ER-2 in CRYSTAL-FACE
science, objectives, logistics

ER-2 instrument team:

P. Bui, J. Halverson, R. Herman, G. Heymsfield,
M. King, M. Mahoney, M. McGill, P. Pilewskie,
F. Valero, J. Wang, …

&

P. Newman, S. Platnick

CRYSTAL-FACE Science Team Meeting

30 January 2001

Outline

- ER-2 overview
- CRYSTAL-FACE payload & instrument descriptions
- ER-2 flight plan issues & example
- Integration & Test strategy

Key personnel

Project office support, logistics: Mike Craig

ER-2 mission manager: Mike Kapitzke

ER-2 lead pilot: Ken Broda

Mission scientists: King, Newman, Platnick

NASA ER-2
Airborne Science Program
Dryden Flight Research Center

Aircraft: 2 Crew: 1 pilot

Length: 62 ft., 1 in. Wingspan: 103 ft., 4 in.

Payload: Nose (600 lbs.), Q-bay (750 lbs.), Wing pods (1360 lbs.), Centerline pod (350 lbs.)

Cruising altitude: ~ 70,000 ft., 20 km (increases as fuel is burned off)

Cruising speed: ~ 410 knots, 210 $m\text{-}s^{-1}$, 12.6 $km\text{-}min^{-1}$, 756 $km\text{-}hr^{-1}$

Time to altitude: ~30-45 min depending on payload

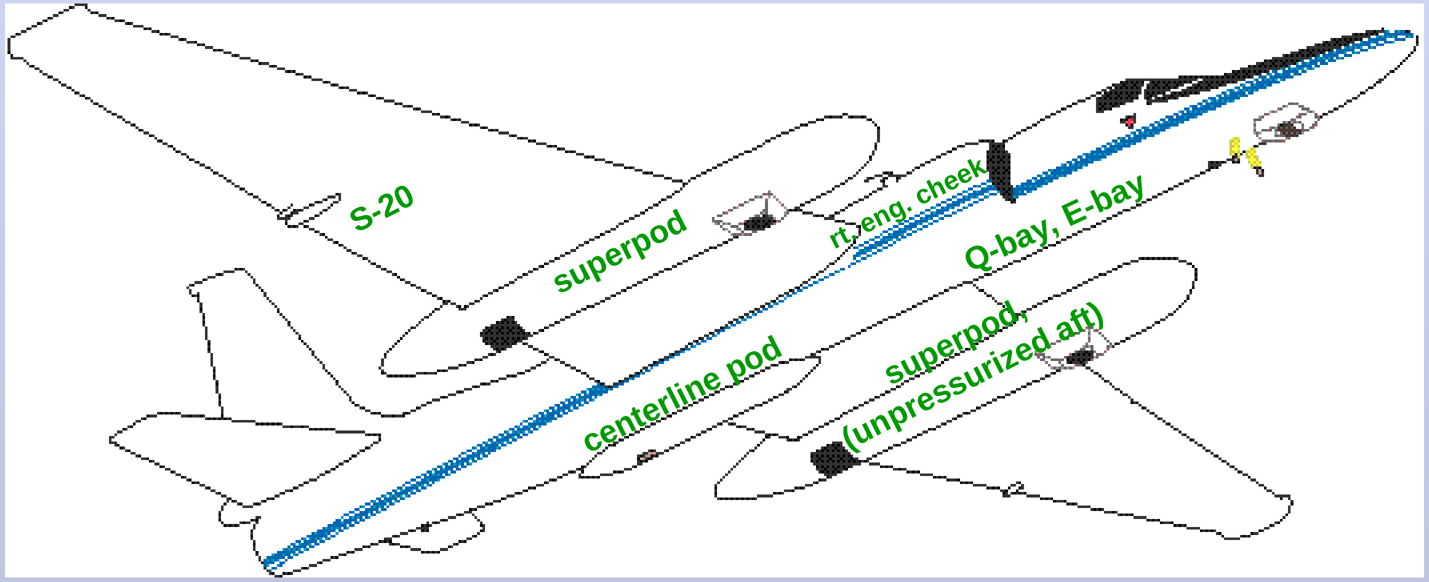
Descent initiated: ~ 30 min prior to landing

Required runway winds: < 15 knt crosswind

Pietersburg, South Africa. August 2000

CRYSTAL-FACE ER-2 Instrument Payload

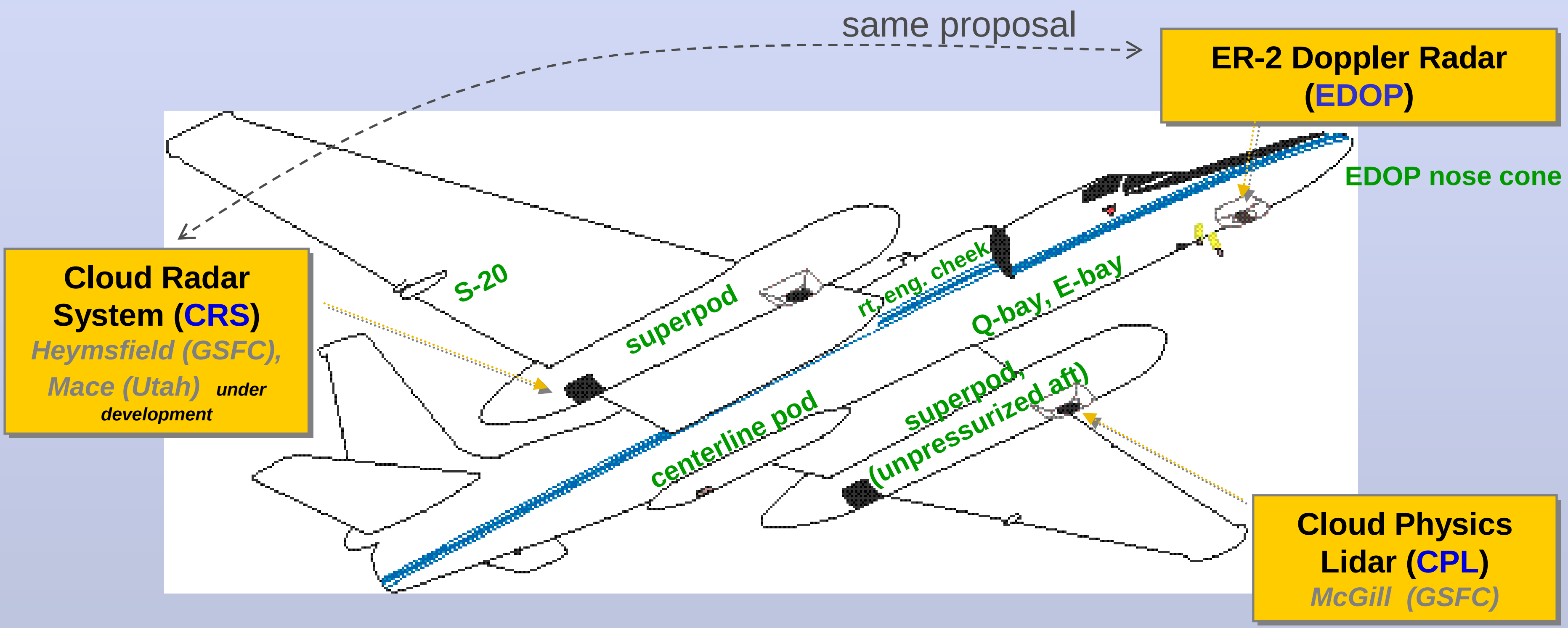
(exact locations subject to cg analysis, integration, etc.)



CRYSTAL-FACE ER-2 Instrument Payload

(exact locations subject to cg analysis, integration, etc.)

