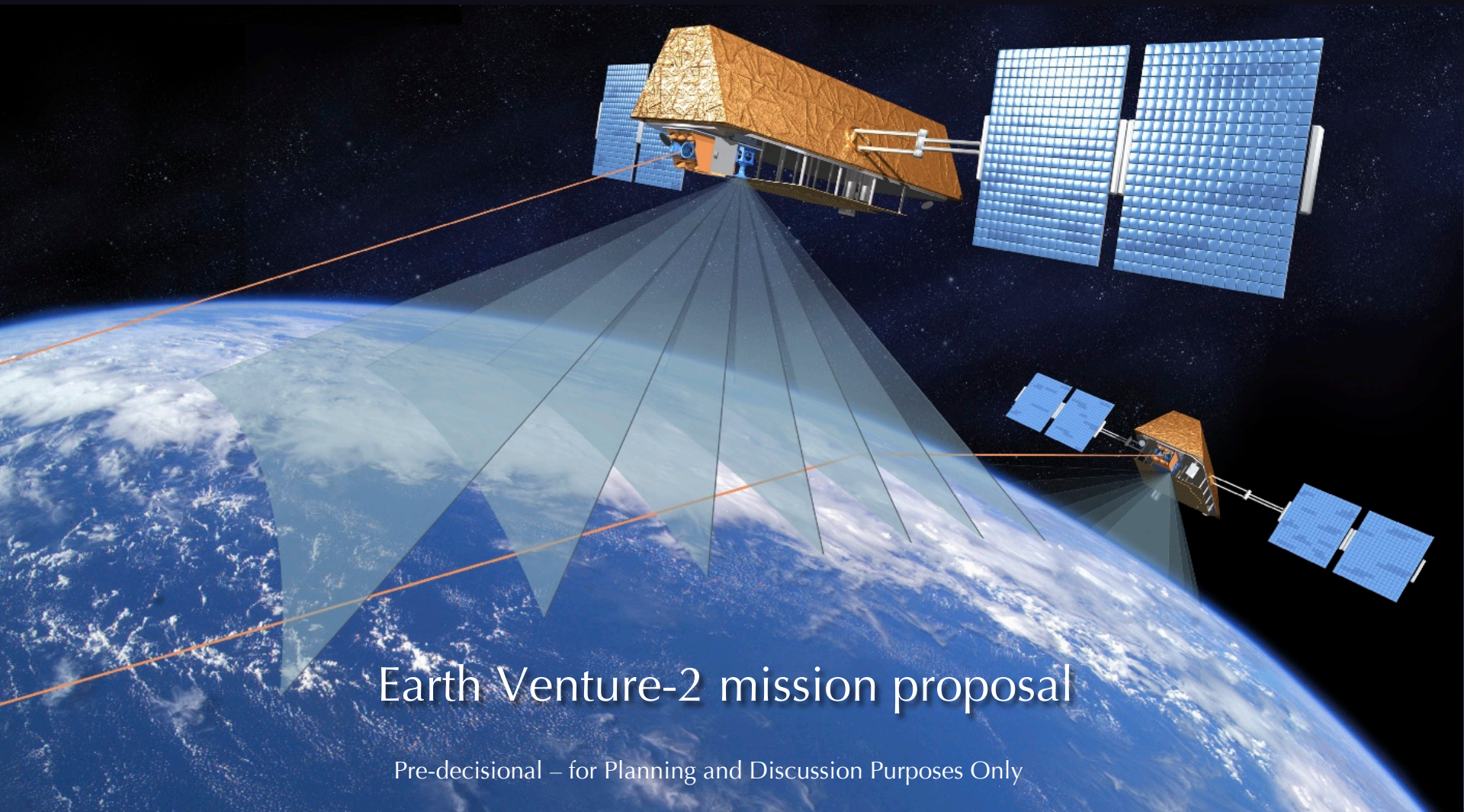
Spaceborne Atmospheric Boundary Layer Explorer (SABLE)

