Climate and Weather Sensors on Iridium-NEXT

A Combined GPS-RO and WindCam System for PBL Remote Sensing

Dong L. Wu, Anthony J. Mannucci, Feiqin Xie, Chi O. Ao, David J. Diner, and Joao P. Teixeira

Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA

© 2011 California Institute of Technology. Government sponsorship acknowledged.

Synergy of GPS RO, WindCam, and ??? on *I-Train*

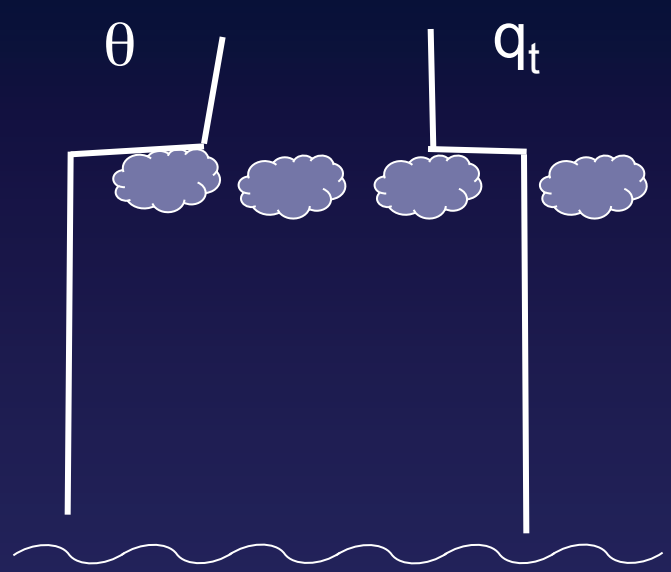
- Climate
  - PBL cloud, humidity, height, and winds
  - Climate monitoring (e.g., Temperature and humidity)
  - Clouds dynamics and feedback processes
- Weather
  - Severe weather forecast (e.g. Tropical cyclone and convection)
  - Dispersion of pollutants and toxic/trace gases (e.g., CO2) in PBL

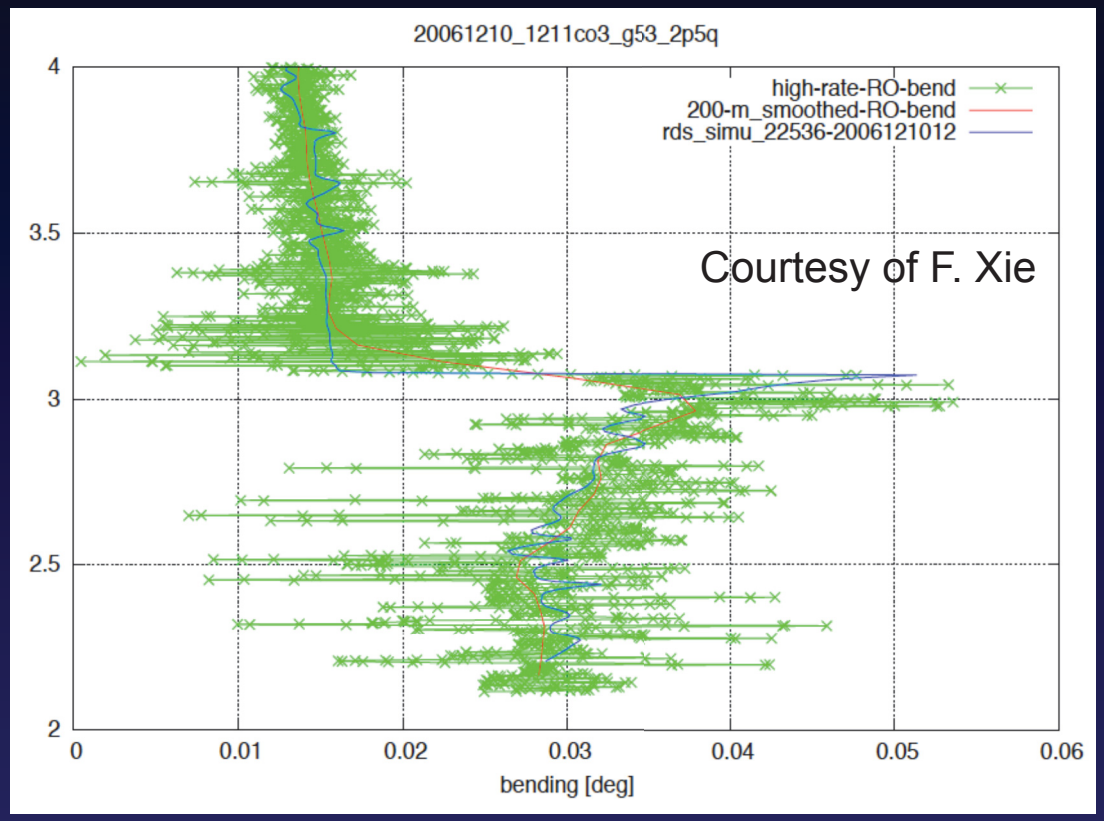
- Challenges for PBL remote sensing
  - Technical readiness
  - Vertical resolution: ~100 m
  - Horizontal resolution: 100-1000 m
  - Shallow layer, diurnal cycle, and global coverage

GPS RO:
A Limb Technique
for PBL Height and Humidity

GPS RO: High Vertical Resolution

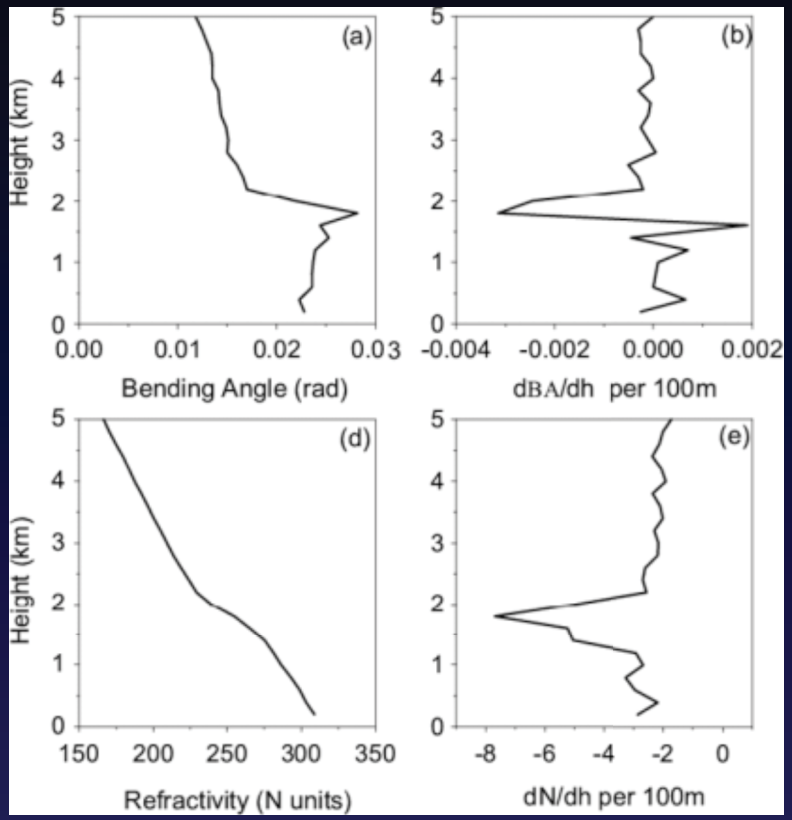
- Enhanced reflectivity sensitivity to PBL inversion
- 50 Hz (~20 m) sampling
- Insensitive to clouds
- Day and night