Active remote sensing instruments



Platnick et al., C-F Science Team Mtg., 30 Jan. 2002

ER-2 Doppler Radar (EDOP)
Cloud Radar System (CRS)

G. Heymsfield, P. Racette, G. Mace, L. Li & L. Tian

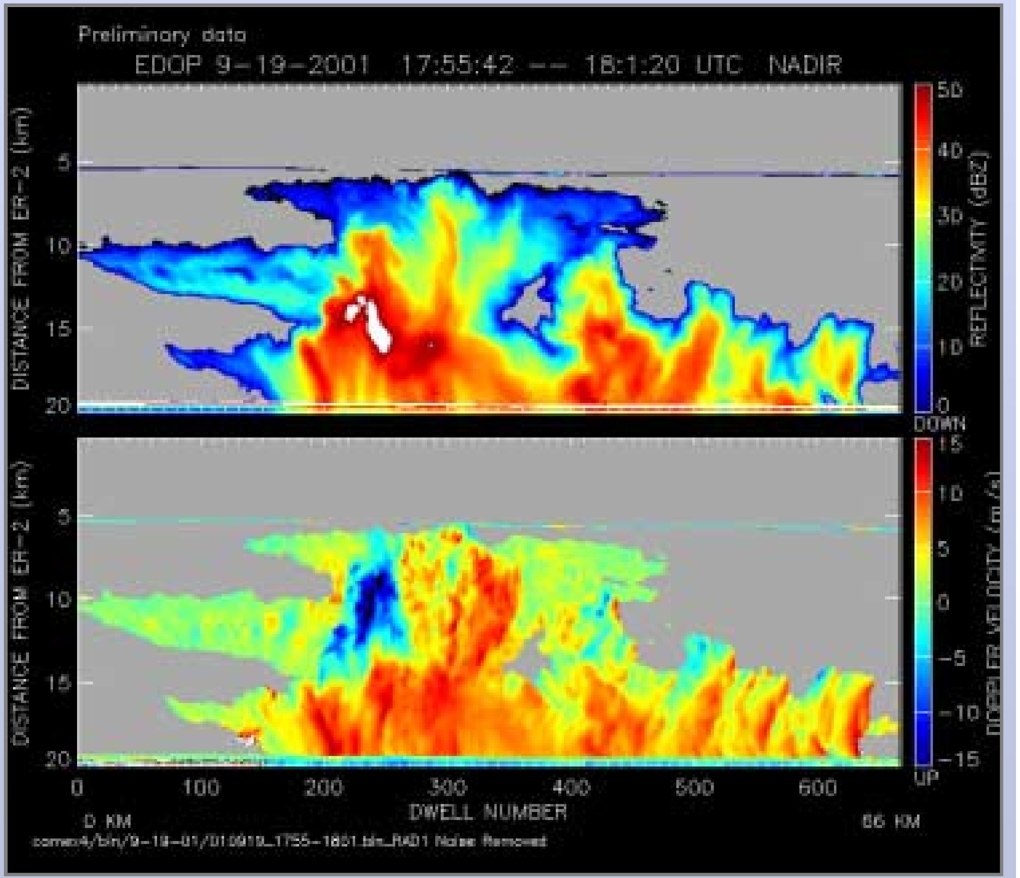
SCIENCE OBJECTIVES

- Vertical radar **reflectivity** & vertical **wind structure** in **convection (EDOP)** and **cirrus (CRS)** generated by convection.
- Relation of cirrus outflow layers to convective updrafts.
- Characterization of cirrus outflow layer altitudes, derived properties such as ***IWC*** based on empirical *Z-IWC* relations, etc.
- Explore new retrieval approaches such as dual-wavelength radar (CRS-EDOP) methods, and CRS/EDOP synergy with other ER-2 instruments.

ER-2 Doppler Radar (**EDOP**)

- *Frequency:* **9.6 GHz**
- *Location:* SLR Nose
- *Antenna:* 3^{o} fixed **nadir**
  3^{o} fixed **forward** (35^{o})
- *Measurements:* reflectivity
  Doppler
  Doppler width
  linear depol. (LDR)
- *Resolution:* **37.5 m** vertical
  ~**1.1 km** footprint at surface
- *Sensitivity:* MDS ~ 0 dBZ_e
  (4.4 kHz PRF,
  0.5 s average,
  10 km range)

Thunderstorm east of Key West, FL.

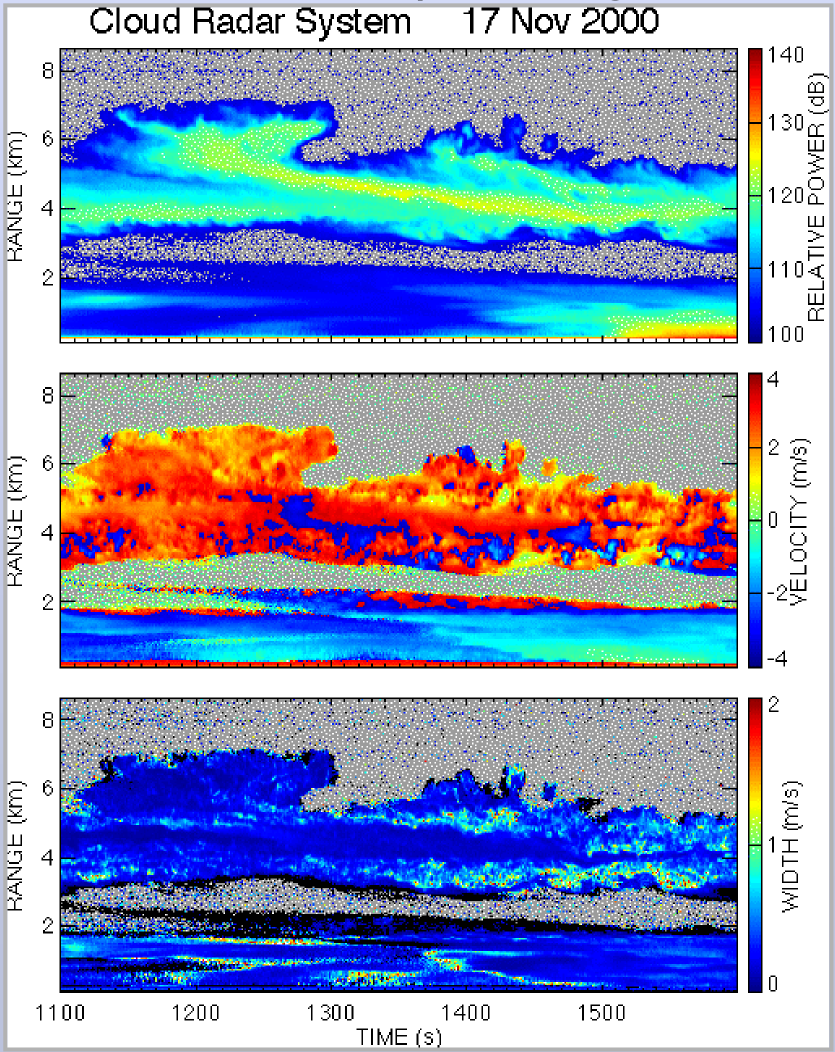


G. Heymsfield et al.

ER-2 Cloud Radar System (**CRS**)

- *Frequency:* **94 GHz**
- *Location:* superpod aft
- *Antenna:* 0.6° x 0.8°
  fixed **nadir**
- *Measurements:* reflectivity
  Doppler
  Doppler width
  linear depol. (LDR)
- *Resolution:* **37.5 m** vertical
  ~ **300 m** footprint at surface
- *Sensitivity:* MDS ~ -30 dBZ_e
  (4.4 kHz PRF,
  0.5 s average,
  10 km range)

Ground-based up-looking, GSFC



G. Heymsfield et al.

EDOP & CRS data and products

- **In the field**:
  - Quicklook images (*Z*, *v*, *IWC*?), selected vertical profiles of *v*, *Z* with preliminary calibration
- **Post-mission**:
  - Calibrate & reformat data into radar Universal Format (UF) readable with IDL libraries.
  - Attenuation and aircraft motion corrections (EDOP); CRS (TBD)
  - Derived products: cloud layer and cloud top heights, *IWC*, vertical air motions, histograms/statistics, along-track (2D) winds
  - ER-2 instrument synergy: **CPL**, **MAS**, **CoSSIR**

Flight coordination & constraint

- Straight and level flight legs covering convection and associated anvil.
- Aircraft motions due to course changes and or gravity wave over thunderstorms directly affect Doppler measurements; reflectivity unaffected.
- Radars operate only above 50 kft due to safety considerations.

