

# **Enhancing ATTREX with Balloon Soundings**

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**with contributions from**

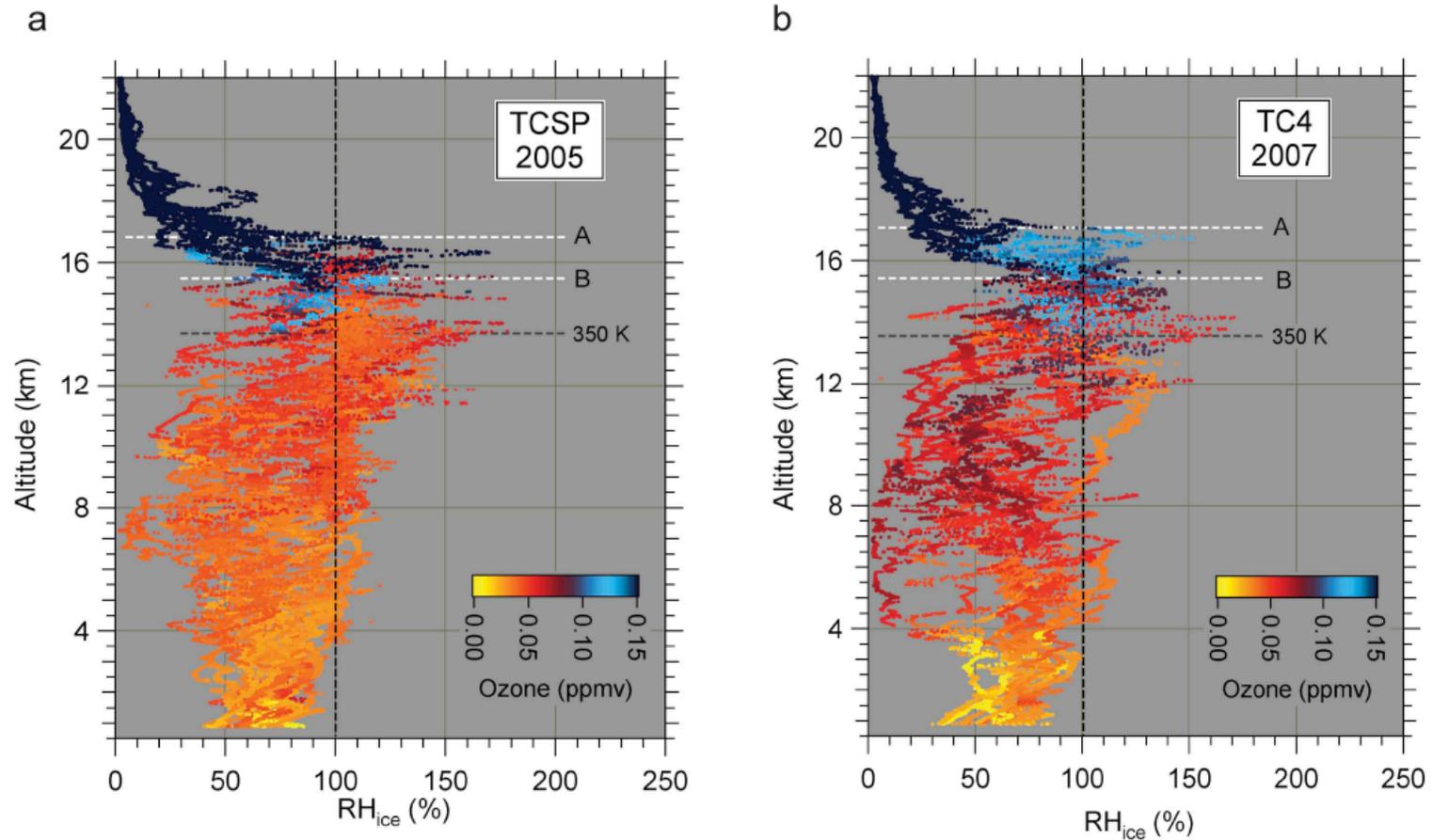
**Masatomo Fujiwara (SOWER, Japan)**

**Dale Hurst (NOAA/GMD)**

# Benefit of balloon soundings to ATTREX

- **Complement aircraft horizontal sampling with high-resolution vertical profiling over deep layer of UT/LS**
  - Vertical structure of TTL
  - Document incidence of supersaturation and dehydration
  - Diagnose waves at multiple time scales – modulation of dehydration and other TTL physical processes
  - Heating rate calculations with temperature, water vapor and O<sub>3</sub>
- **Validate aircraft and satellite H<sub>2</sub>O measurements with reference balloon instrument (CFH)**
  - Global Hawk - ULH, DLH and UCATS
  - Satellites: Aqua (AIRS), Aura (MLS), NPP (CrIS/ATMS)