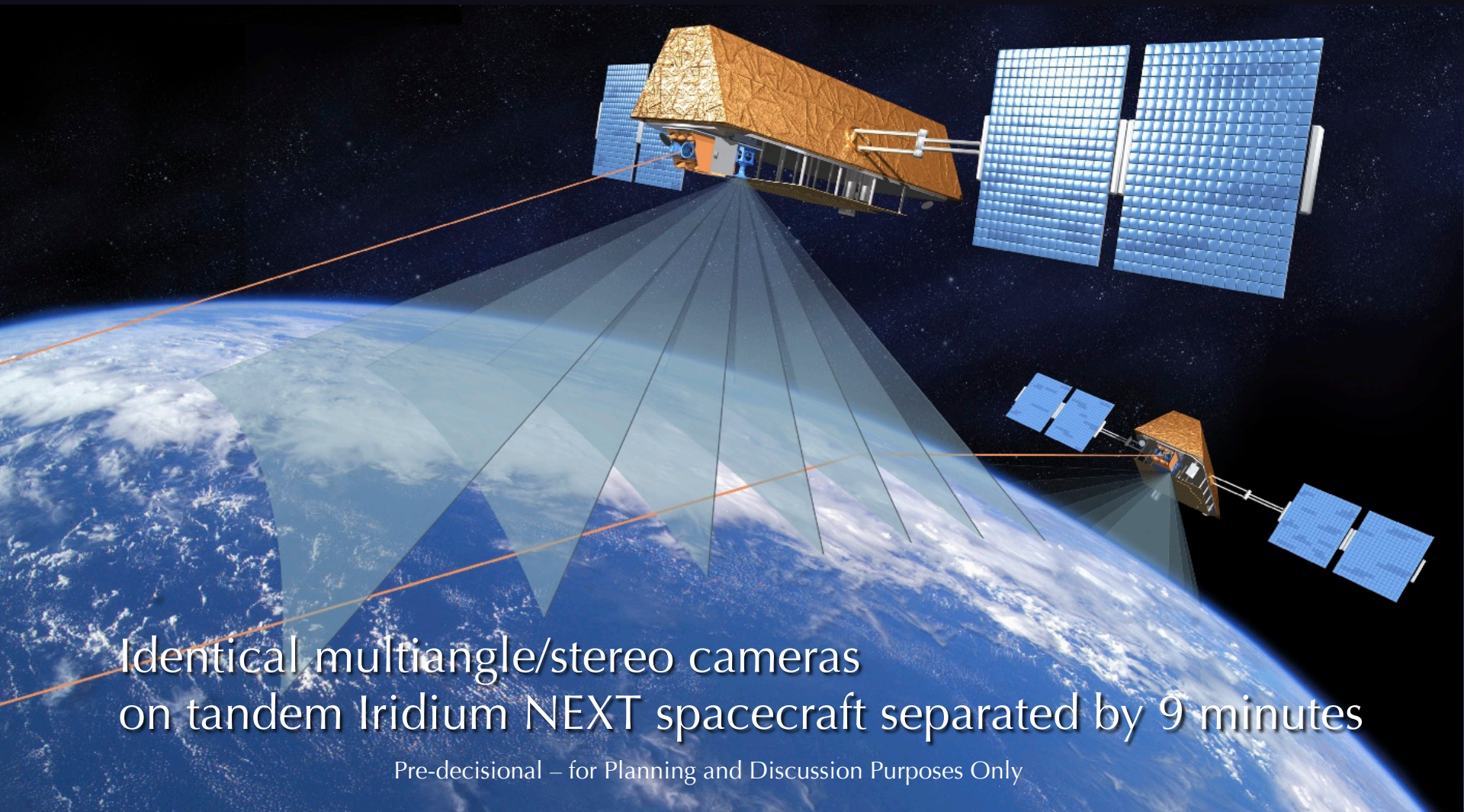


Earth Venture-2 mission proposal

Pre-decisional – for Planning and Discussion Purposes Only

Proposed SABLE objective:

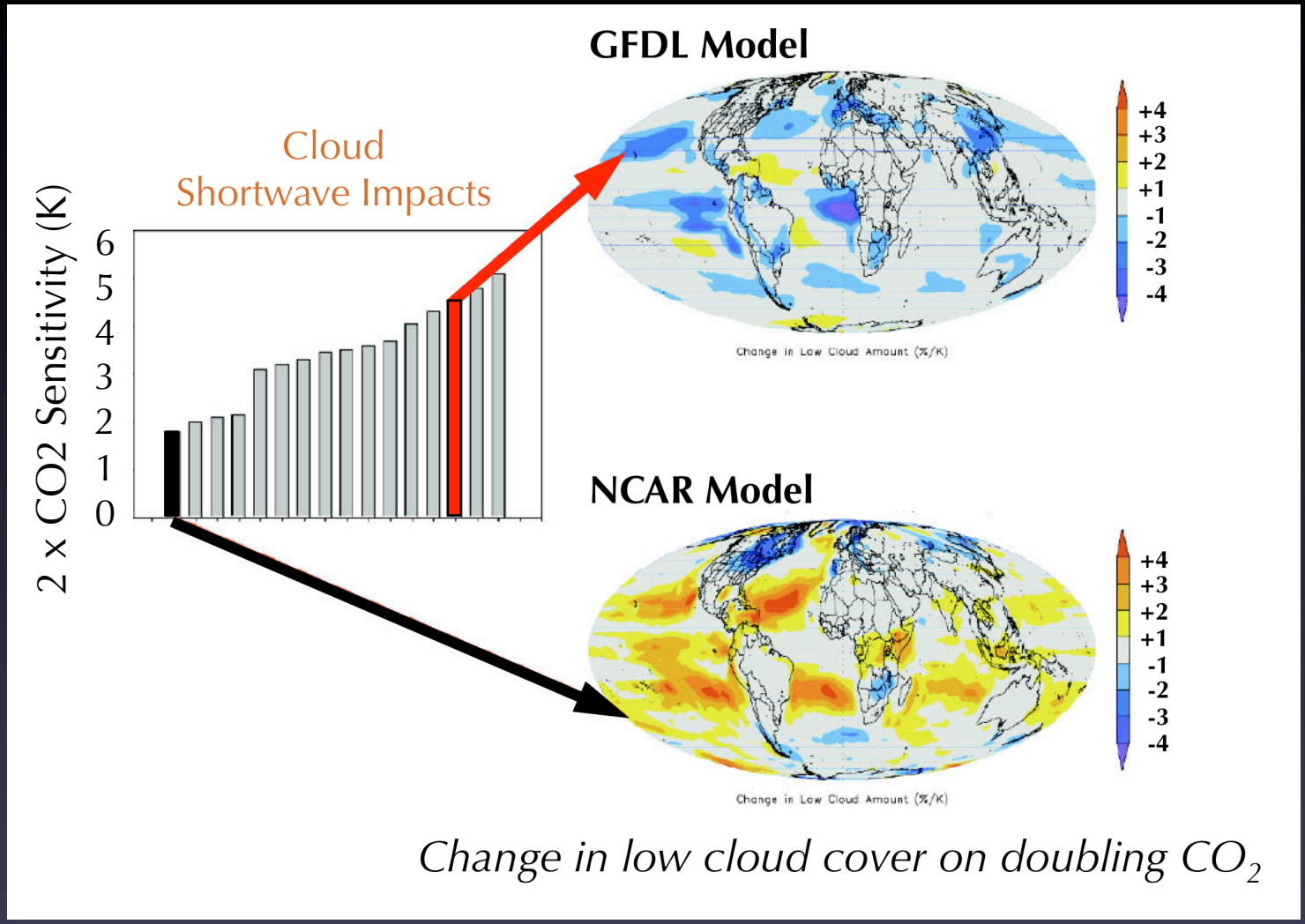
Measure cloud top heights and cloud top winds
to quantify and map cloud-top entrainment rate



Identical multiangle/stereo cameras
on tandem Iridium NEXT spacecraft separated by 9 minutes

"The shortwave impact of changes in boundary-layer clouds…constitutes the largest contributor to inter-model differences in global cloud feedbacks. The relatively poor simulation of these clouds in the present climate is a reason for some concern."