EDOP nose

G. Heymsfield et al.

Cloud Physics Lidar (CPL)

Matthew McGill / Goddard Space Flight Center, Code 912
Dennis Hlavka, William Hart / Science Systems & Applications, Code 912

CPL is a **3-wavelength lidar** (1064, 532, 355 nm) using photon-counting detection

SAFARI was the first field campaign for the new CPL instrument

CPL instrument in flight configuration

CPL data products:

• Quicklook summary images for each flight.
• **Layer boundaries** for PBL, elevated aerosol layers, clouds
• **Optical properties**, including
  - layer extinction-to-backscatter ratio (S) used
  - layer extinction profile
  - layer optical depth
  - images for extinction and optical depth
  - depolarization ratio
  - layer transmission profile

<u>Preliminary</u> data products available **24 hours after data collection**, *except* extinction profiles which take longer to properly calculate. All data products are 1 second averages produced from the raw 1/10 second data, and for each wavelength (355, 532, 1064 nm).

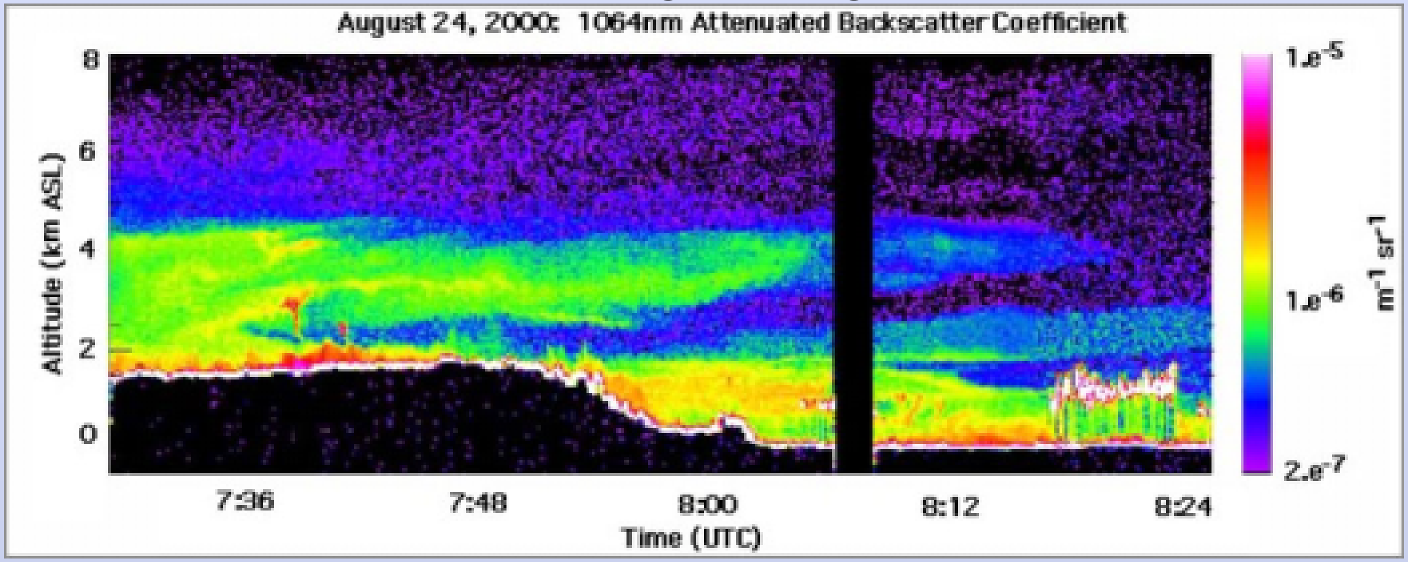
<u>ER-2 instrument synergy</u>: lidar-radar data combination using Cloud Radar System (**CRS**).

Fllight plan needs: passes over **groundbased lidars and sunphotomers for calibration**. CPL data processing algorithms are set up to include ancillary data sources (e.g., sunphotometer data, met data, etc.).

CPL web site: **http://virl.gsfc.nasa.gov/cpl/**

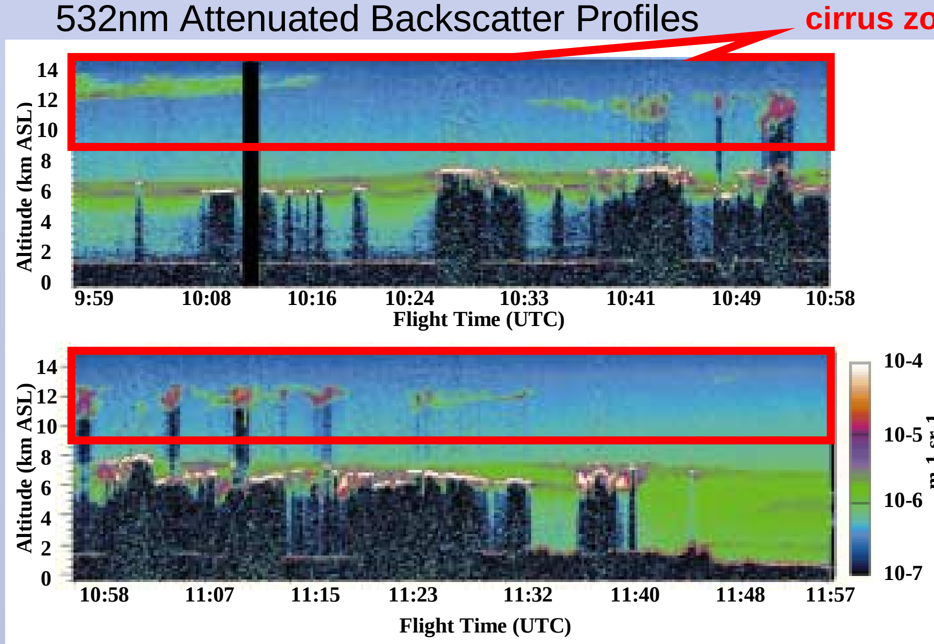
McGill et al.