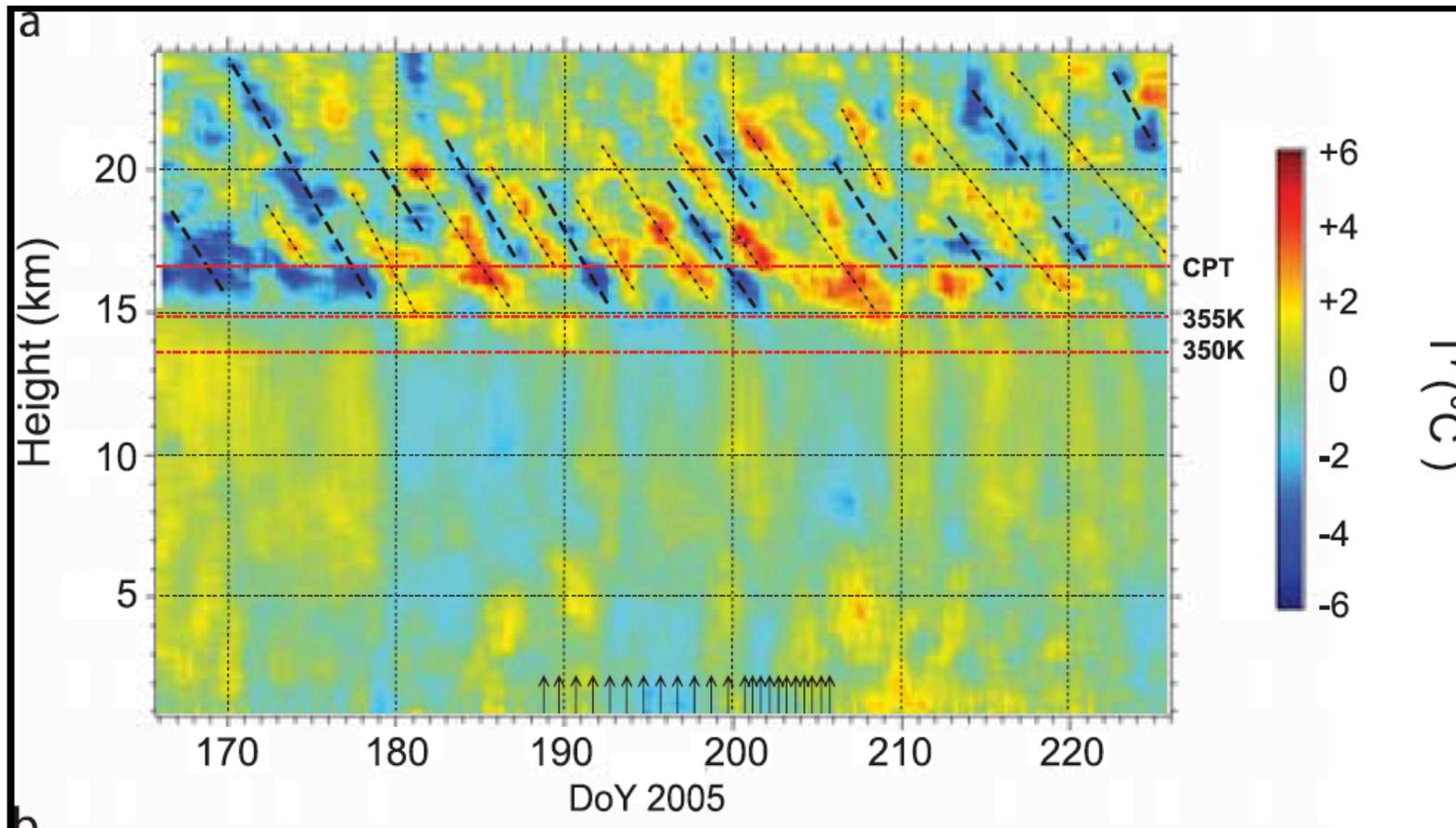
# Supersaturation and ozone in the TTL



CFH and ECC at Costa Rica – NH summer

Selkirk et al 2010, Figure 4

