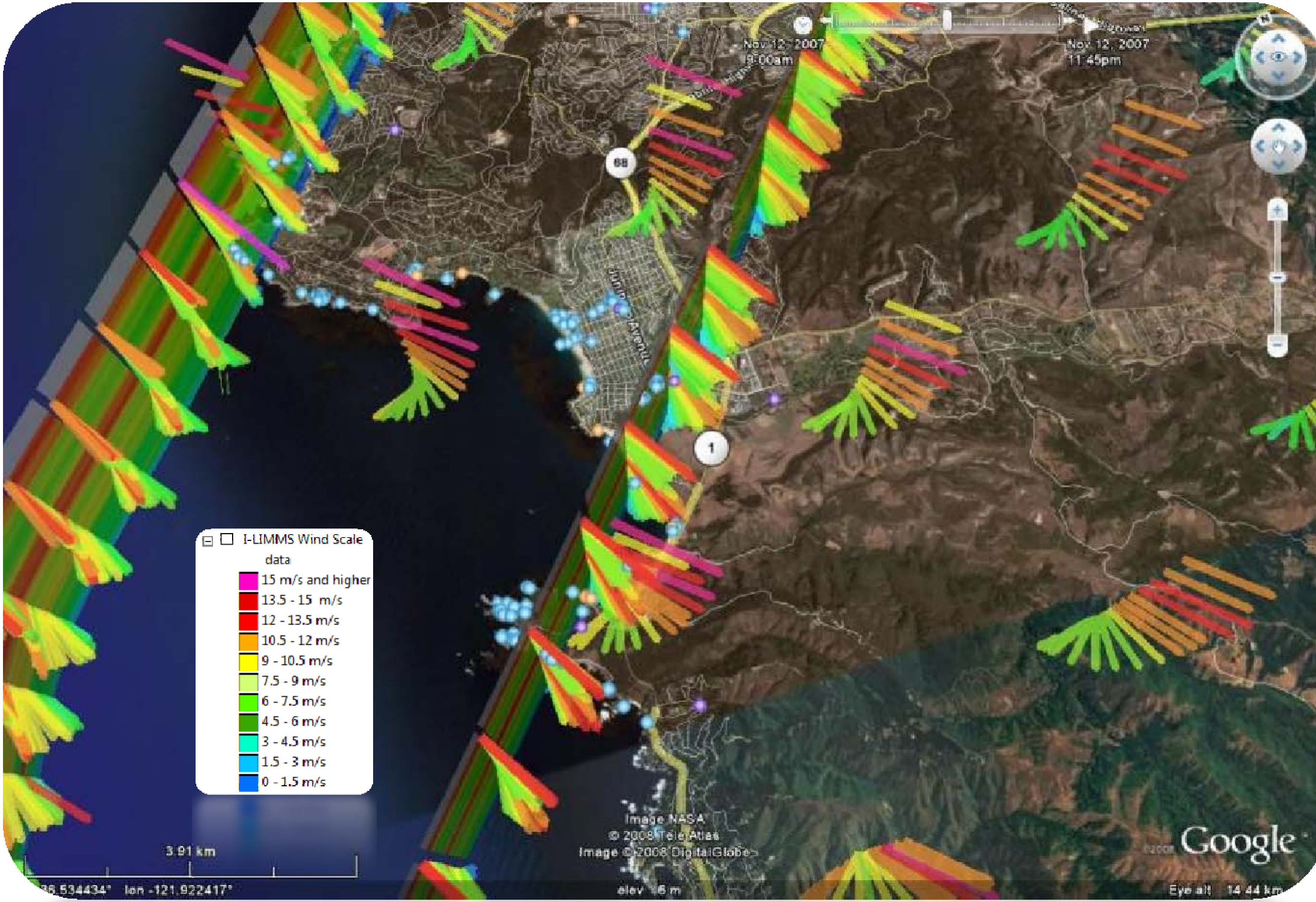
1. Open File



Comparison with 4km MM5



Comparison with 4km MM5



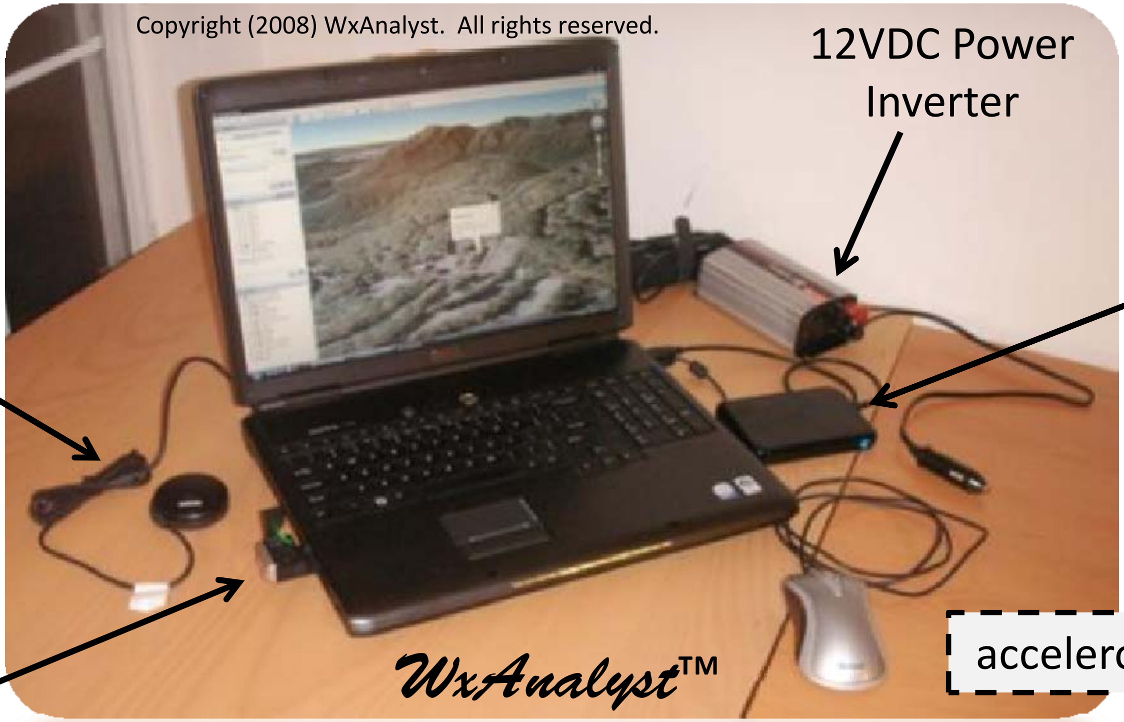
Real-time Processing
(1) Control of Google Earth API

- Interactive Location, User Queries (GIS functions), Data Loads on-the-fly
- Animation & time controls