Cloud & Aerosol Profiling, 24 August 2000 – SAFARI

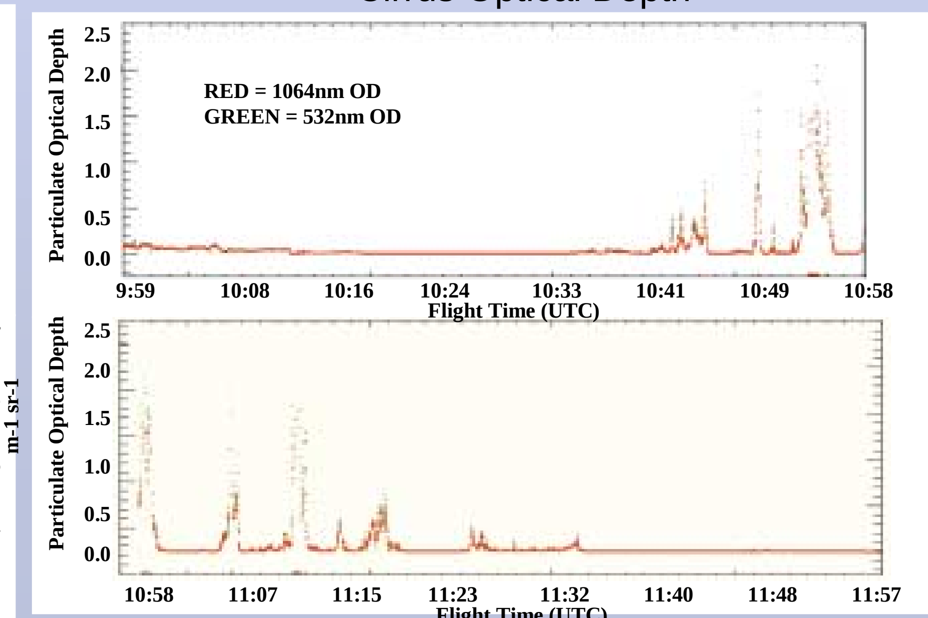


Cirrus Optical Depth Retrieval, 4 September 2000

532nm Attenuated Backscatter Profiles



Cirrus Optical Depth



McGill et al.

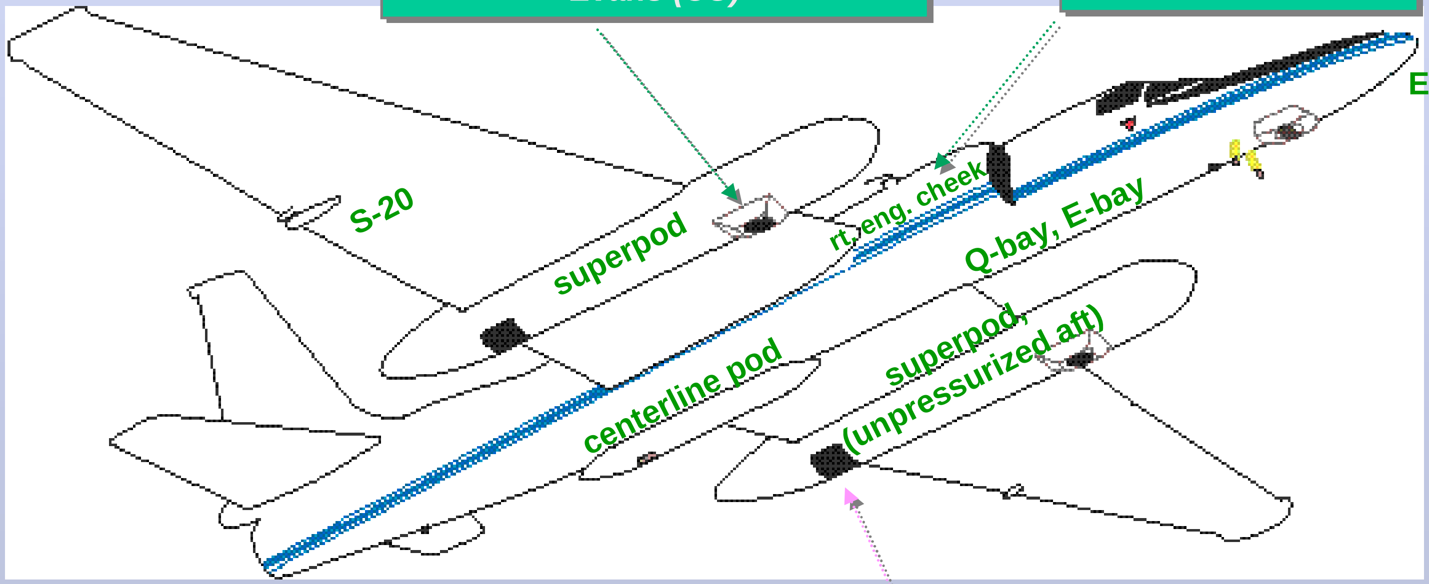
CRYSTAL-FACE ER-2 Instrument Payload

(exact locations subject to cg analysis, integration, etc.)

Passive remote sensing instruments

Conical Scanning Sub-mm wave Imaging Radiometer (CoSSIR) *Wang (GSFC), Evans (CU)*

Microwave Temp. Profiler (MTP) *Mahoney (JPL)*



EDOP nose cone

MODIS Airborne Simulator (MAS) *King (GSFC), Platnick (UMBC)*

Conical Scanning Submillimeter-wave Imaging Radiometer (CoSSIR)

J. R. Wang [1], K. F. Evans [2], P. Racette [1], and J. Piepmeier [1]

[1] NASA/GSFC, [2] U. Colorado

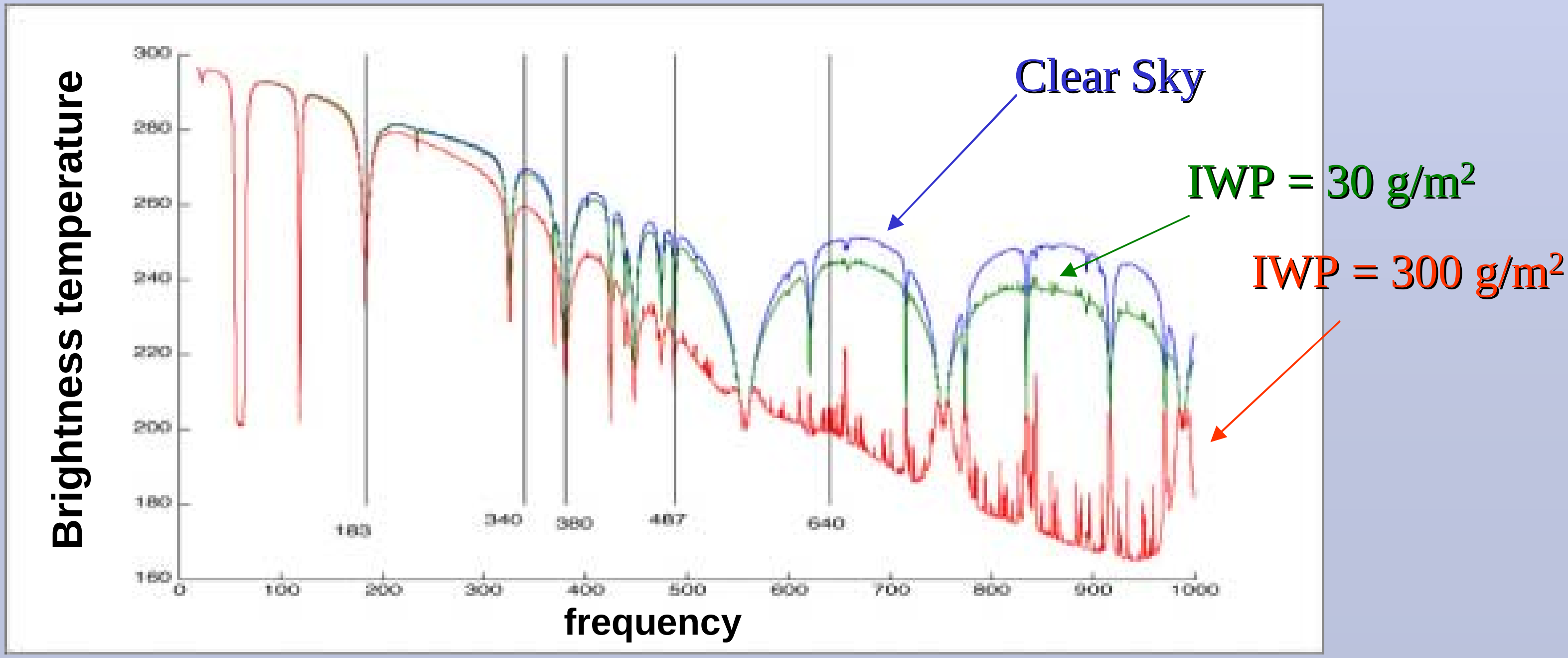
Scientific Objectives:

- Develop and evaluate a promising **new** cirrus remote sensing technique
- Provide accurate cirrus **retrievals**, **with error bars**, for validation of existing satellite cirrus sensing algorithms (e.g., from MODIS and GOES data).
- Provide **water vapor profiles** and cirrus ***IWP*** (Ice Water Path) and $\boldsymbol{D_{me}}$ (median mass diameter) to the CRYSTAL community for constraining cirrus cloud models
- Measure **spatial pattern** of *IWP* and D_{me} from the edge of anvil to precipitating regions to improve understanding of the connection between deep convection and the the production of anvil cirrus.

CoSSIR: 15 channels between 183-640 GHz

f* (GHz) – *physics	**Channels (GHz)**	**Polarization**
183 *$H_2O(z)$*	±1, ±3, ±6.6	H
220 *H_2O lower trop.*	±3	H
380 *$H_2O(z)$*	±0.8 ,±1.8,±3.3, ±6.2	H
487 *habit*	±0.7, ±1.2, ±3.3	V & H
640 *IWP, D_e*	±4	H

Modeled Response of Upwelling Radiation to Cirrus Clouds



Wang et al.

Conical Scanning Submillimeter-wave Imaging Radiometer (CoSSIR)

Heritage:

- **MIR** (Millimeter-wave Imaging Radiometer, 89-340 GHz) – SUCCESS, FIRE-ACE
- Response to moderate cirrus at 340 GHz. At frequencies ≤ 220 GHz, MIR responds to intense cirrus only (CLS surface signals totally attenuated).
- **CoSSIR will be more sensitive** to cirrus than MIR, excellent complement to visible-IR measurements.

Data Products:

- Preliminary water vapor profiles and cirrus parameters (IWP and D_{me}) available ~ 2 days after flights. Refined data products archived about 6 months later.
- C-F instrument synergy: retrieved products based on combined data of CoSSIR and other instruments, e.g., **CRS**, **MODIS**/**MAS**, **CPL**, **FIRSC** (Proteus) will be made available; schedule depends on availability of data from other sensors.

Flight Coordination:

- Coordination with FIRSC (**Proteus**) and in-situ sensors (**WB-57**)

Wang et al.

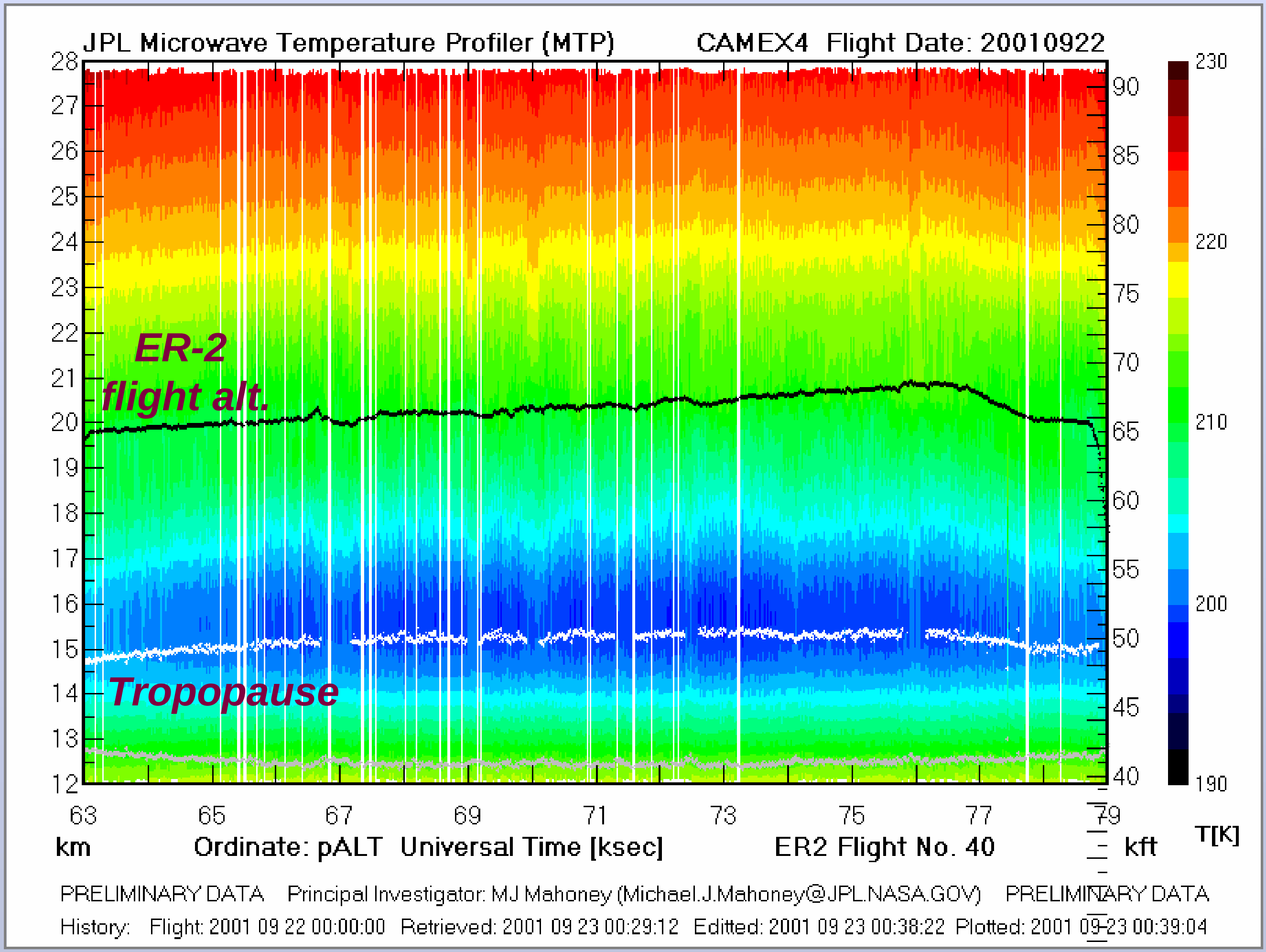
ER-2 Microwave Temperature Profiler (MTP)

M. J. Mahoney, JPL, California Institute of Technology

ER-2 on the ramp at JAX NAS during CAMEX-4. Photo Credit: mjm

- MTP measures the **temperature profile** above, below & at flight level by observing the natural thermal emission from oxygen molecules between 55 and 59 GHz
- MTP Sensor and Data Unit located on **right engine cheek** (see figure)
- **ER-2 Heritage**: 280 Flights (1570 Flight Hours)

ER-2 Microwave Temperature Profiler (MTP)



Example MTP-derived temperature field along ER-2 flight track over **TS Humberto during CAMEX-4**. Vertical white stripes are data edited out because of radio frequency interference.