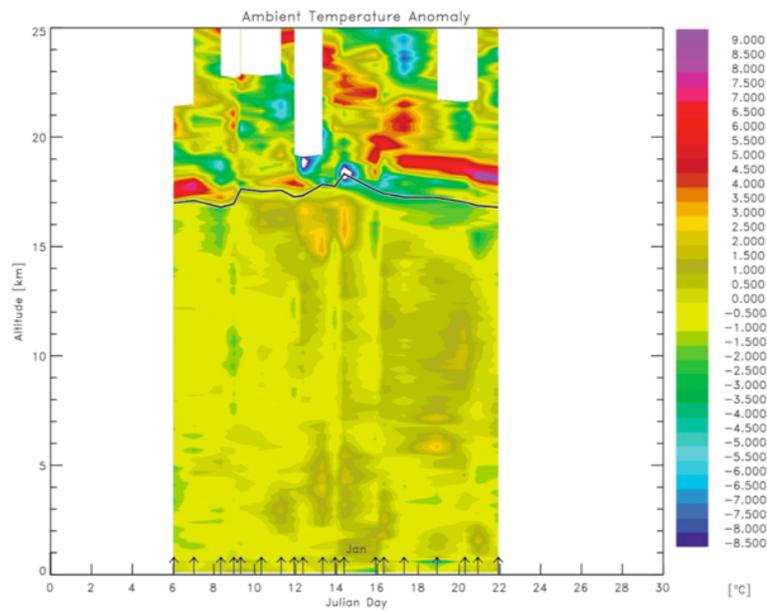
# Tropical Waves in ITCZ NH summer



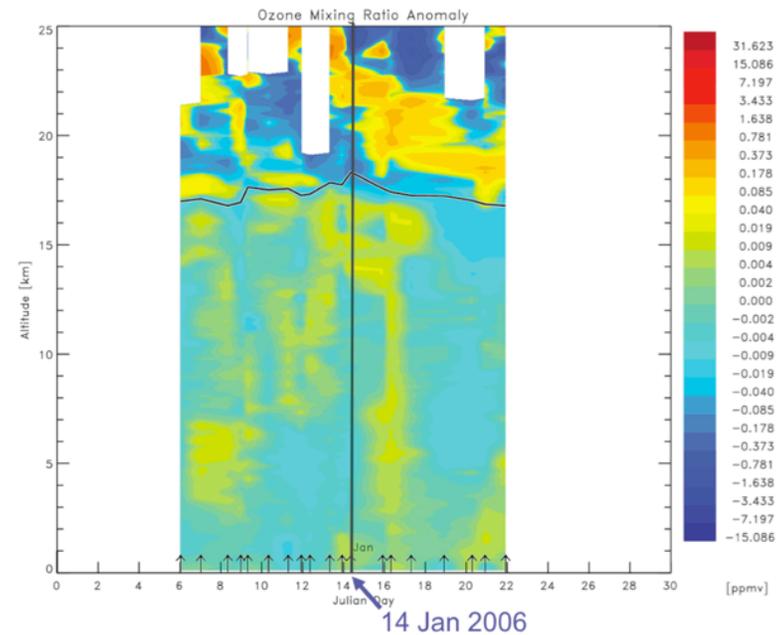
Radiosondes at Costa Rica – TCSP – July 2005