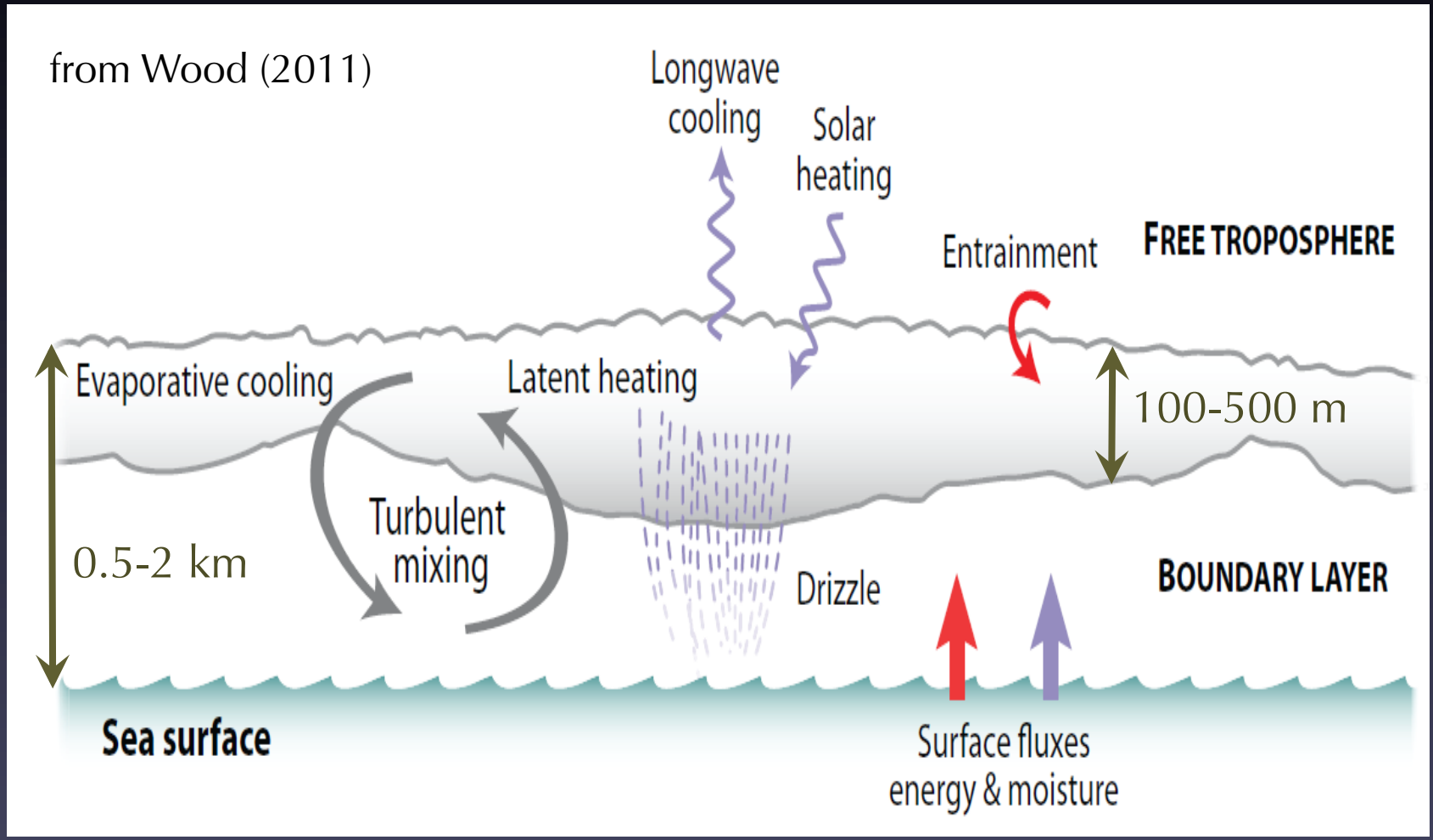
— IPCC 2007



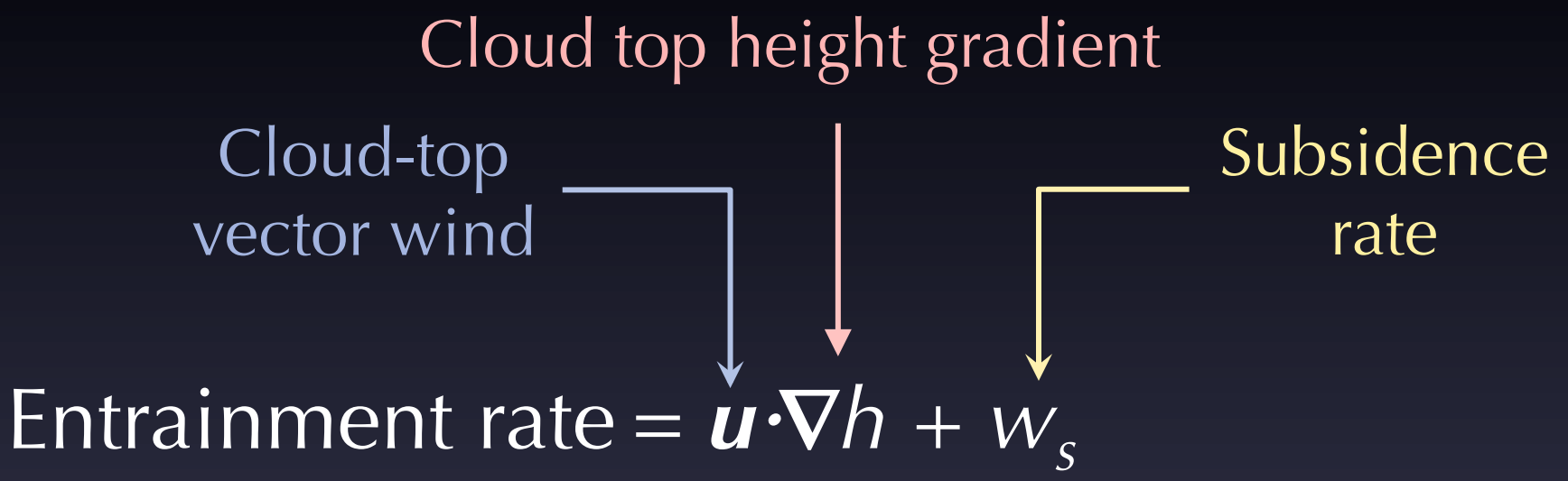
Stephens (2005) /B. Soden
Bony and Defresne (2005)