Mahoney

ER-2 Microwave Temperature Profiler (MTP)

Derived products:

Temperature profile/curtain along the ER-2 flight track, tropopause altitude, isentrope surfaces

Science objectives:

Provide mesoscale meteorological context for *in situ* measurements, use derived isentrope surfaces to study dynamical phenomena

Data availability and analysis plan:

Within <1 hour after data taken from a/c, final data within 6 months of end of deployment

Issues and Concerns:

• **MTP uses radiosondes (RAOBs) for absolute temperature calibration**. Transit flights to/from DFRC offer most opportunities for flights near RAOB launch sites. Specifically, we would like to the ER-2 (and WB-57) to **fly near the coast in transit** to and from Key West, rather than fly directly across the gulf to pick up the LCH, SIL, TLH, (JAX, XMR,) TBW, MIA & EYW RAOB launch sites.

• MTP experienced more radio frequency interference during CAMEX-4 than during any previous mission. Can be **mitigated by avoiding the use of the VHF antenna** (located 1 meter from MTP). However, **during test flights, an effort should be made to track down sources of the interference** before deployment.

Mahoney

MODIS Airborne Simulator (MAS)

M. D. King, S. Platnick
NASA GSFC, UMBC

Ames Sensor Facility instrument, NASA Ames:
J. Myers, M. Fitzgerald, et al.

Sensor Characteristics:

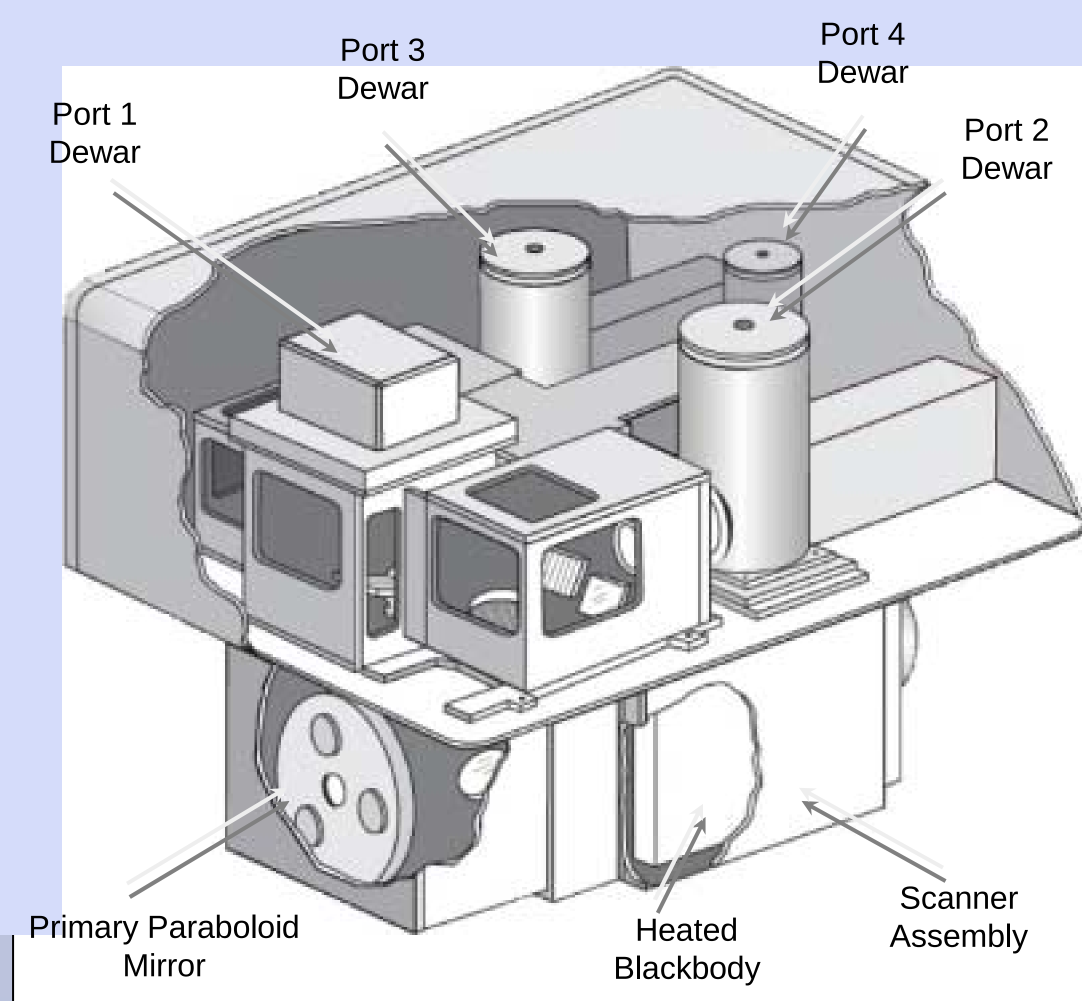
•**50 spectral bands**, from 0.47 to 14.3 µm

•instantaneous field of view: 2.5 mrad **50 m at nadir** (from ER-2 flight altitude)

•scan ±43°, 716 pixels in scan line, ~ **37km swath**

•scan rate 6.25 Hz, 16 bits per channel, 1.72 GB hr^{-1}

•Calibration:
– solar bands: integrating sphere
– thermal: 2 on-board blackbodies



MODIS Airborne Simulator (MAS)

Products: cloud mask (S. Ackerman), thermodynamic phase, optical thickness, particle size (effective radius), and water path

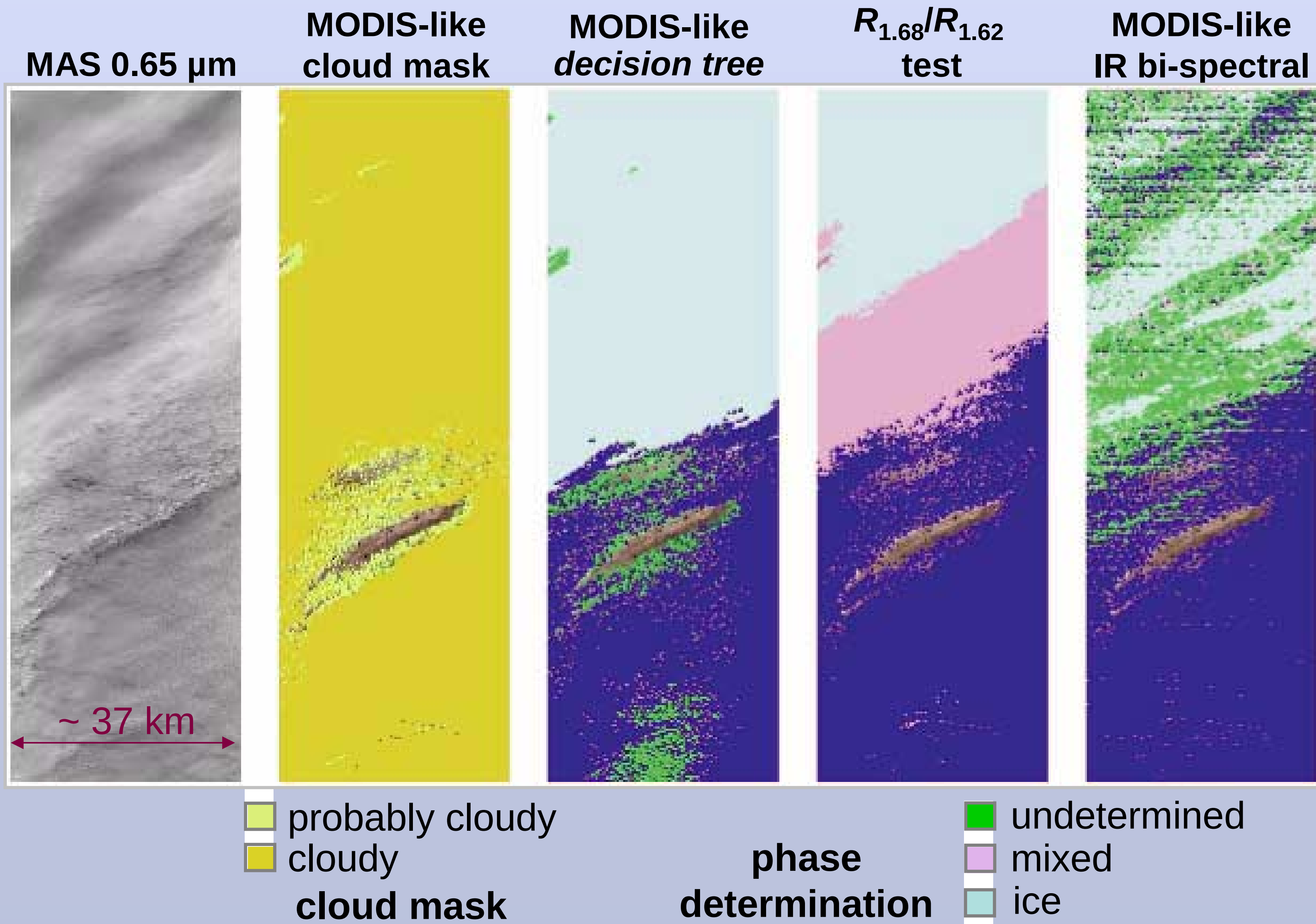
- Phase from MAS SWIR spectral features, IR techniques, cloud mask tests
- Optical thickness, size use solar reflectance technique, VIS through MWIR
  - non-absorbing bands at 0.65, 0.86; absorbing bands at 1.6, 2.1, 3.7 µm