Selkirk et al 2010, Figure 7a

# Equatorial wave disturbances



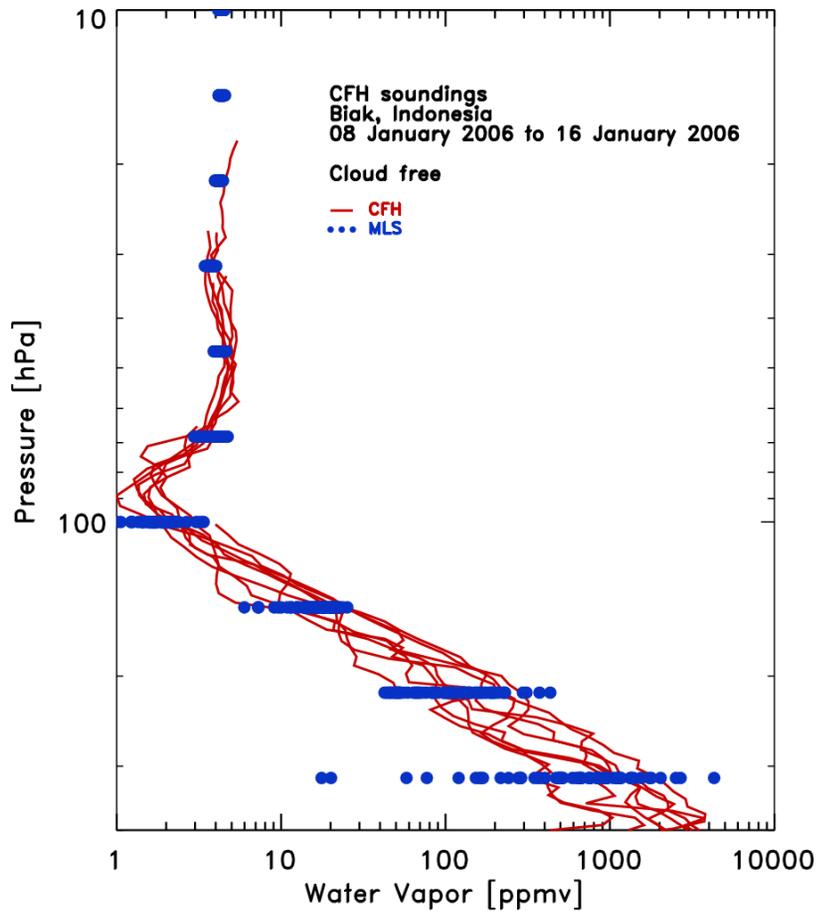
T anomaly



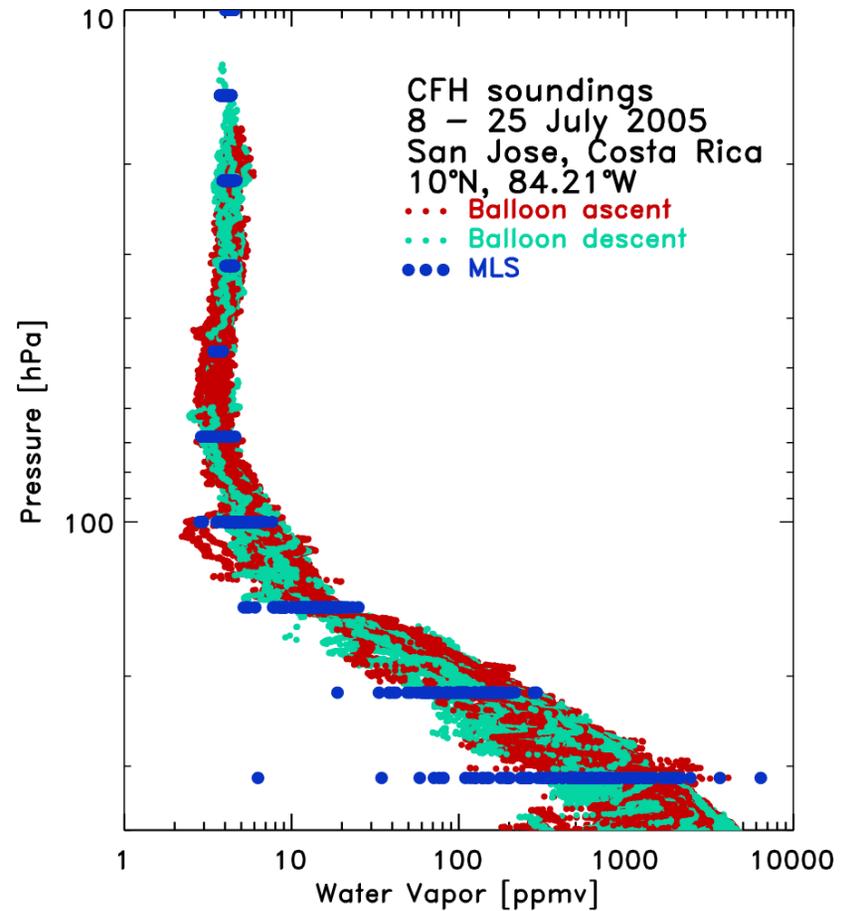
O<sub>3</sub> anomaly

**CFH/ECC at Biak – January 2006**

# Validation: CFH comparison to MLS



**Biak – January 2006**



**Costa Rica – July 2005**

# Sounding Science Goals

- Characterize fine-scale vertical structure of WV, O<sub>3</sub>, T and winds in UT/LS
- Diagnose transient waves in the TTL and their effect on relative humidity and ozone
- Document incidence of supersaturation and potential dehydration events
- Validation of GH and satellite water vapor measurements

# Balloonsonde instruments

- **WATER VAPOR** – frostpoint hygrometers
  - **CFH** (SOWER, Ticosonde, GRUAN)
  - **FPH** (NOAA GMD)
- **OZONE** – ECC ozonesonde
- **TEMPERATURE / Pressure**
  - **Vaisala RS92** – routine launches
  - **Vaisala RS80**
  - **InterMet** (current CFH and FPH payloads)
  - **Hi-resolution temperature sonde** – F. Hasebe
- **RELATIVE HUMIDITY** – Vaisala RS92 useful in TTL with **corrections by L. Miloshevich**
- **WINDS** – radiosondes and ozonesondes with GPS
- **AEROSOLS/CLOUDS** - COBALD backscatter sonde – ETH/T. Peter et al.

# Sounding payloads

## A. Water Vapor payload

- CFH or FPH – water vapor
- ECC ozone sonde