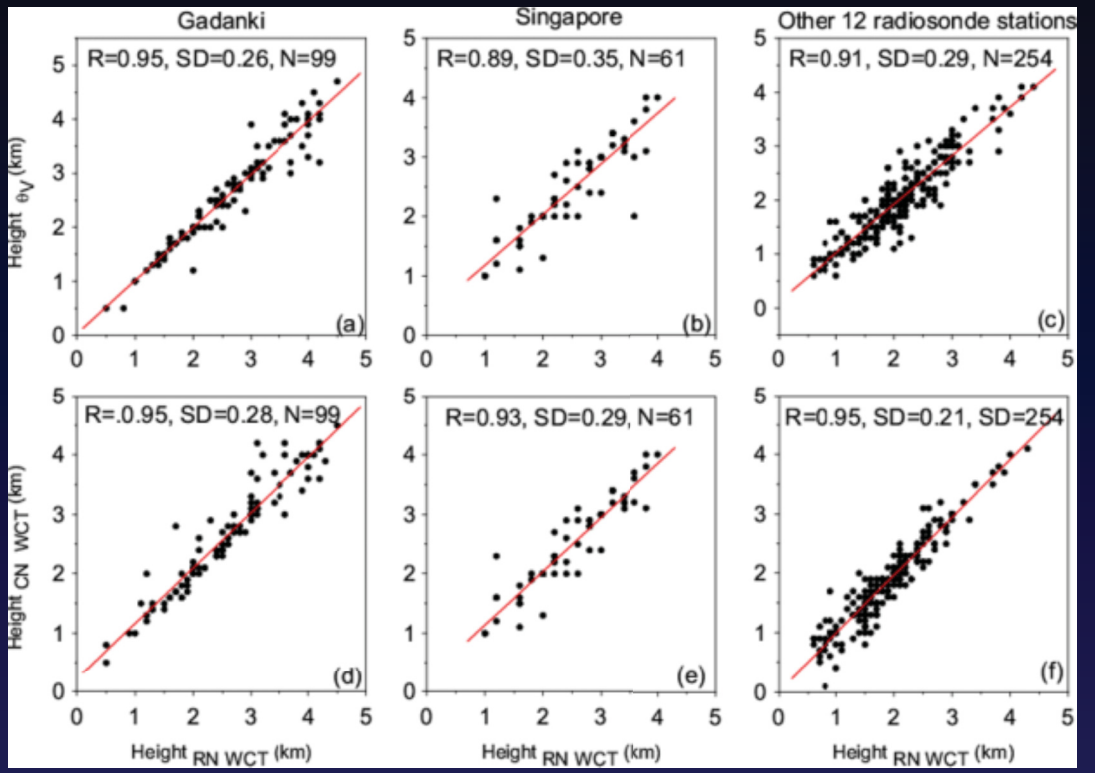




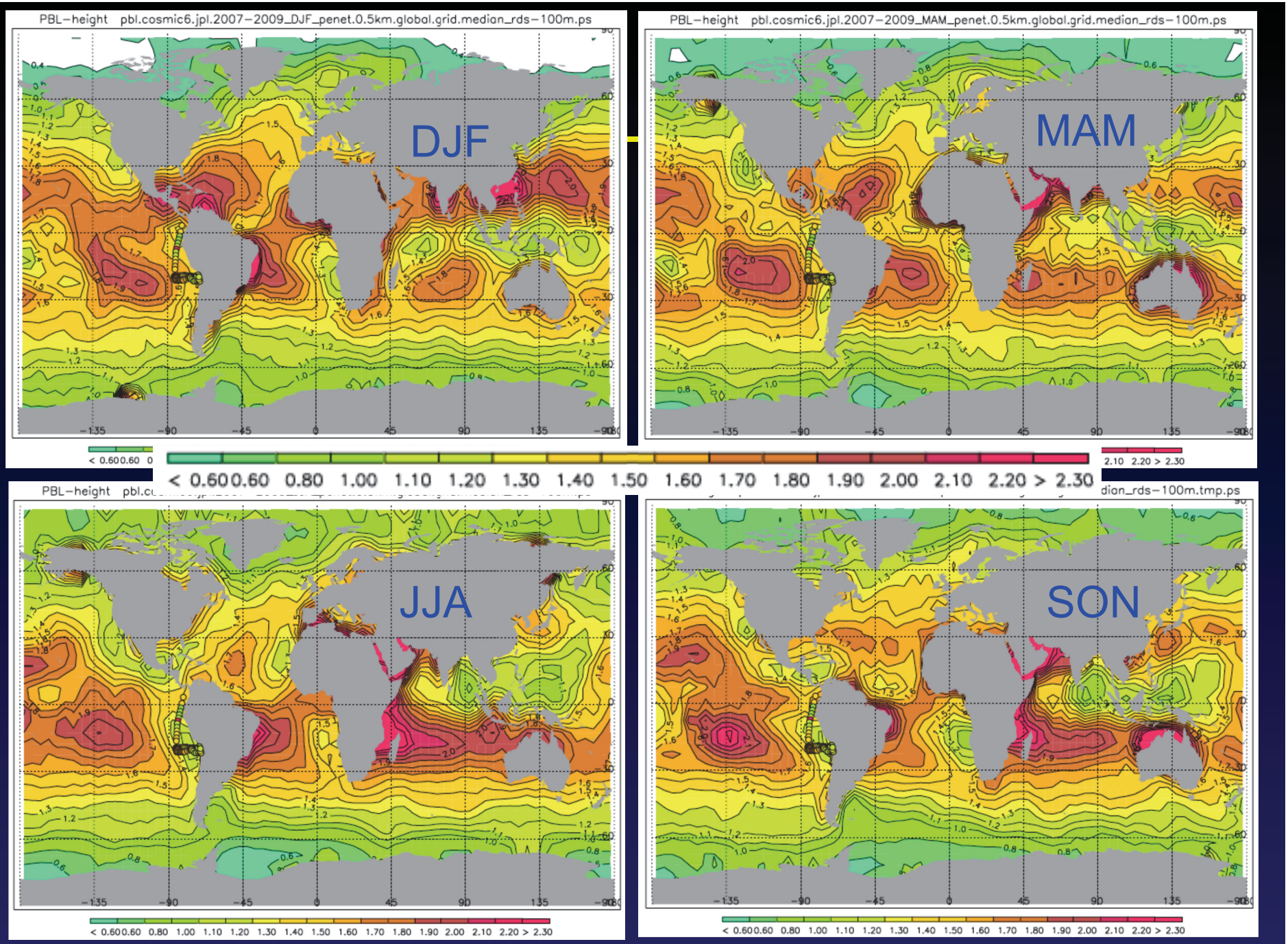
Bending angle (Deg)

PBL Top





Ratnam and Basha [2010]

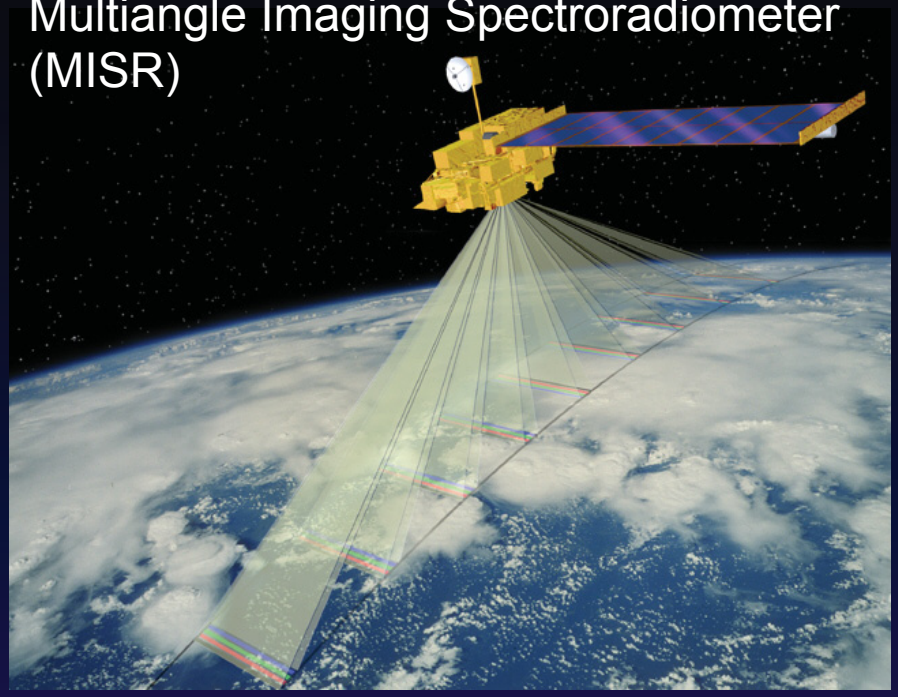


Courtesy of F. Xie

WindCam:
A Stereo Technique
for Cloud Height and Winds

Stereoscopic Viewing Technique

Multiangle Imaging Spectroradiometer (MISR)



9 view angles at Earth surface:
Nadir ±26º, ±46º,±60º, ±70º

4 bands at each angle:
446, 558, 672, 866 nm

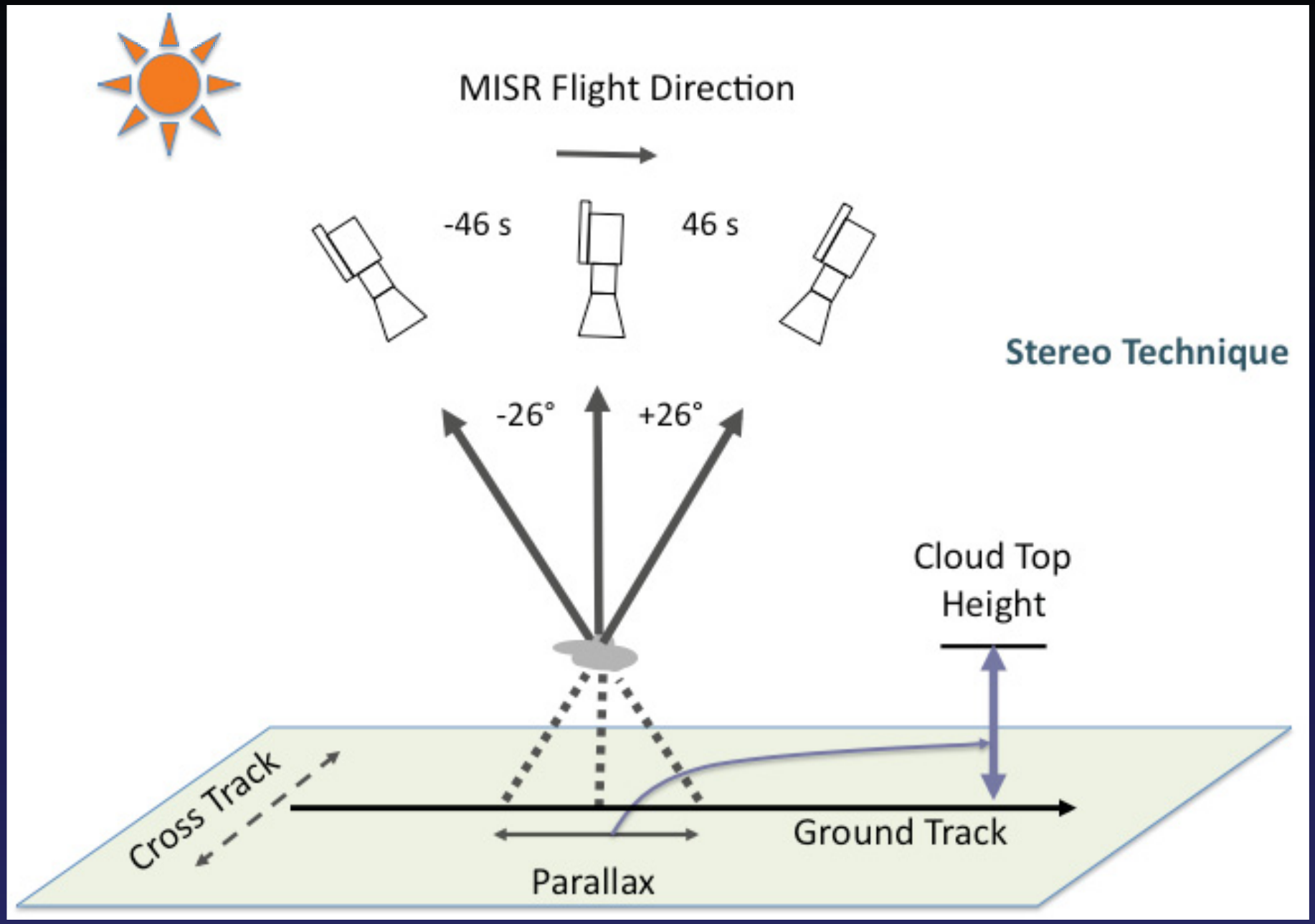
Daylight pole-to-pole coverage with 400-km swath