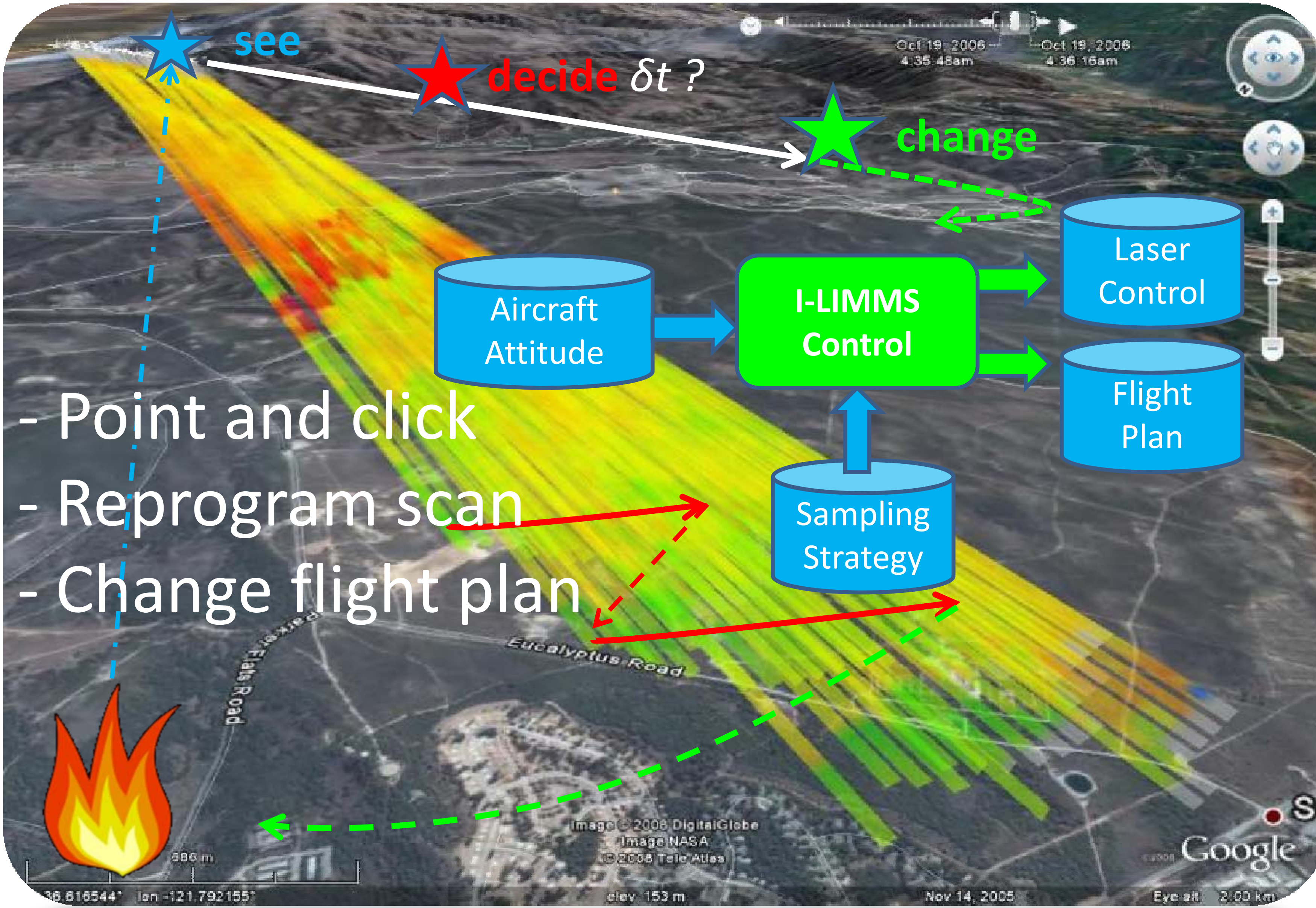
Real-time Processing

(2) Decouple from Internet

- Local data server
  - Preload to region of operations



How long for mid-flight correction?