- Radiosonde – Temperature/pressure/winds and telemetry
- COBALD – option
- Vertical resolution 10-50 m; altitude to 25-30 km

## B. Ozonesondes

- ECC ozonesonde
- Radiosonde – PTU
- Same resolution and altitude as WV payload

## C. Radiosondes - numerous routine sites in W. Pacific

- Temperature/Pressure (PT)
- Relative Humidity (U)
- Winds

# Potential Partners

- **SOWER (Japan)** – M. Shiotani, F. Hasebe, M. Fujiwara, H. Vömel
  - Soundings of Ozone and Water in the Equatorial Region (W. Pacific)
  - Multiple campaigns over last 20 years at sites across the Pacific, Indonesia, Viet Nam
  - SOWER partners include Indonesian National Institute of Aeronautics (**LAPAN**)
- **NOAA GMD** – S. Oltmans, D. Hurst
  - Longest-running program of frostpoint measurements
  - Infrastructure in Hawaii
  - Maintains **SHADOZ** network (ozonesondes)
- **GRUAN/DWD** – H. Vömel
  - GCOS Reference Upper Air Network
  - Vömel developed Cryogenic Frostpoint Hygrometer
- **Ticosonde/SHADOZ** (NASA/UNA-Costa Rica) – H. Selkirk, J. Valverde, H. Vömel
  - Regular CFH launches in Costa Rica since 2005
- **ETH Zurich** - T. Peter et al.
  - COBALD aerosol sonde
- **BMRC** (Darwin)
- **ARM** – Tropical West Pacific
- **Aerospace** – Raman lidar WV at Barking Sands, HI (John Wessel, Steve Beck)