275 m - 1.1 km resolution

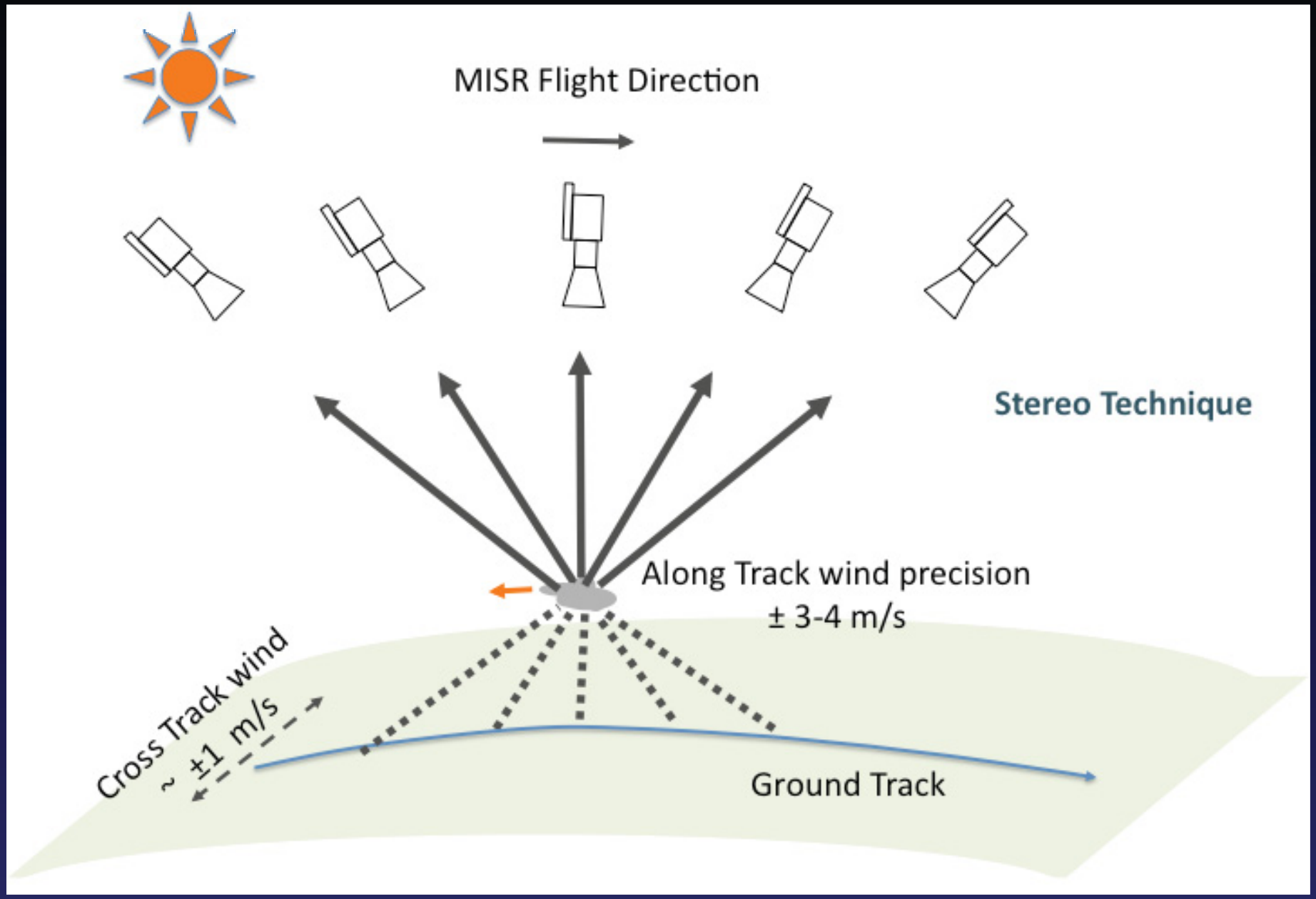
7 minutes to observe each scene at all 9 angles