Entrainment rate:

The rate at which dry free-tropospheric air is incorporated into the moist ABL by turbulent mixing



Mass Balance Equation



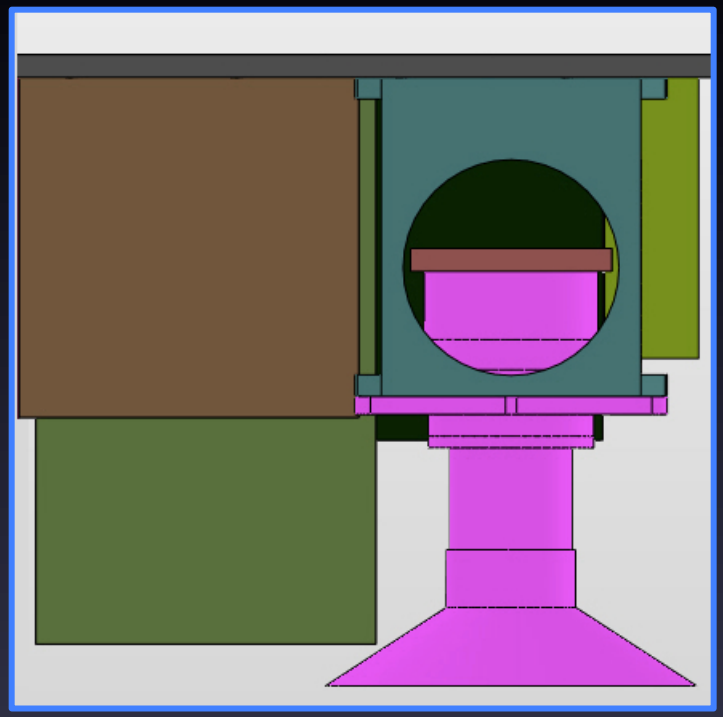
$$w_s = h\nabla\cdot\boldsymbol{u}$$

CTH, CTW, and their spatial gradients are derived from the dual StereoCam data

Proposed SABLE payload

StereoCam on each S/C would

- Measure CTH and horizontal and vertical CTW using time-lapse and stereo images
- Acquire 645 nm pushbroom imagery at 7 view angles up to ±60° at Earth surface
- 300 m resolution, 1400 km swath