Flight plans: **Aqua/Terra**, **Proteus**, **TO** coordination; **in situ validation**

Field products: preliminary calibration L1B files & quicklook imagery (~24 hrs), selected retrievals (~48 hrs)

C-F inst. synergy: phase comparisons w/**RSP** & airborne **POLDER** (Proteus); retrieval consistency with spectral flux measurements from **SSFR** (ER-2, TO); *IWP* with **CoSSIR**, **CRS**, **FIRSC**; τ with **CPL**

MAS phase algorithm comparison example from FIRE-ACE (over sea ice)

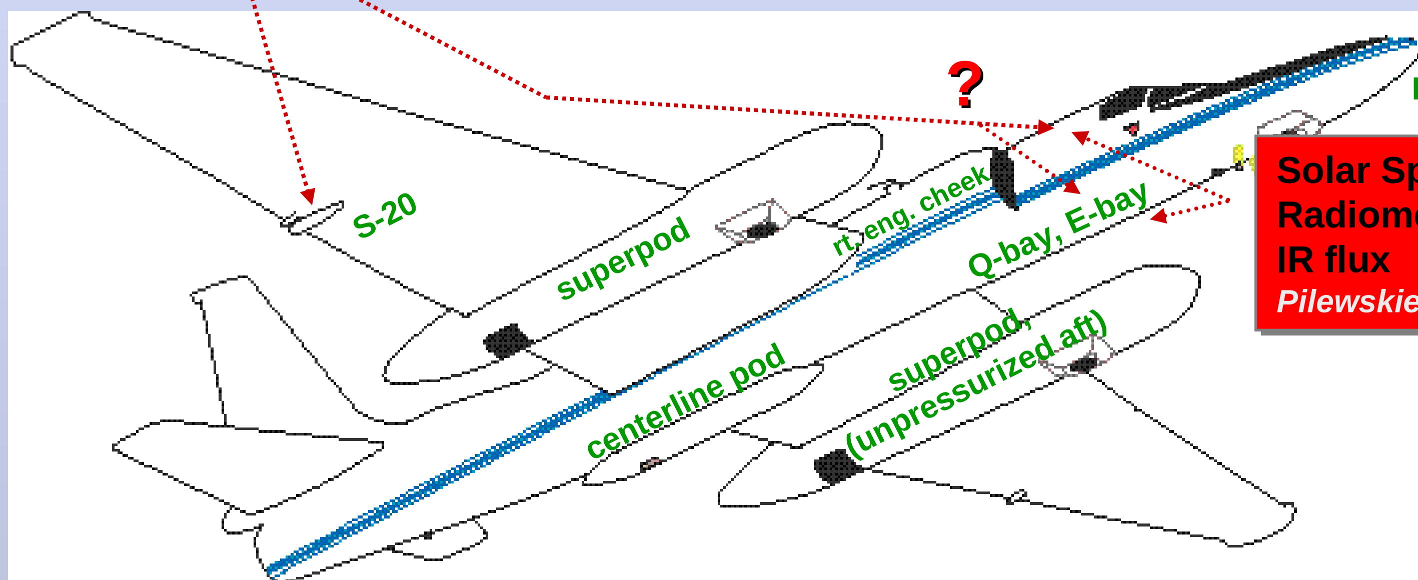


Platnick et al., C-F Science Team Mtg., 30 Jan. 2002

CRYSTAL-FACE ER-2 Instrument Payload
(exact locations subject to cg analysis, integration, etc.)

Broadband/spectral flux instruments

Radiation Meas. System (RAMS) *Valero (Scripps)*



Solar Spectral Flux Radiometers (SSFR), IR flux
Pilewskie (Ames)

Platnick et al., C-F Science Team Mtg., 30 Jan. 2002

Solar Spectral Flux Radiometer (SSFR)
– also on Twin Otter for C-F

ARC Radiation Group: P. Pilewskie, W. Gore, M. Rabbette, L. Pezzolo, J. Pommier, S. Howard, R. Bergstrom

- hemispheric FOV
- wavelength range:
  300 nm to 1700 nm
- spectral resolution: 8-12 nm
- simultaneous zenith and nadir viewing
- accuracy: 3-5%; precision: 0.5%

ER-2 heritage:

FIRE-ACE (1998)

SAFARI-2000 (2000)

Solar Spectral Flux Radiometer (SSFR)

- **Measure Quantities**: Upwelling (F↑) and down- welling (F↓) spectral Irradiance
- **Derived Quantities**
  - Spectral Albedo: F↑/ F↓
  - Net Flux: F↓- F↑
  - Flux Divergence (absorption): $(F\downarrow - F\uparrow)_{top} - (F\downarrow - F\uparrow)_{bottom}$
  - Fractional absorption: $(F\downarrow - F\uparrow)_{top} - (F\downarrow - F\uparrow)_{bottom} / F\downarrow_{top}$
- **Retrieved Quantities**: particle size (r_e), optical thickness (τ), LWP