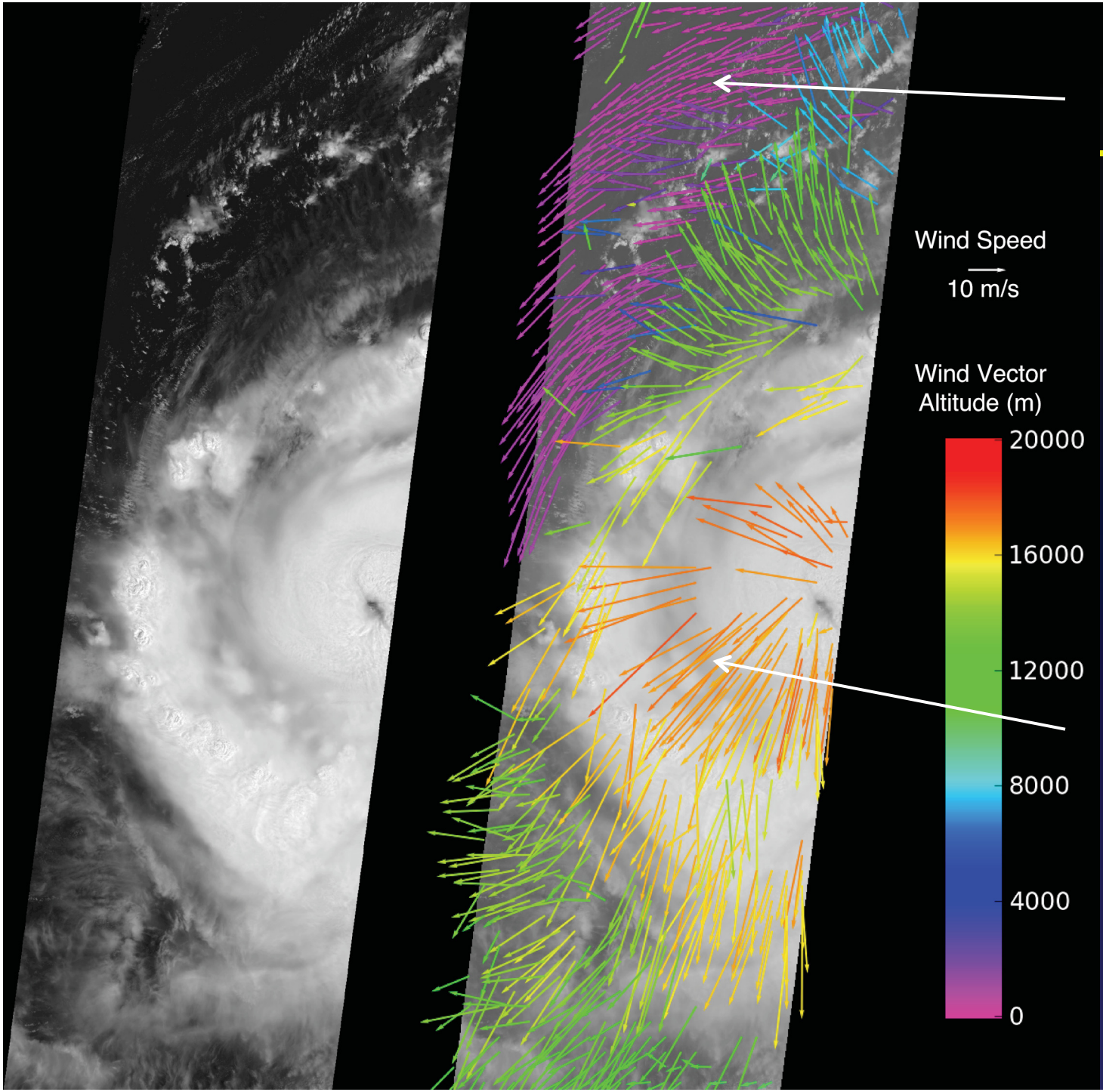
Global data since March 2000

MISR High-Resolution Cloud Top Height and Winds



MISR High-Resolution Cloud Top Height and Winds





Boundary layer wind field

Hurricane Earl
8/30/2010

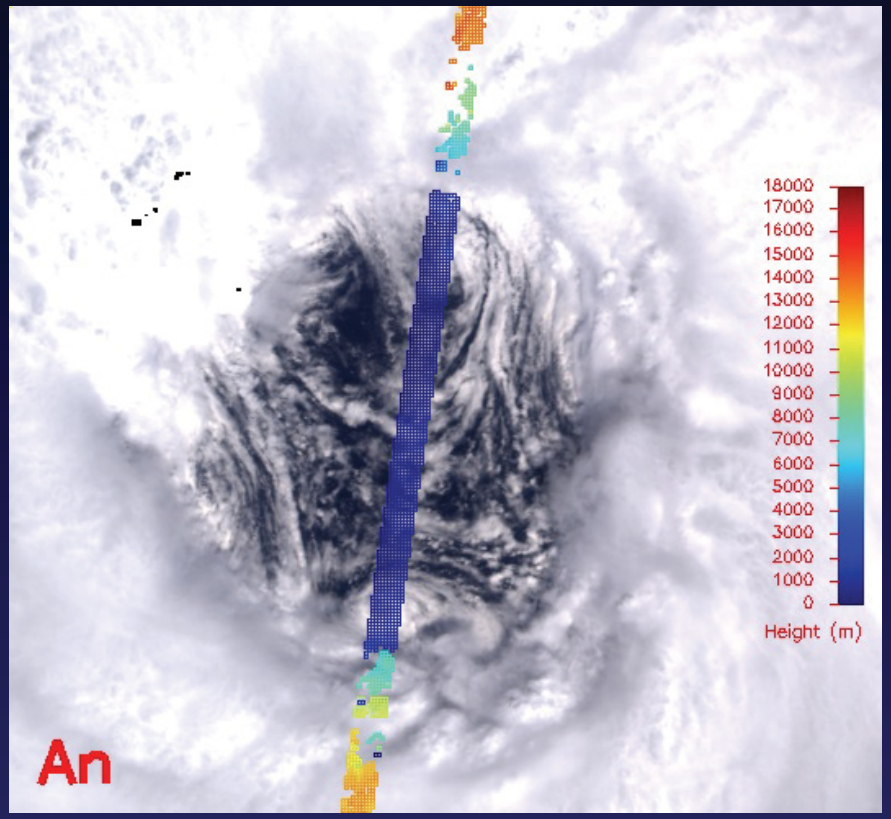
(orbit 37285)

High-level outflow

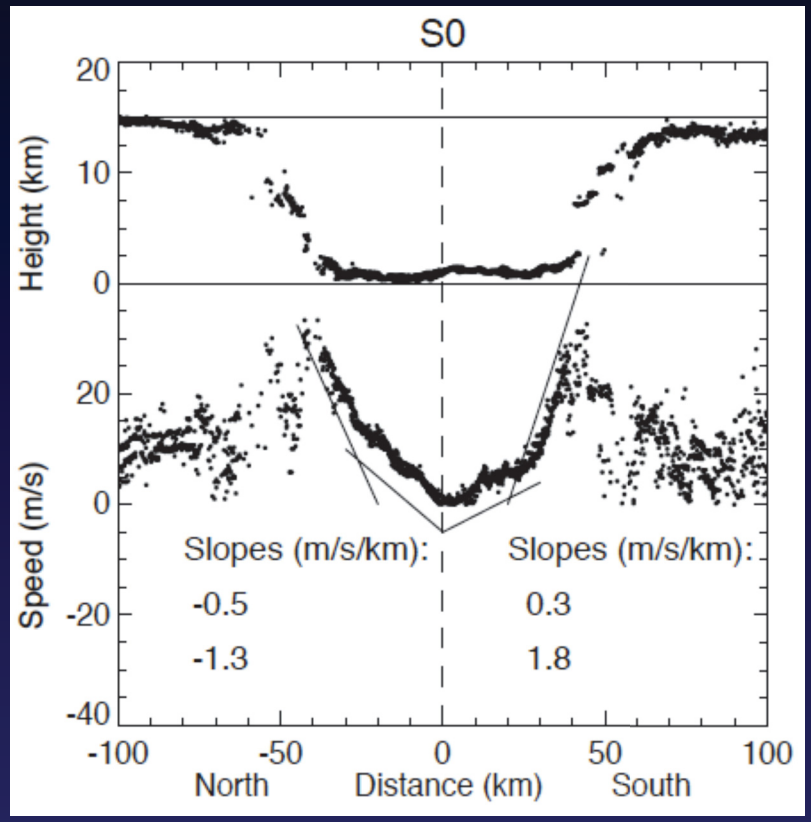
Courtesy of Kevin Mueller

Boundary-Layer Clouds inside Tropical Cyclone's Eye

- Tangential wind speed at 1.1 km resolution
- Detailed angular rotation and structures
- Monitoring and forecasting cyclone intensity



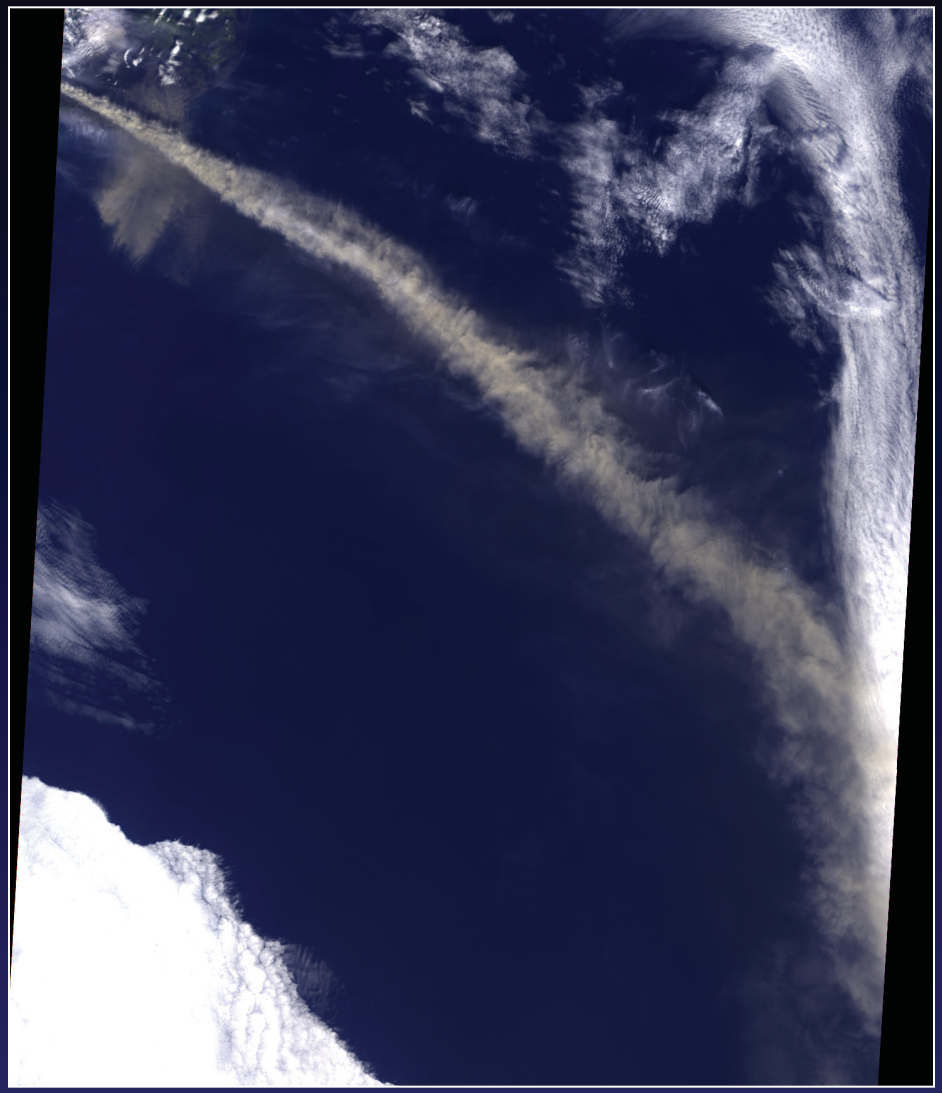
Hurricane Alberto (2000)