# Potential Balloonsonde Sites

- **Guam**
  - routine 2 X daily radiosondes
- **Darwin** – 11°S, 131°E (BMRC, ARM TWP)
  - routine 2 X daily radiosondes
- **Biak** – 1.17S, 136.06E (SOWER, LAPAN)
  - equatorial site, ~ midway between Darwin and Guam
  - infrastructure and personnel support of LAPAN
- **Tarawa** - 1.35°N, 172.92°E (SOWER/Kiribati Met Service)
- **Other SOWER/LAPAN sites**
  - Watukosek 7.57S, 112.65E
  - Bandung (6.90S, 107.60E)
  - Kototabang (0.20S, 100.32E)
- **Other TWP sites**
  - Manus
  - Nauru
- **Hilo, HI** (NOAA GMD)
  - weekly SHADOZ ozonesondes
- **Costa Rica (UNA-Heredia)** - 10°N, 84.2°
  - within range of DFRC for Fall 2011
  - weekly SHADOZ ozonesondes, monthly CFH

# Potential sounding programs for ATTREX

## 1. CFH - GH ops sites – Guam, Darwin

- Characterize cold TTL, subvisible cirrus (Guam)
- GH validation
- Satellite validation
- Every other day

## 2. CFH - equatorial sites – e.g. Biak

- Characterize cold TTL, subvisible cirrus
- Diagnose WV/O<sub>3</sub> structure of equatorial waves
- Satellite validation
- Minimum every other day
- Span cycle of MJO

## 3. FPH – Hilo (NOAA GMD)

- Characterize TTL in East/Central Pacific downstream of western Pacific
- Observations of SVCs (cf. Pfister et al 2001)