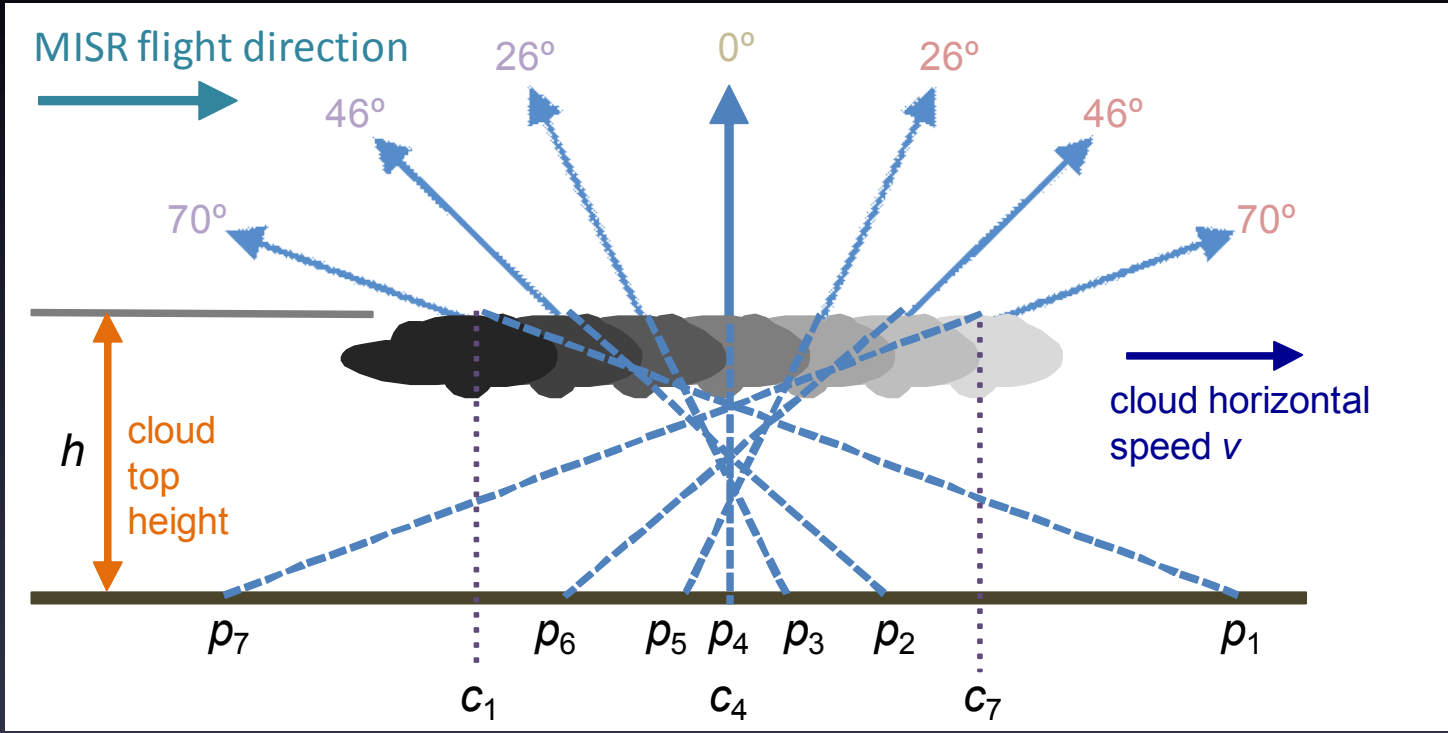
GPS Radio Occulation on each S/C would

- Derive atmosphere refractivity profile vs. altitude
- Determine ABL top height and moisture profile using radio occultation
- Provide high sensitivity and ABL penetration

StereoCam parameters

Parameter	Requirement	Justification
View angles at Earth surface	0° (nadir)	Geometric calibration and stereo consistency checks
	±26°	Stereo imagery
	±46°	Stereo quality checks
	±60°	Thin clouds
Spectral band	645 nm 65 nm bandwidth	High scene contrast High SNR
Cross-track footprint	<300 m @ 0°, ±26°	Detection of spatial contrast
	300–350 m @ ±46°	
	600–700 m @ ±60°	
Swath width	1400km	3-day global coverage
Temporal separation	9 minutes	Adequate time base

MISR retrieval approach



Largest wind uncertainty results from correlation between along-track motion and height parallax