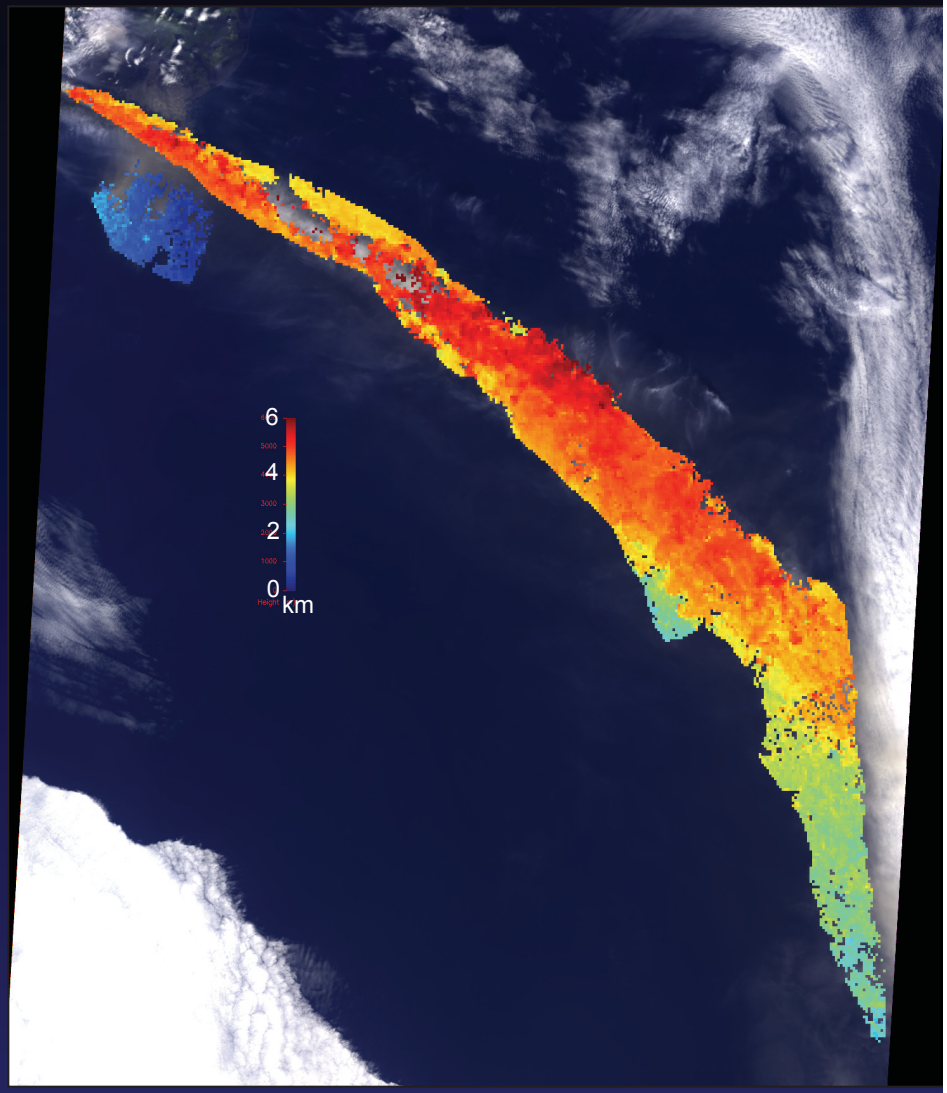


Radial Distance from Center (km)

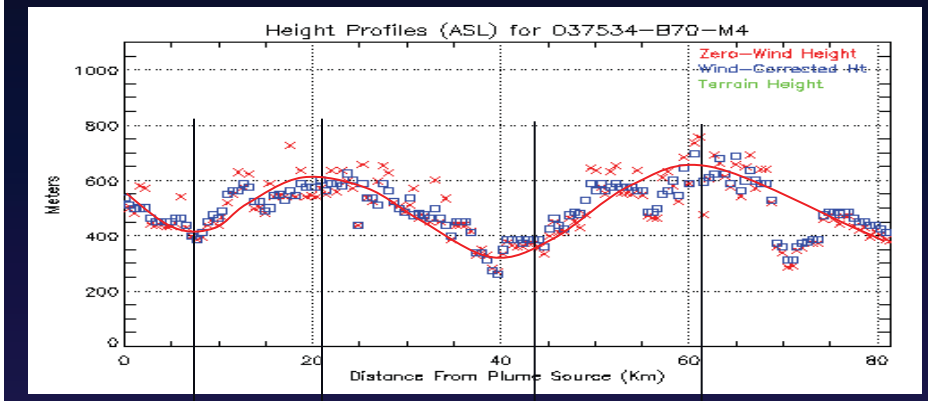
MISR Stereo-Derived Ash Plume Heights

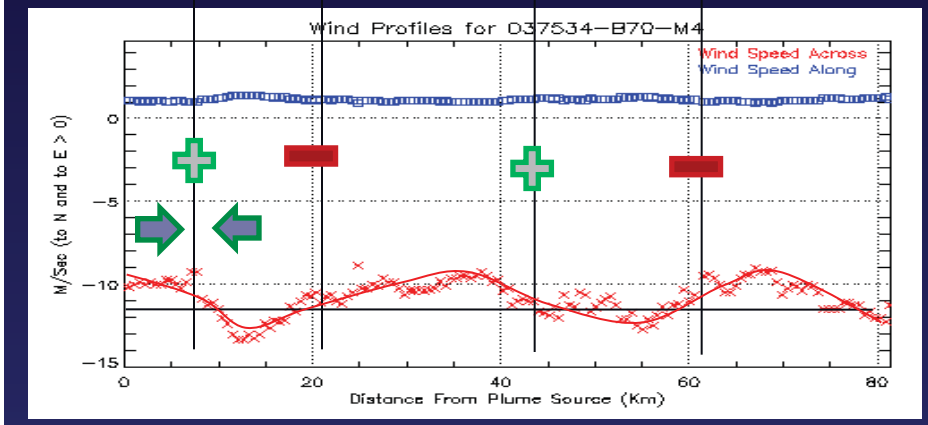
Eyjafjalljökull Volcano – May 07, 2010





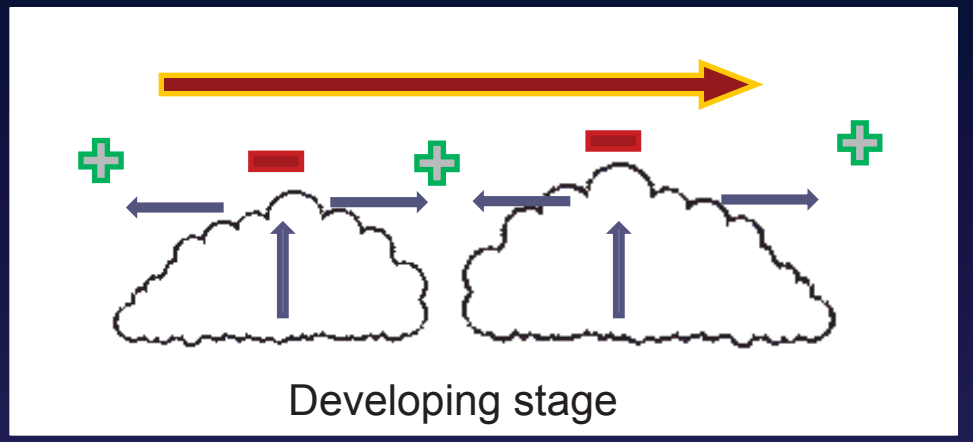
PBL Height-Wind Relationship





Courtesy of Matt Scholes

- What is the correlation between cloud top height and the wind divergence?
- How are cellular structures related to wind convergence/divergence?
- What determine cloud height variations?

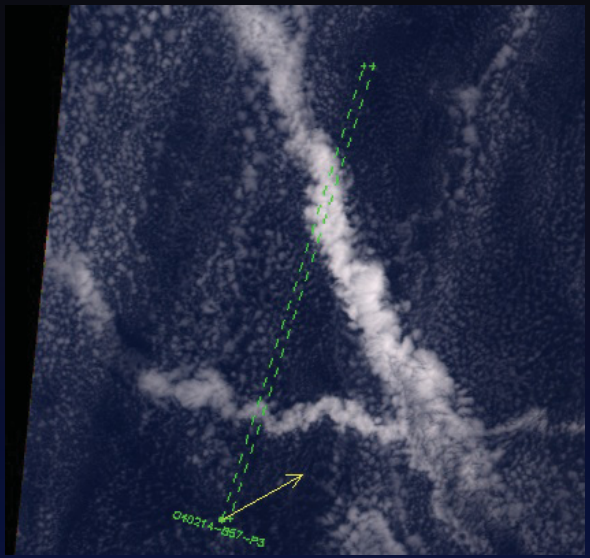


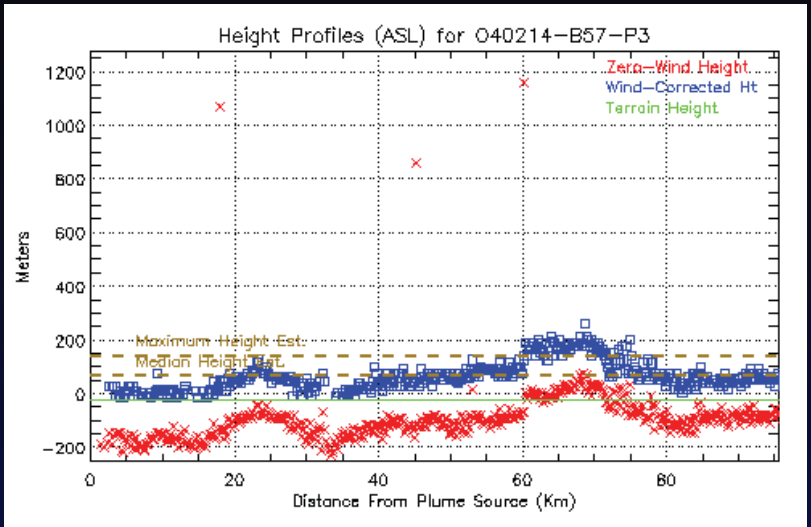
Wind Con/Divergence
Background wind
Relative motion