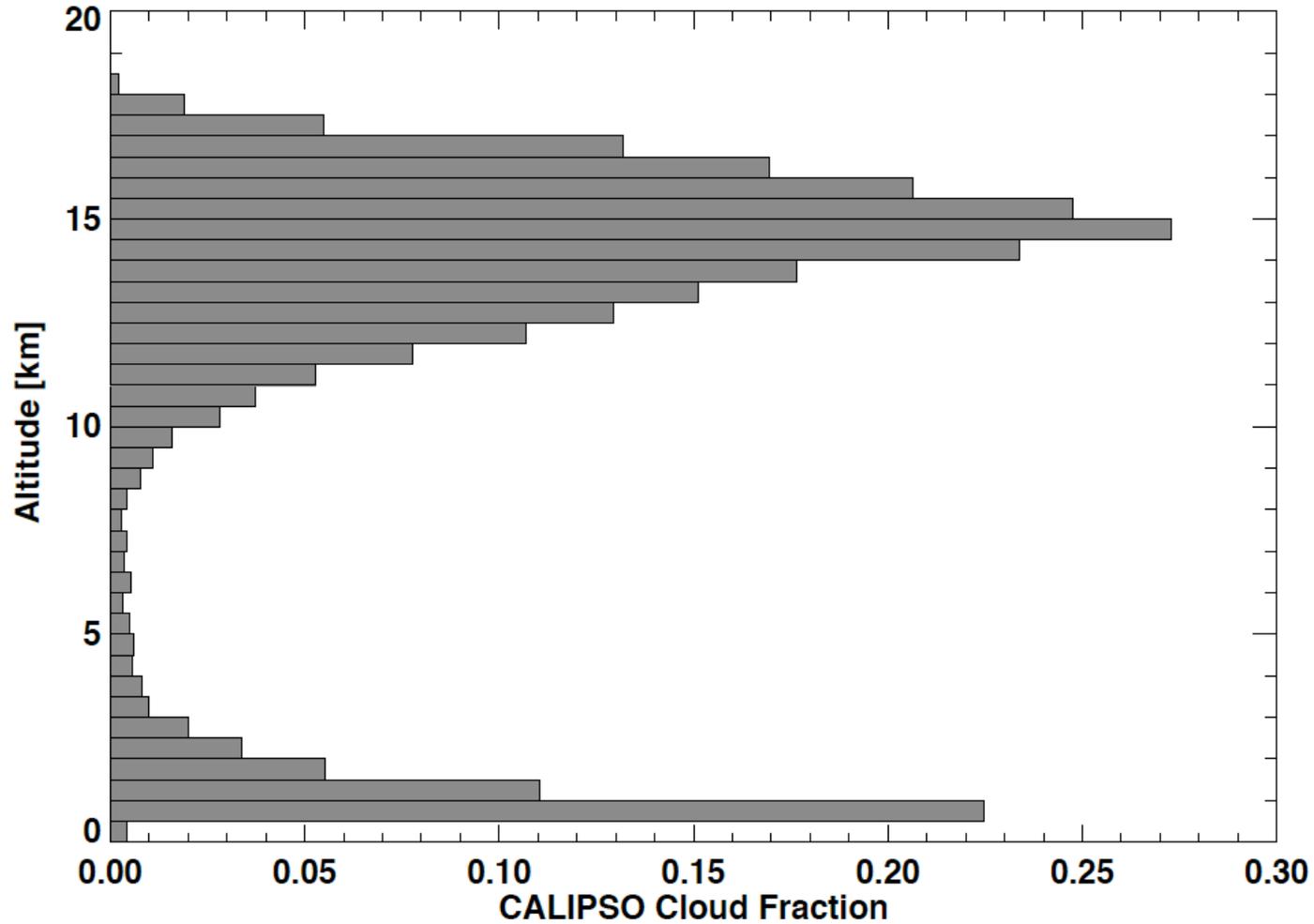
## 4. Enhanced radiosoundings

- Pre-existing sites (Darwin, Guam, Micronesia)
- 4X daily to diagnose winds with with T and winds (as in Joan Alexander's talk)

# Strategic Questions

- Guam has utility for TTL science with balloons, but...
- A bit far from the tropics for equatorial waves, still in cold T region in DJF.
- Still lots of TTL cirrus at Guam.
- Base soundings in Guam or elsewhere?
  - Manus [2°S, 147°E] (ARM TWP)
  - Nauru [0.5°S, 167°E] (ARM TWP),
  - Biak [1°S, 136°E]
  - Watukosek, Indonesia [8°S, 113°E] (SOWER)