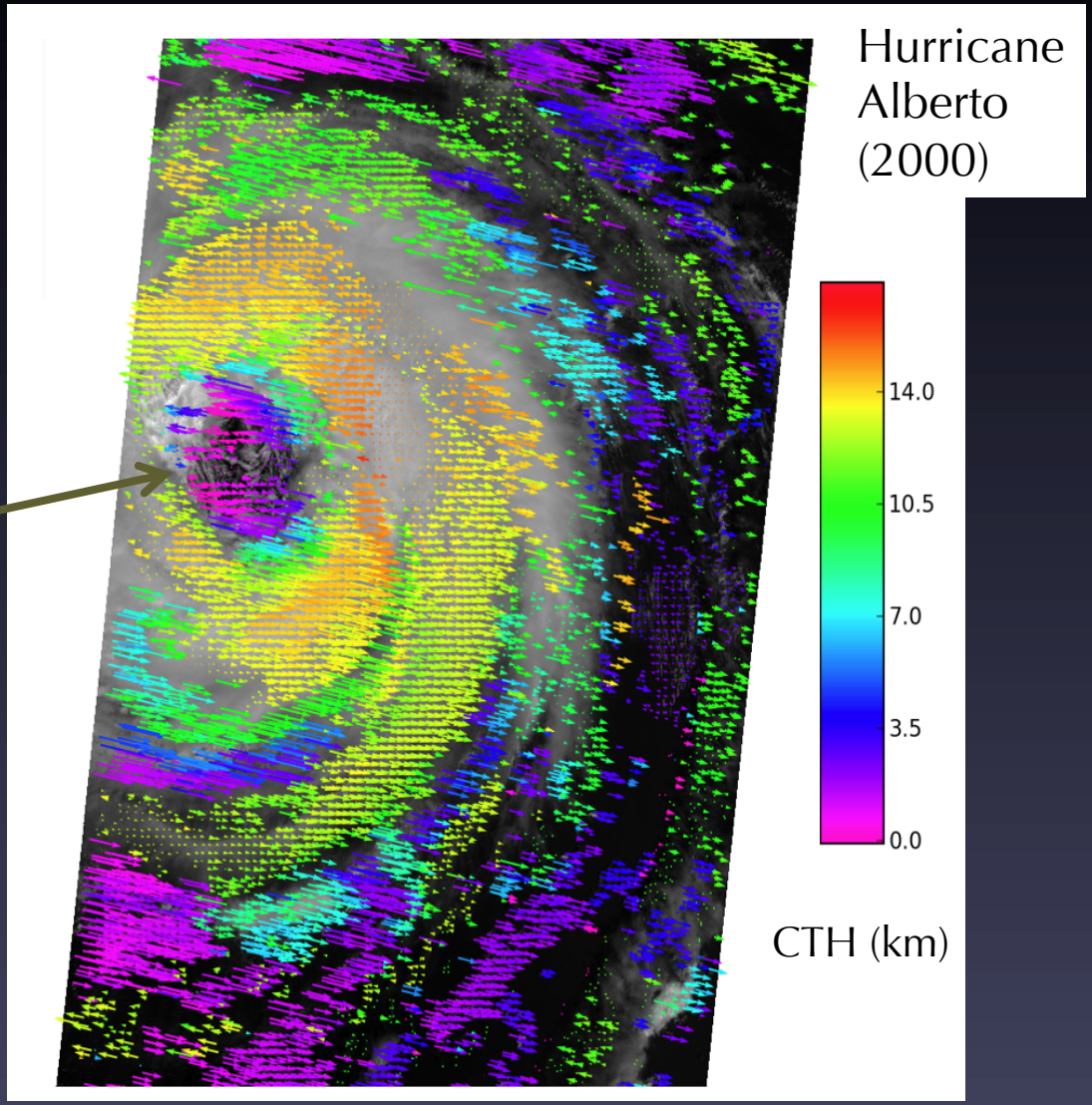
Requires negligible vertical motion

MISR high-resolution cross-track winds

High resolution, cross-track wind speed as a function of cloud-top height is derived from MISR imagery.