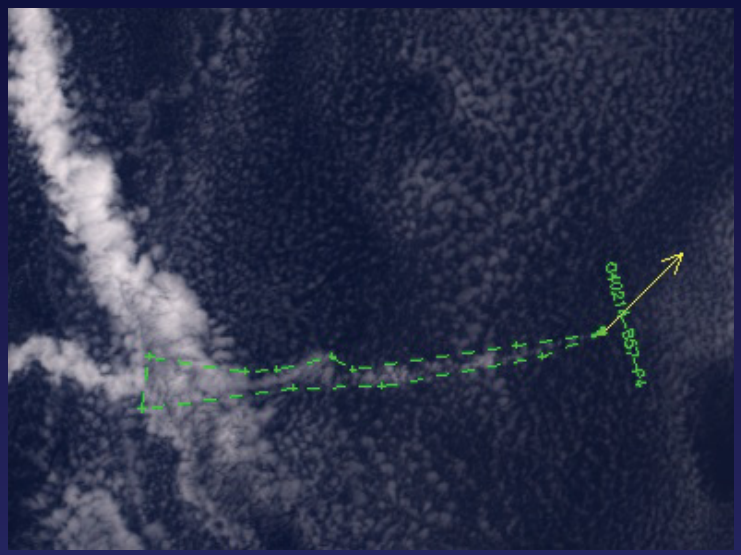
Clouds from Ship Tracks (Aerosol-Cloud Interactions)

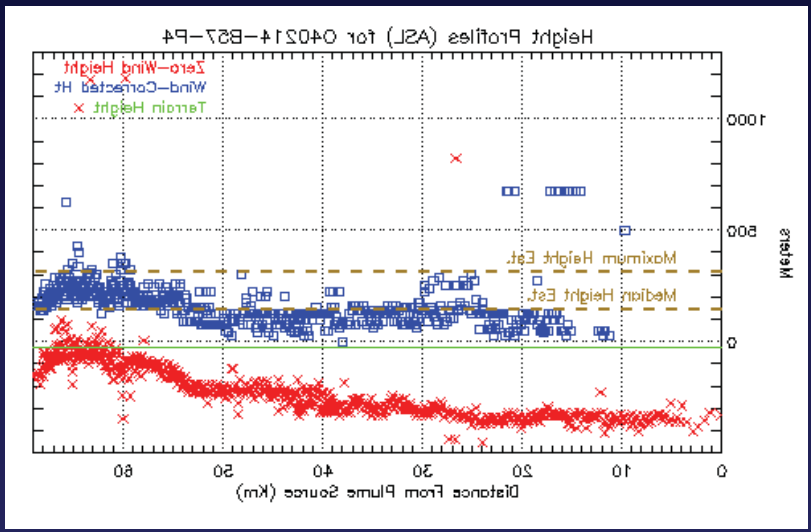
Height Precision:

< 50 m

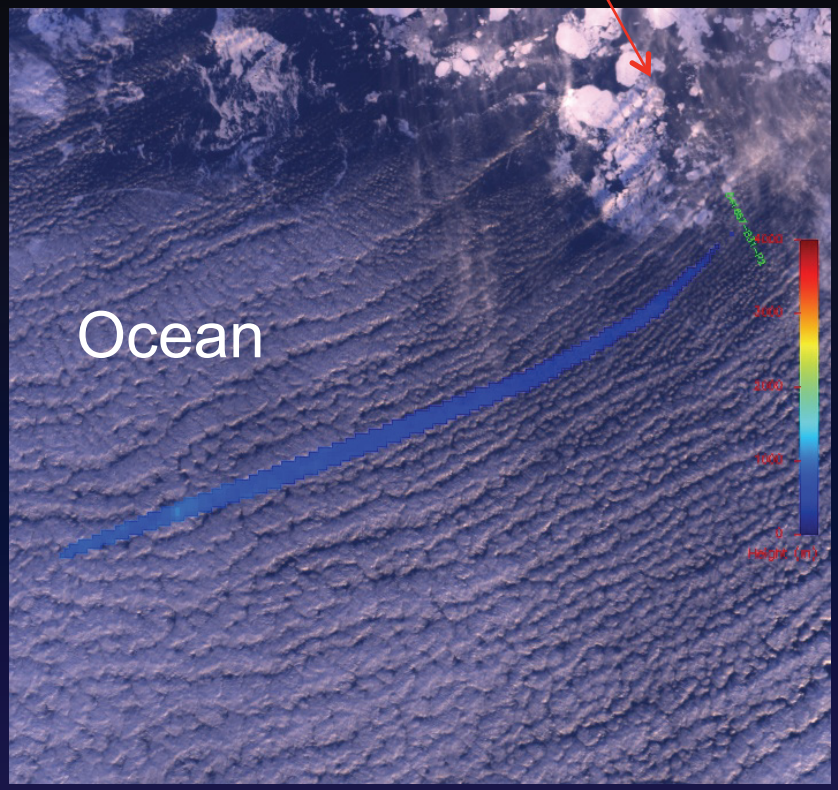


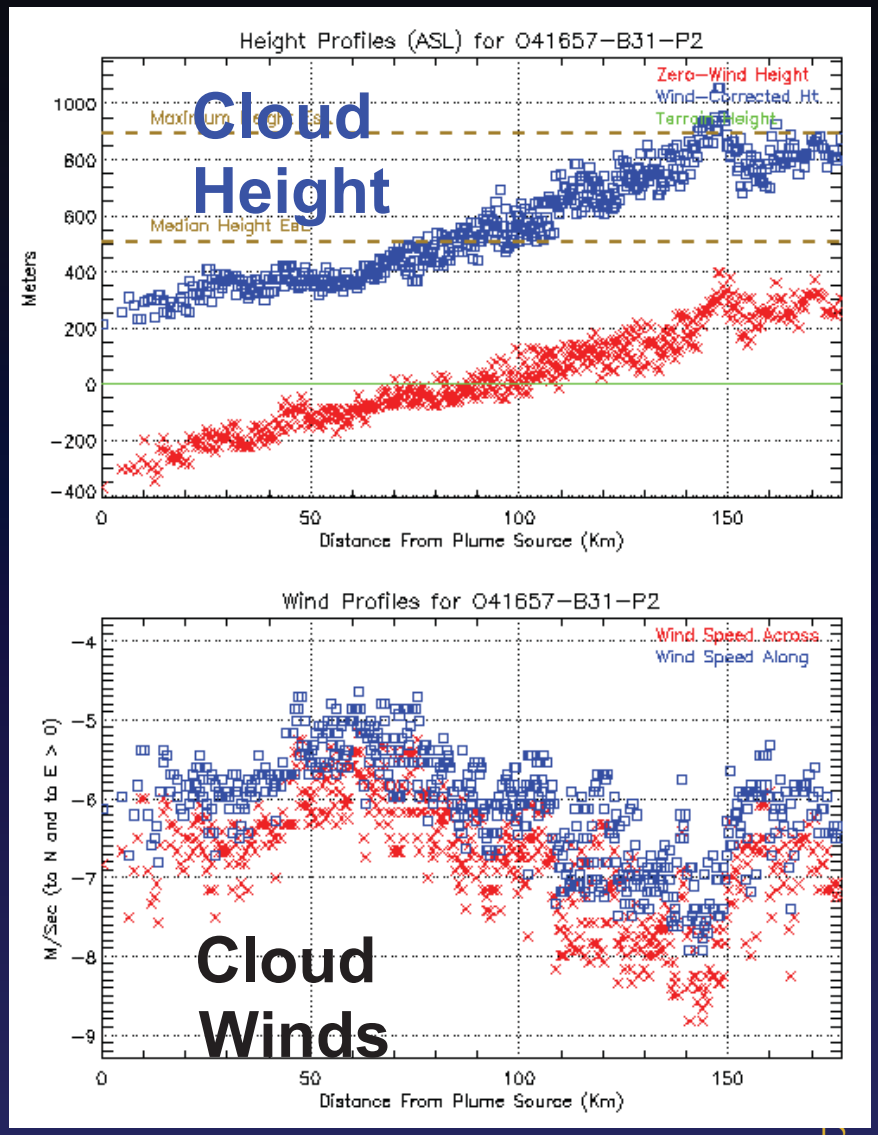






Arctic Roll Clouds



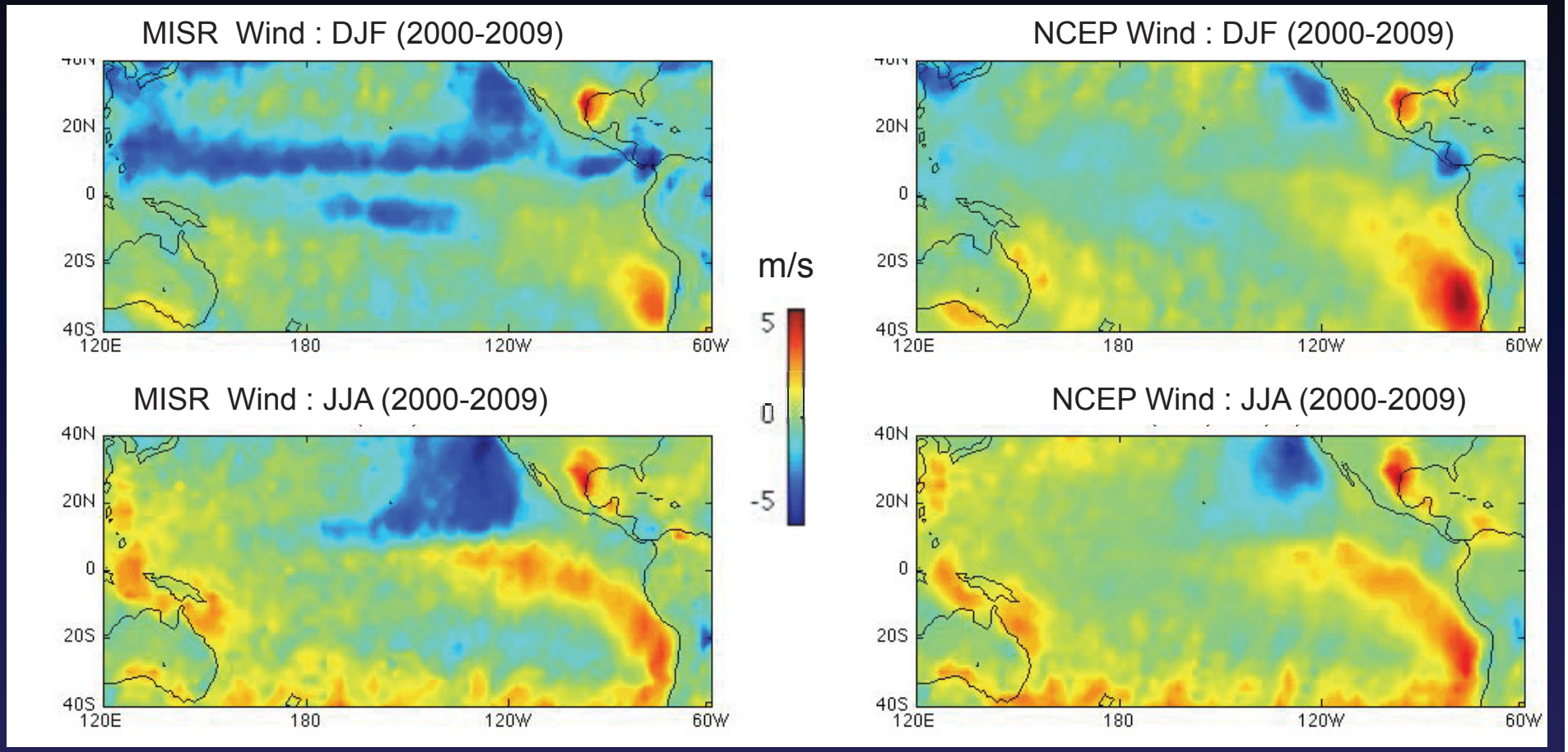


- Arctic cold air outbreak on Oct 17, 2007 over Beaufort Sea
- Cloud rolls originated from sea ice edge
- Retrievals from MINX showing cloud height increases from 200 m to 800 m in 150 km with increasing wind speed

Meridional Winds

MISR (0-3 km)

NCEP/NCAR reanalysis (0-3 km)



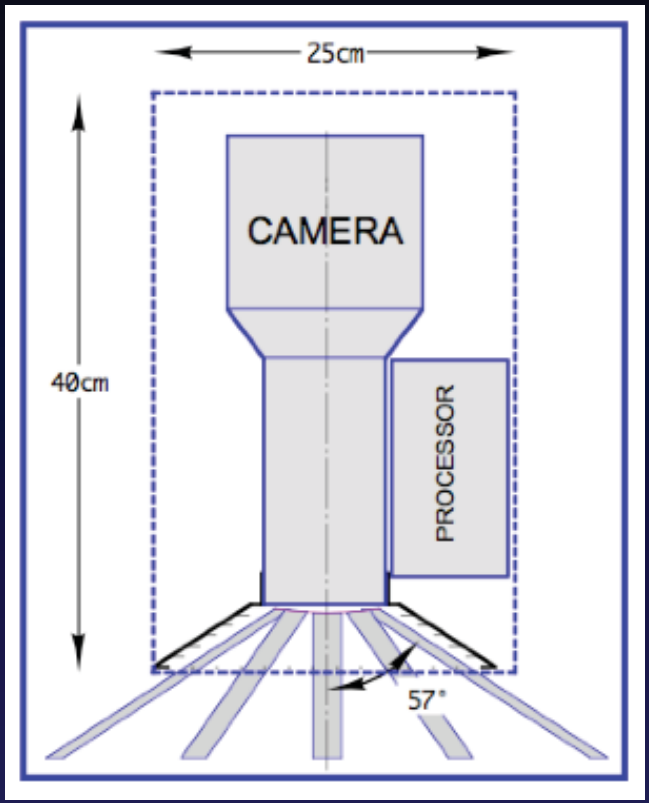
Courtesy of Jae N. Lee

WindCam: A Concept for Small Satellite

MISR	WindCam
9 narrow angle cameras, 4 VNIR bands	1 wide angle camera, 1 red band
View angles: Nadir, 26º, 46º, 60º, 70º	View angles: Nadir, 40º, 60º, 70º
Resolution preserved by varying the camera focal lengths vs. angle	Resolution preserved by varying the detector sizes vs. angle
Mass: 150 kg Power: 75 W Data rate: 7 Mbps	Mass: 17 kg Power: 23 W Data rate: <3 Mbps
Spatial resolution: 275 m 400 km swath Global coverage - 9 days	Spatial resolution: 250 m 1000 km swath Daily global coverage from 3 platforms

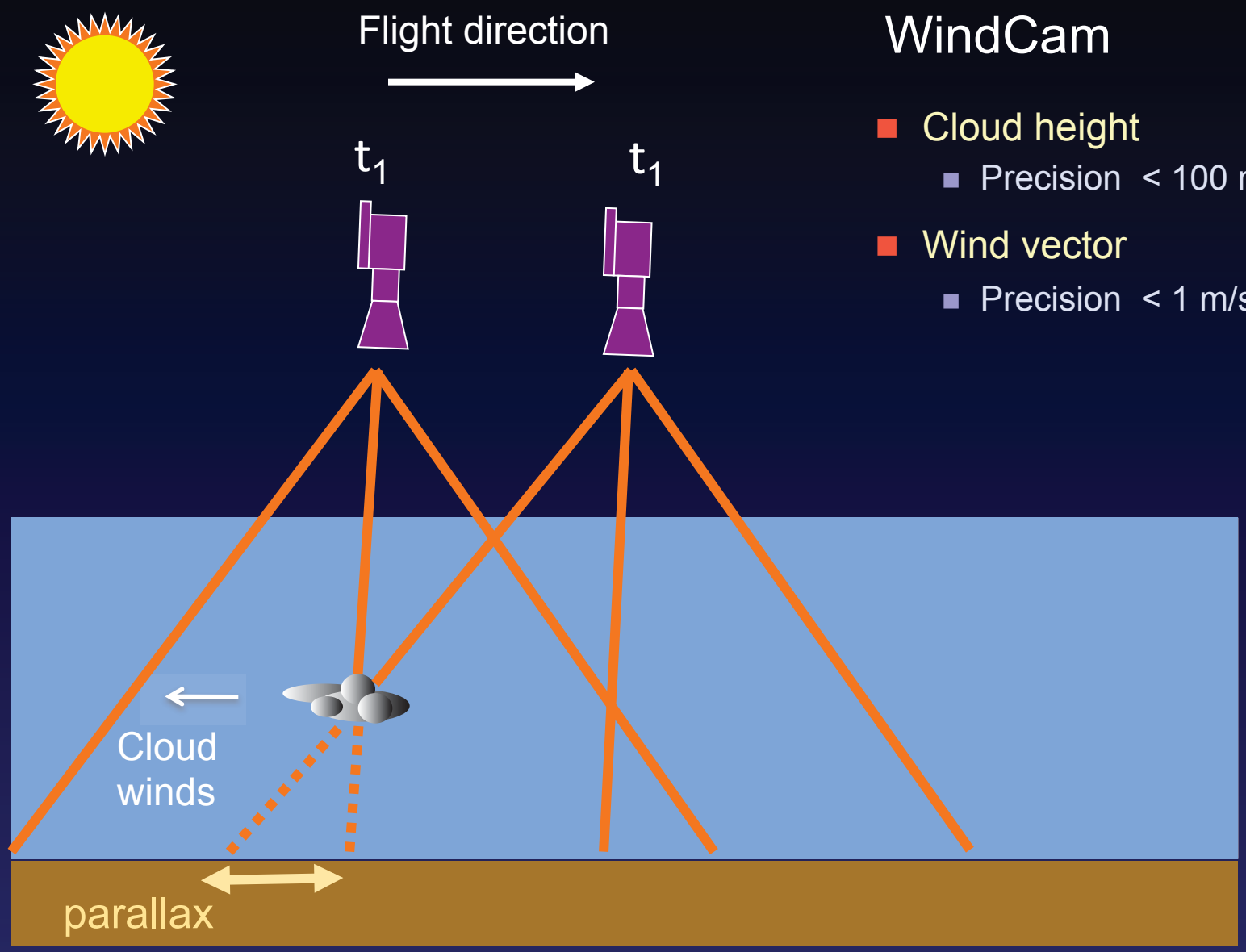
Diner et al. (2008)