# Guam DJF Cloud Climatology

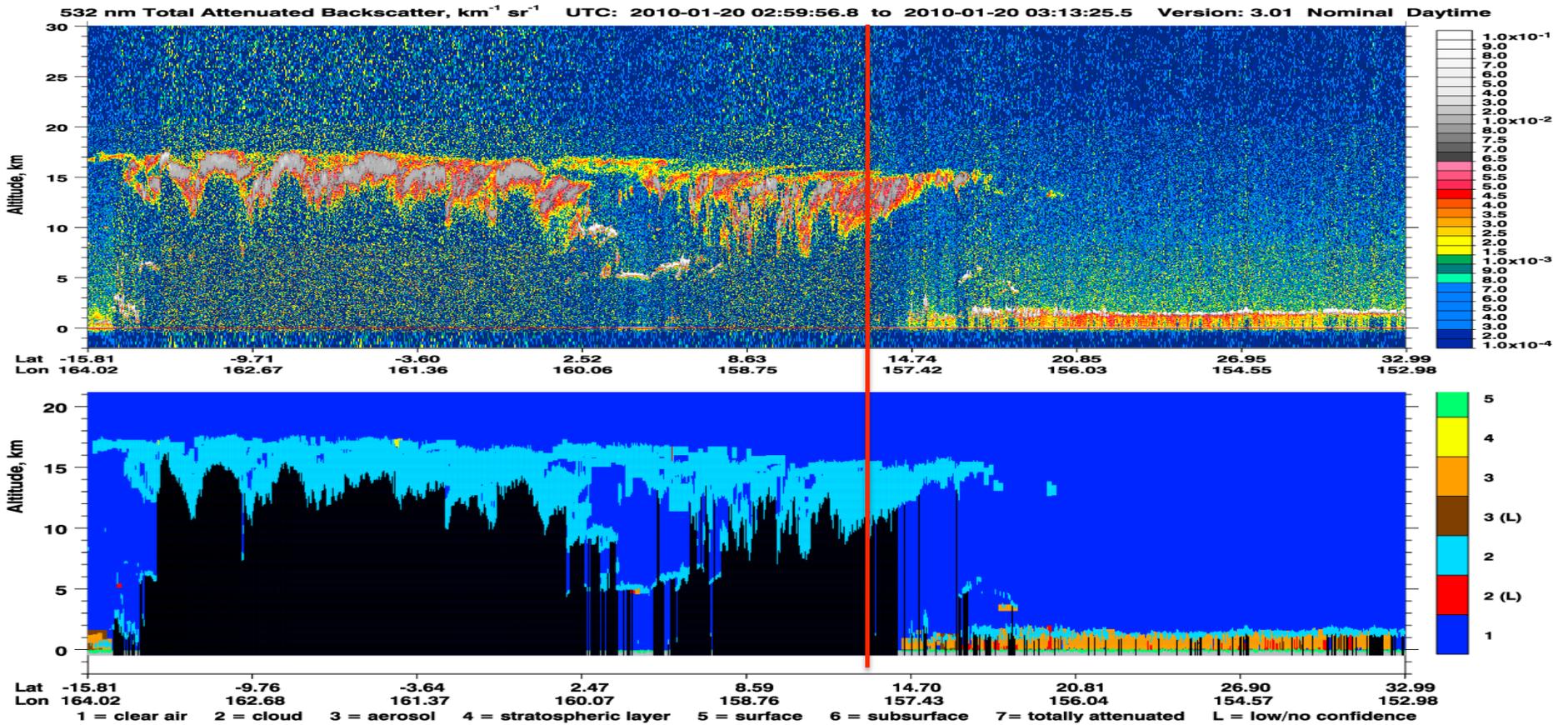
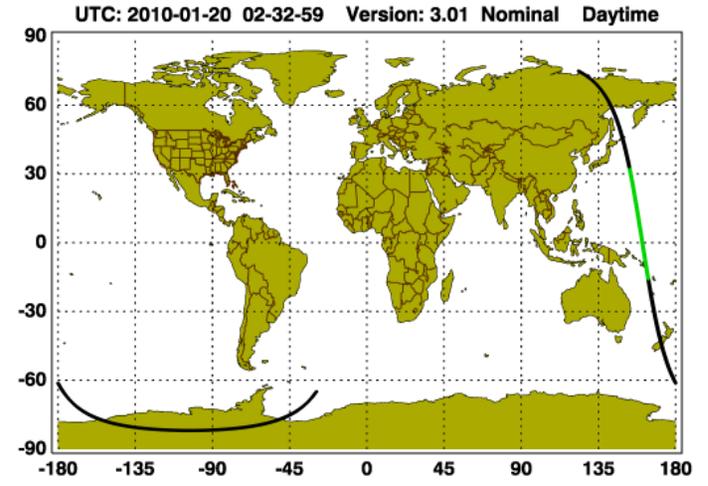


Credit: L. Munchak, NCAR

# CALIPSO Sample...

Jan 20, 2010, ~1330 Local Time

Guam



# Discussion/Summary...

- How to best meet needs?
  - Science (want tropical waves and clouds)
  - Validation of GH H<sub>2</sub>O: base at instrument site
- Guam as a target offers both
  - Still have TTL thin cirrus in-situ above Guam
  - Validation opportunities
- Integrate Soundings with GH flight patterns
  - How does GH ascend/descend? Can we spiral around an island?

# Partner status

- NOAA/GMD/CIRES (Hurst, Oltmans)
  - Interested in helping.
  - Need funding for 1 person (maybe 2 for initial Dryden deployment) + instruments
- SOWER very interested
- Others? Have discussed, waiting on replies
- University partners as part of NSF GV proposal
- Not contacted ETH Zurich (COBALD) yet.