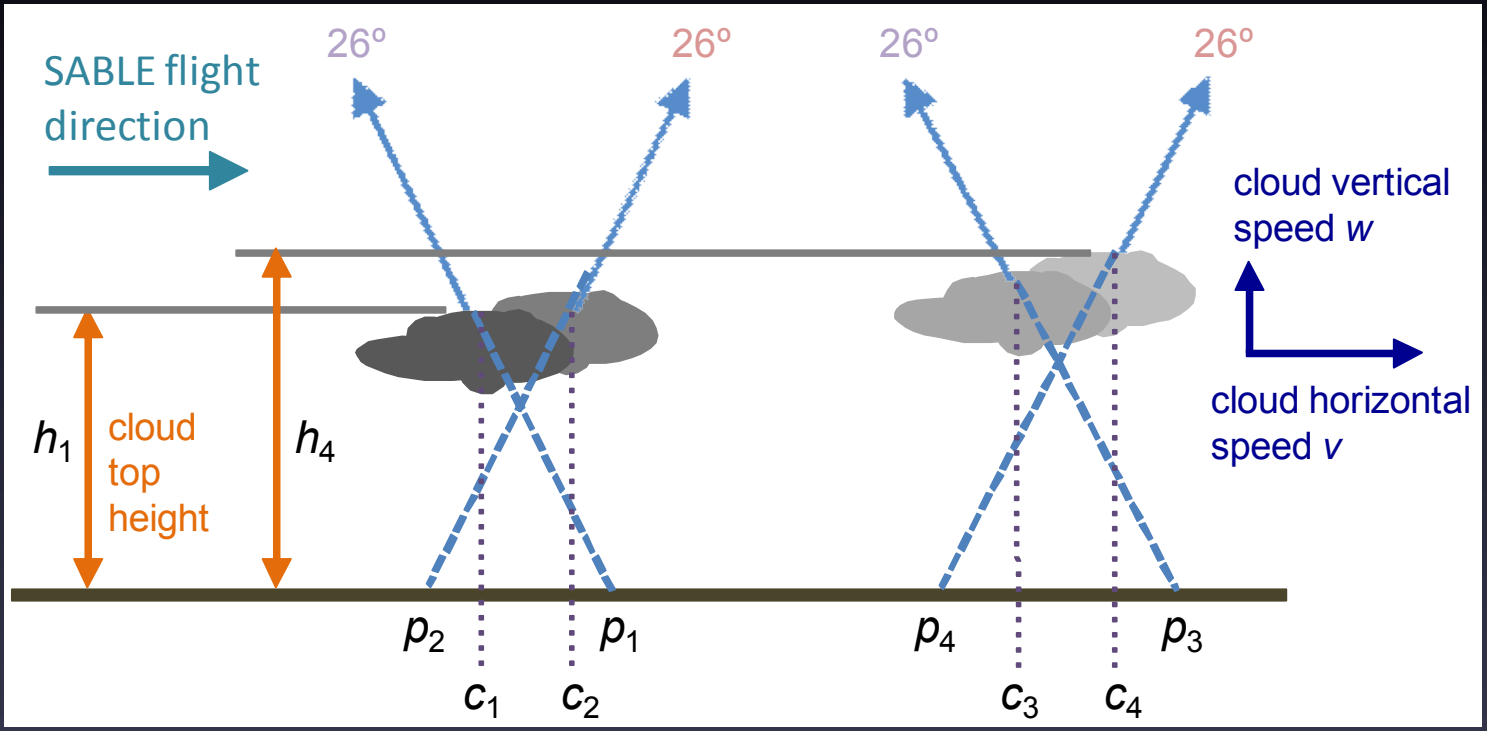
Detailed rotational structure inside the hurricane eyewall.

Spatial resolution 1.1 km
Vertical resolution 500 m
Accuracy 2-3 m/s



Credit: Kevin Mueller, Catherine Moroney

Proposed SABLE retrieval approach using tandem StereoCams



Along-track motion and height parallax are *independent*

Sensitive to vertical motion

Dual StereoCam CTH uncertainties

CTH uncertainty contributor	Height uncertainty (m) (1σ)			
	Position error 1 m (with GPS)		Position error 67 m (without GPS)	
	Center	Edge	Center	Edge
Parallax error	47	64	83	94
Along-track wind error	11	16	17	21
Net result (instantaneous)	48	66	85	96
Monthly mean	18	25	32	36

Dual StereoCam CTW uncertainties

CTW component	Wind uncertainty (m s^{-1}) (1σ)			
	Position errors = 1 m (with GPS)		Position errors = 67 m (without GPS)	
	Center	Edge	Center	Edge
Instantaneous				
Along-track (*v*)	0.10	0.12	0.16	0.17
Cross-track (*u*)	0.15	0.26	0.19	0.29
Vertical (*w*)	0.21	0.24	0.33	0.36
Monthly Mean				
Along-track (*v*)	0.04	0.05	0.06	0.07
Cross-track (*u*)	0.06	0.10	0.07	0.11
Vertical (*w*)	0.08	0.09	0.12	0.13

Summary

Single platform multiangle imagery (MISR)	**Dual platform multiangle imagery (proposed SABLE mission)**
Height and along-track wind uncertainties are coupled	Height and wind uncertainties are independent
Wind uncertainties are 2-3 m s^{-1}	Wind uncertainties are an order of magnitude smaller
Retrieval assumes zero vertical wind	Retrieval derives vertical wind
Entrainment rate uncertainty ~9 mm s^{-1}	Entrainment rate uncertainty ~1 mm s^{-1} (~20% of typical value)