WindCam



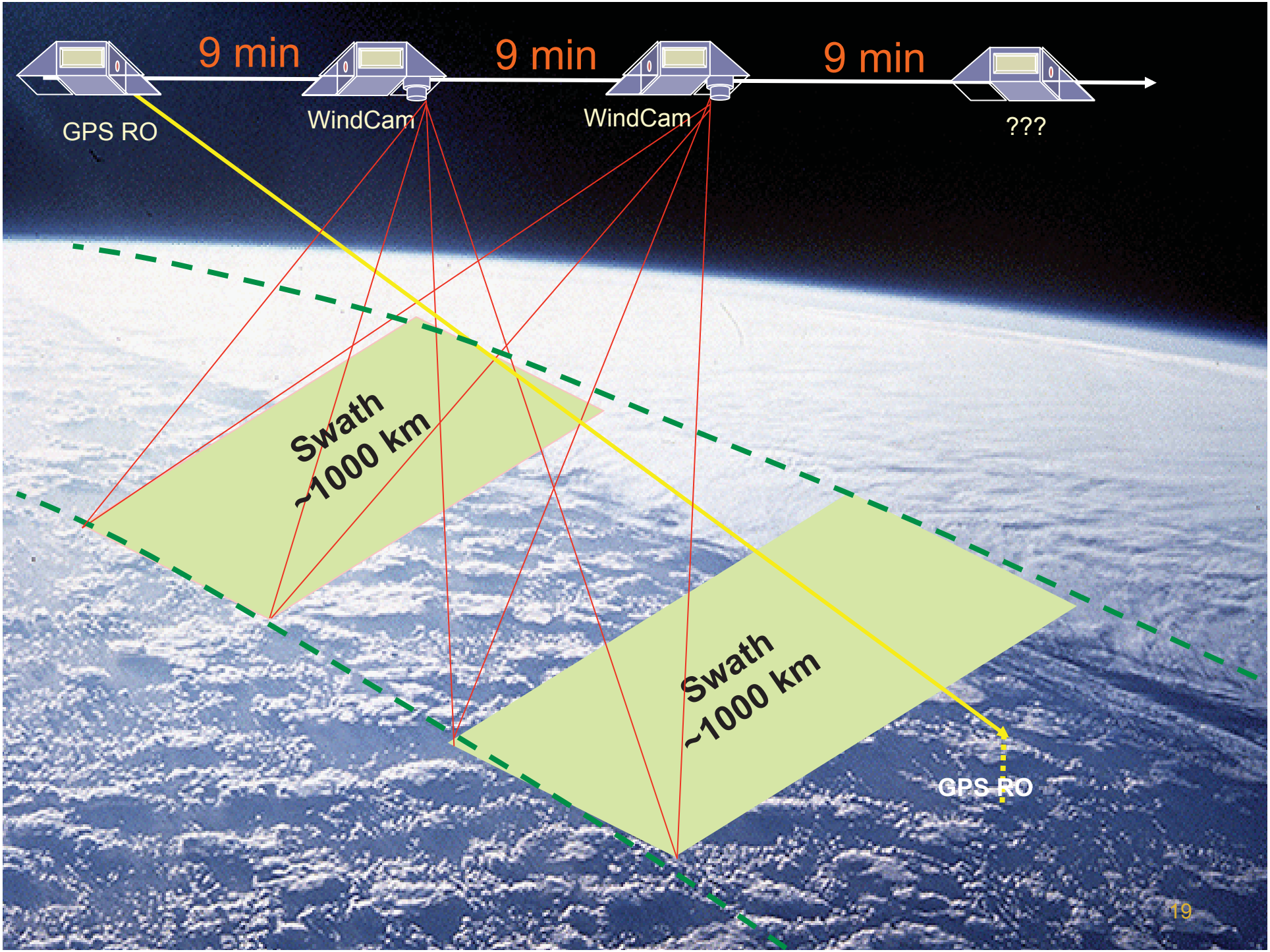
Flight direction

WindCam: Twin Satellite Formation

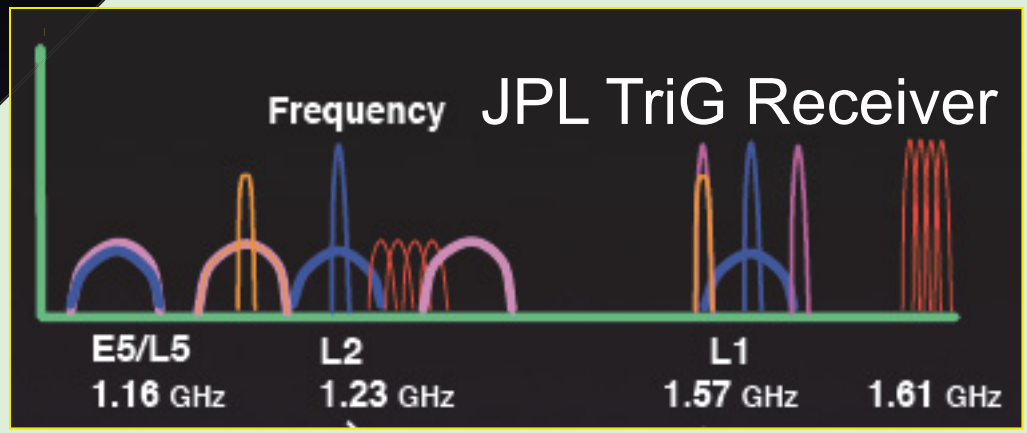


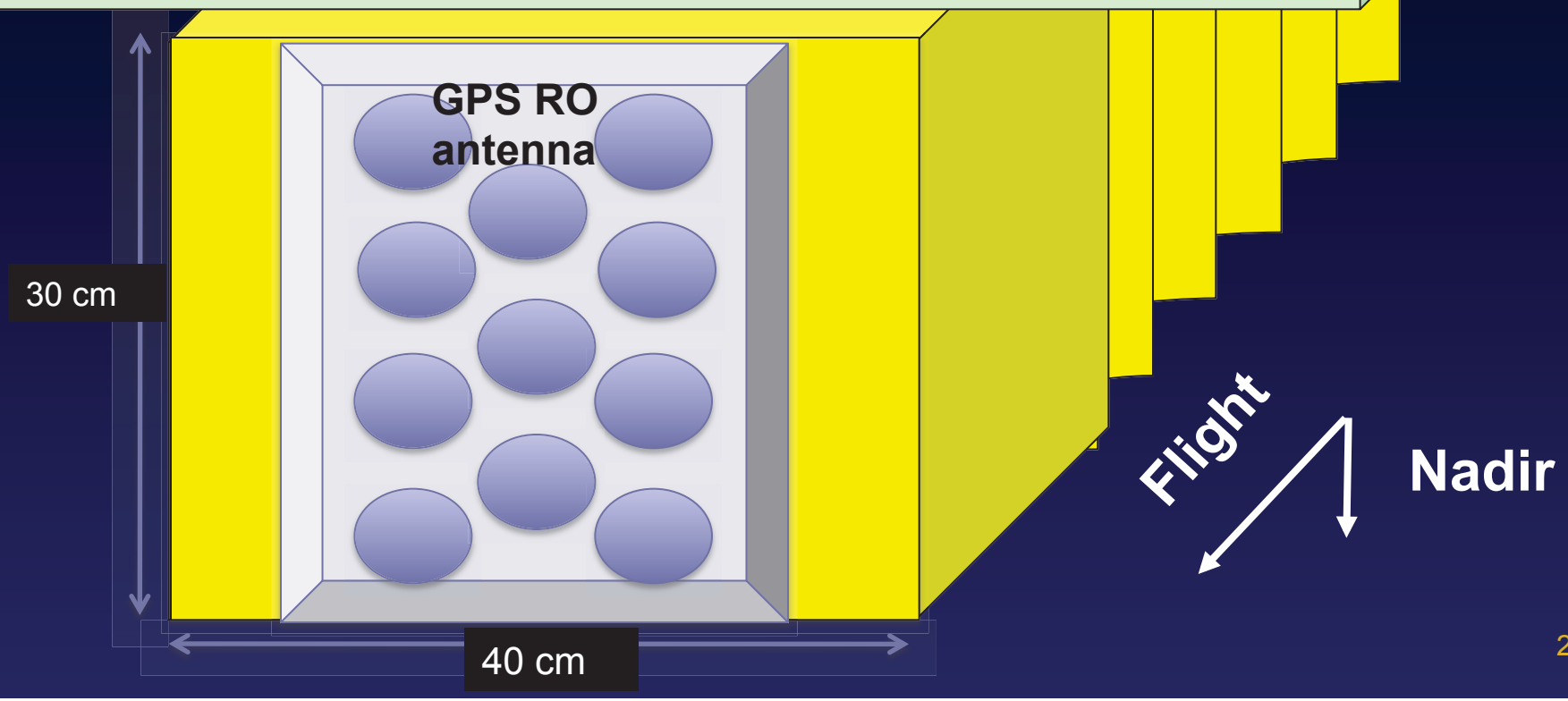
WindCam

- Cloud height
  - Precision < 100 m
- Wind vector
  - Precision < 1 m/s


9 min
9 min
9 min
GPS RO
WindCam
WindCam
???
Swath
~1000 km
Swath
~1000 km
GPS RO

GPS RO on Iridium-NEXT



Multi-freq tracking
High gain antenna
Mass: ~10 kg
Power: 10-35 W

Courtesy of Tom Meehan