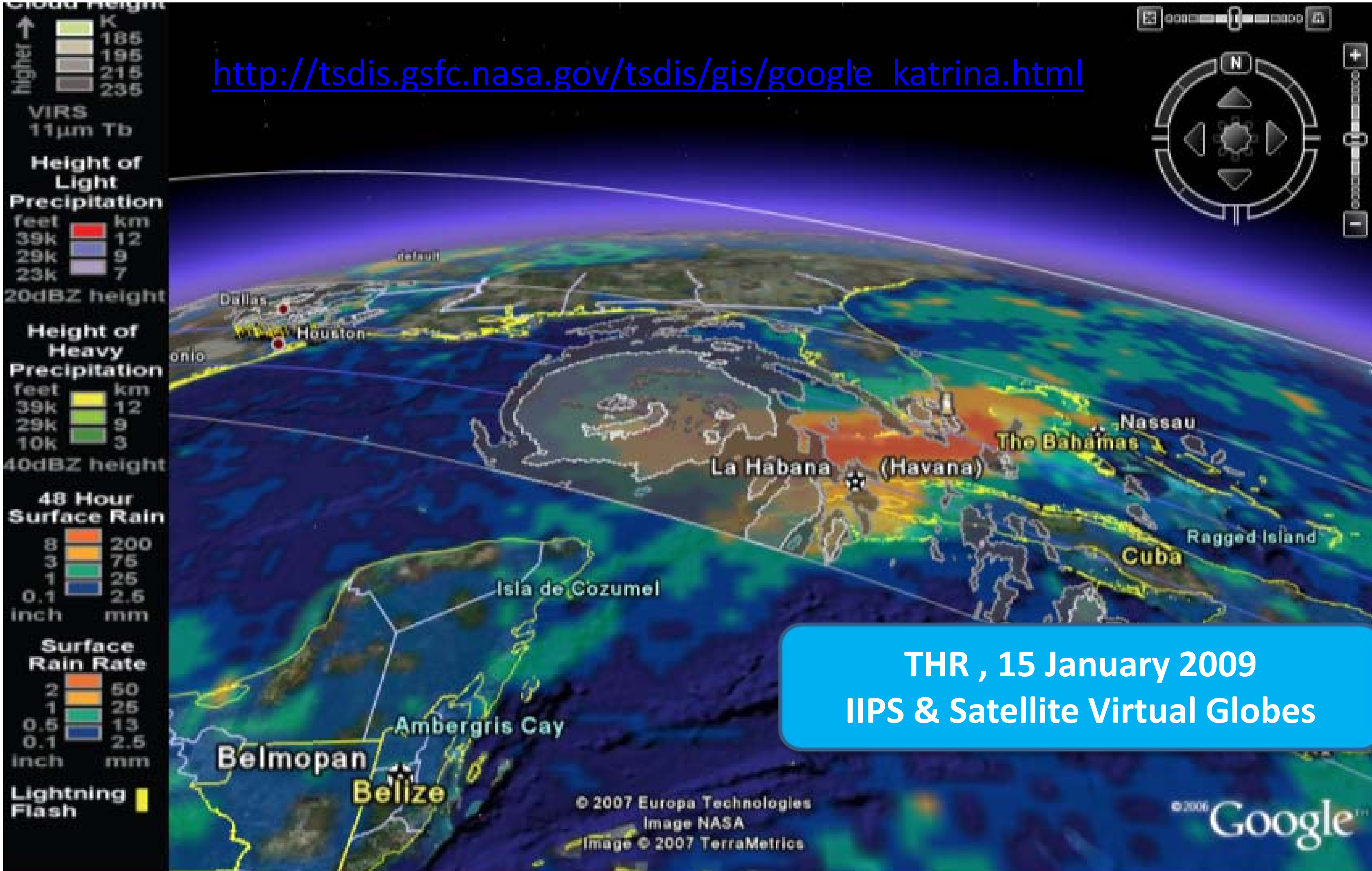


Summary

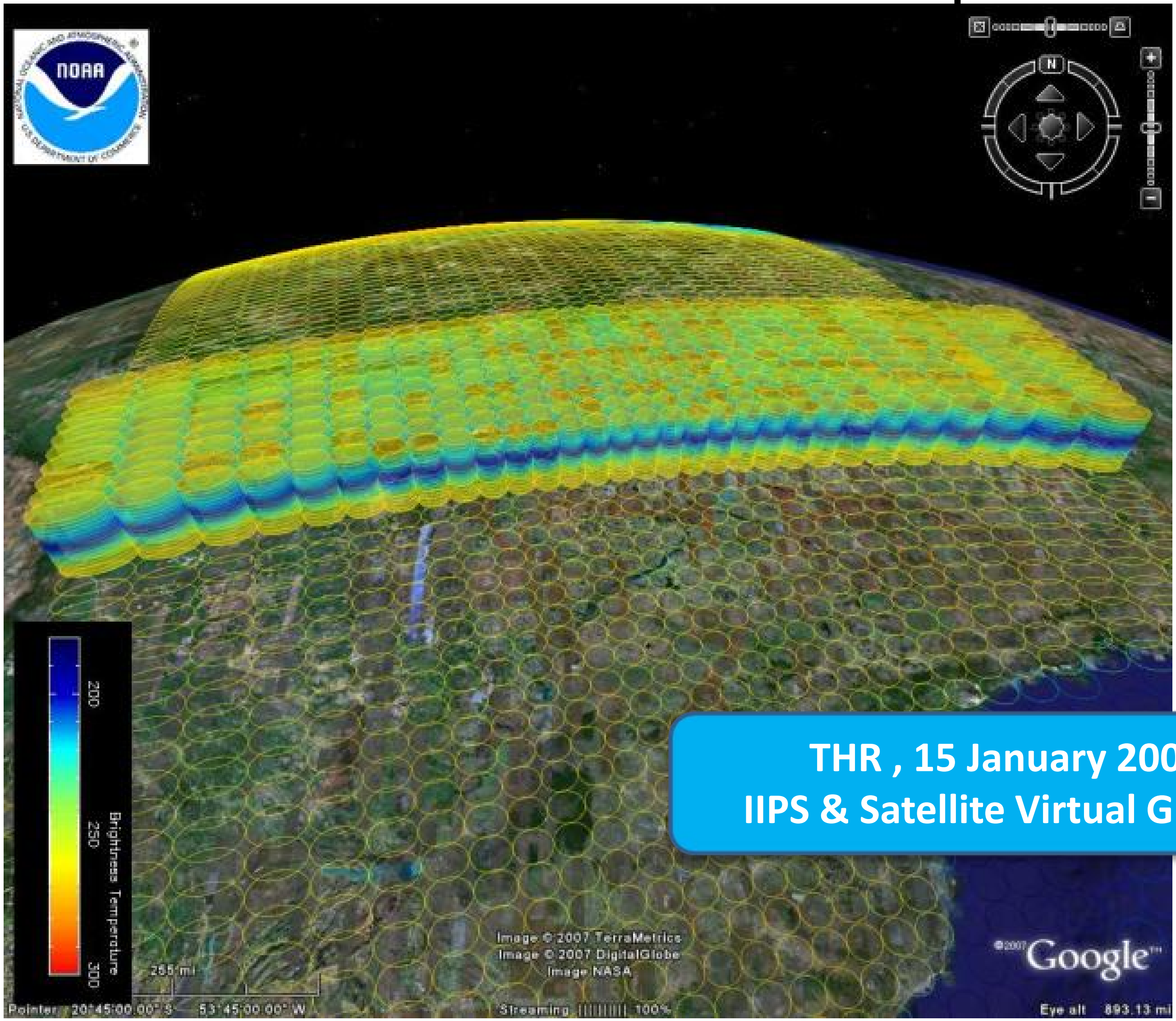
- Google Earth renders airborne lidar data
  - profiles, cross sections, shot arrays, etc.
  - displays correlative data
  - easy to use, low in cost
- Real-time functions demonstrated
  - GE API demonstrated
  - GE does NOT require internet
  - query functions (GIS) feasible
- http://www.swa.com/ald/ILIMMS
- GE excellent for Space-Based applications

Space-Based Application

TRMM – Owen Kelley



Space-Based Applications
AMSU Profiles – Tom Kleespies



THR , 15 January 2009
IIPS & Satellite Virtual Globes