ARM-UAV

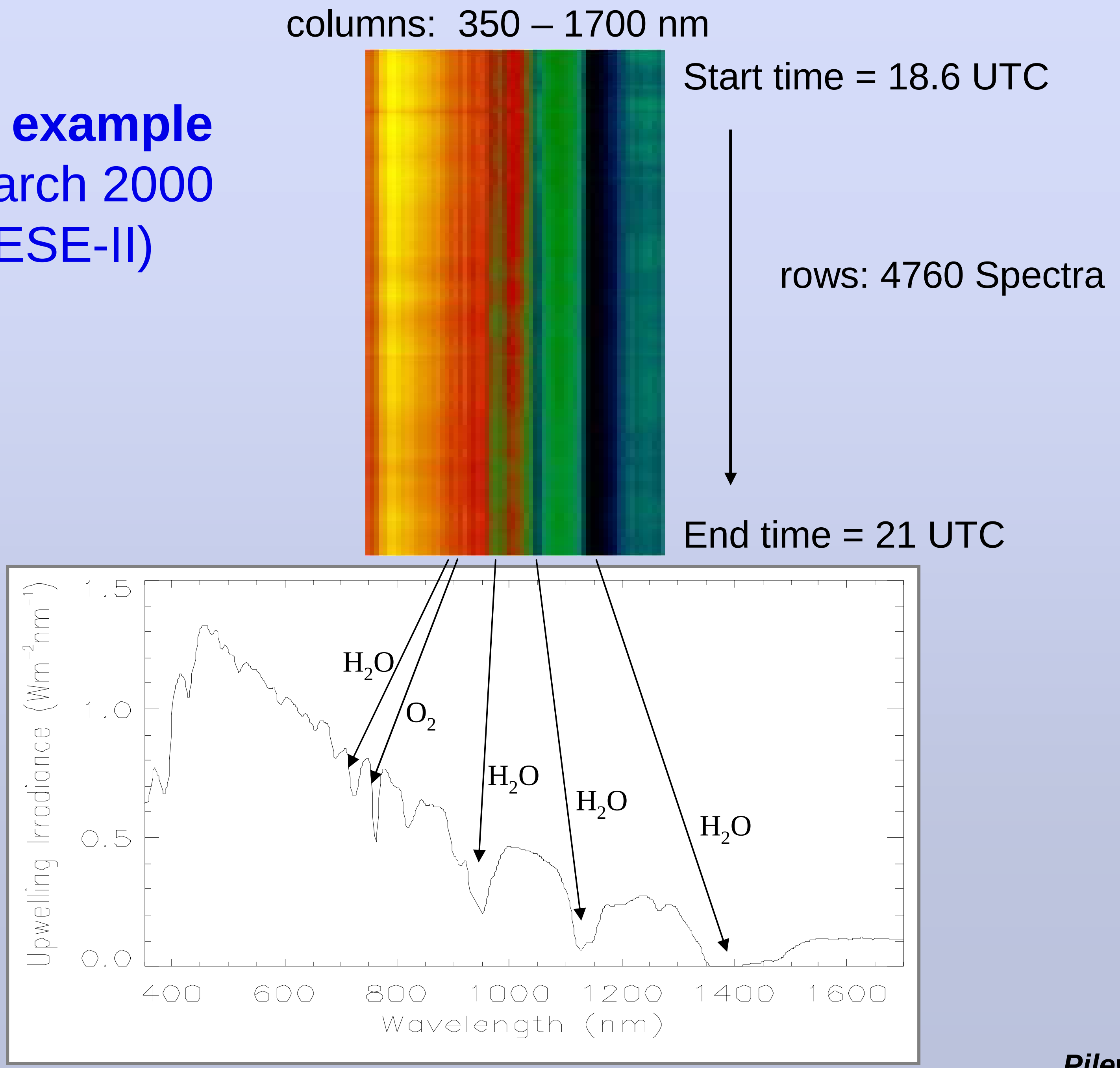
The ARM-UAV Pyrgeometer Sensor

- **Kipp & Zonen CG-4 Pyrgeometer, Modified by Sandia National Laboratory for Aircraft use**
- Designed for high altitude and harsh environments
- Excellent dome/body thermal coupling
- Entire sensor tracks ambient air temperature
- Platinum RTD temperature sensors for repeatability and stability

Pilewskie et al.

SSFR example

(29 March 2000 ARESE-II)



Pilewskie et al.

RAdiation Measurement System (RAMS) on the ER-2 and the WB-57

F. P. J. Valero, S. Pope, et al.

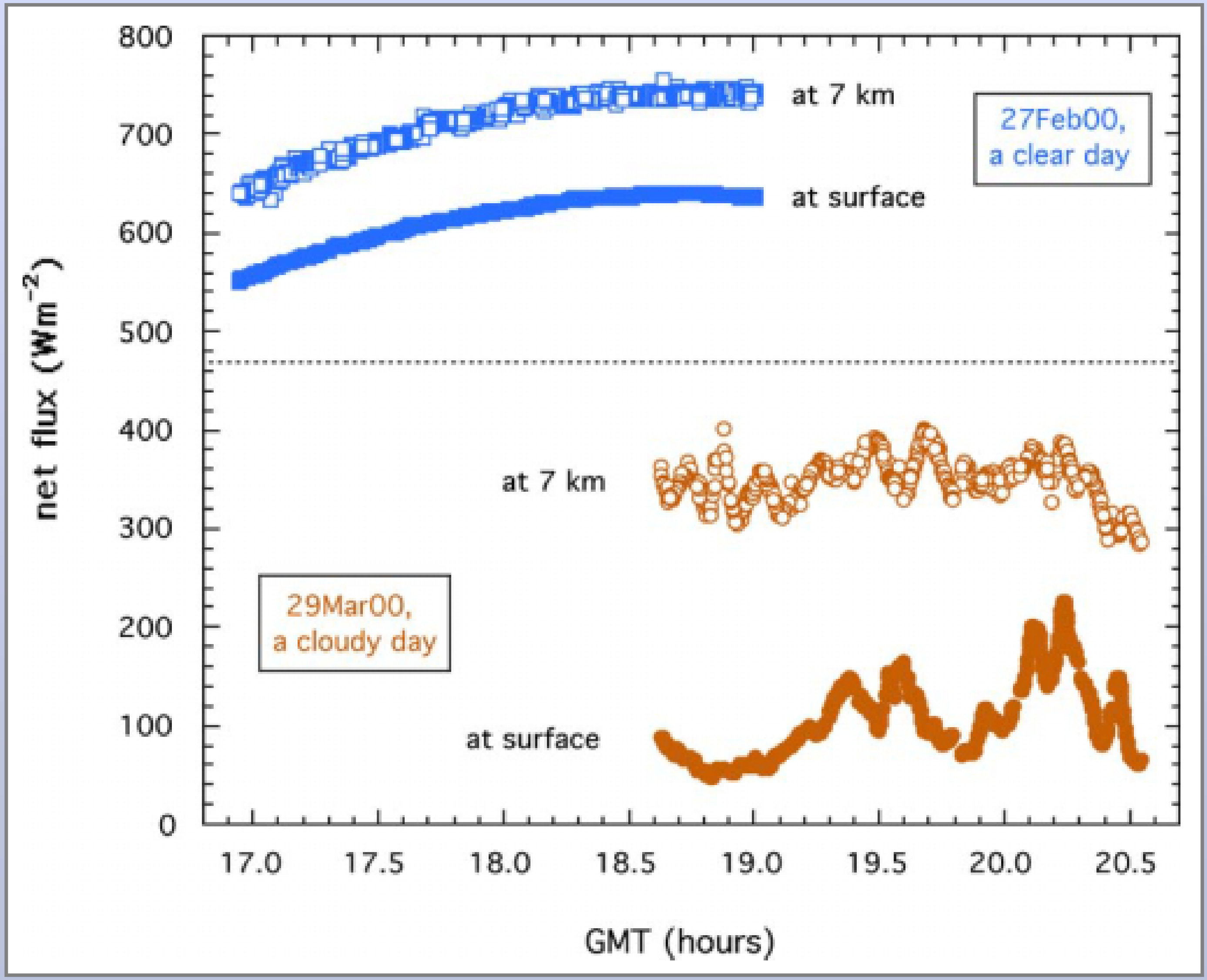
•**ER-2 locations**: S-20 pod, Q-bay (space TBD), NFOV instrument/pod

• **solar broadband** radiometers (TSBRs) – upwelling and downwelling irradiances from 0.224 to 3.91 µm.

• **infrared broadband** radiometers (IRBRs) – upwelling and down-welling irradiances from 4.0 to at least 50 µm.

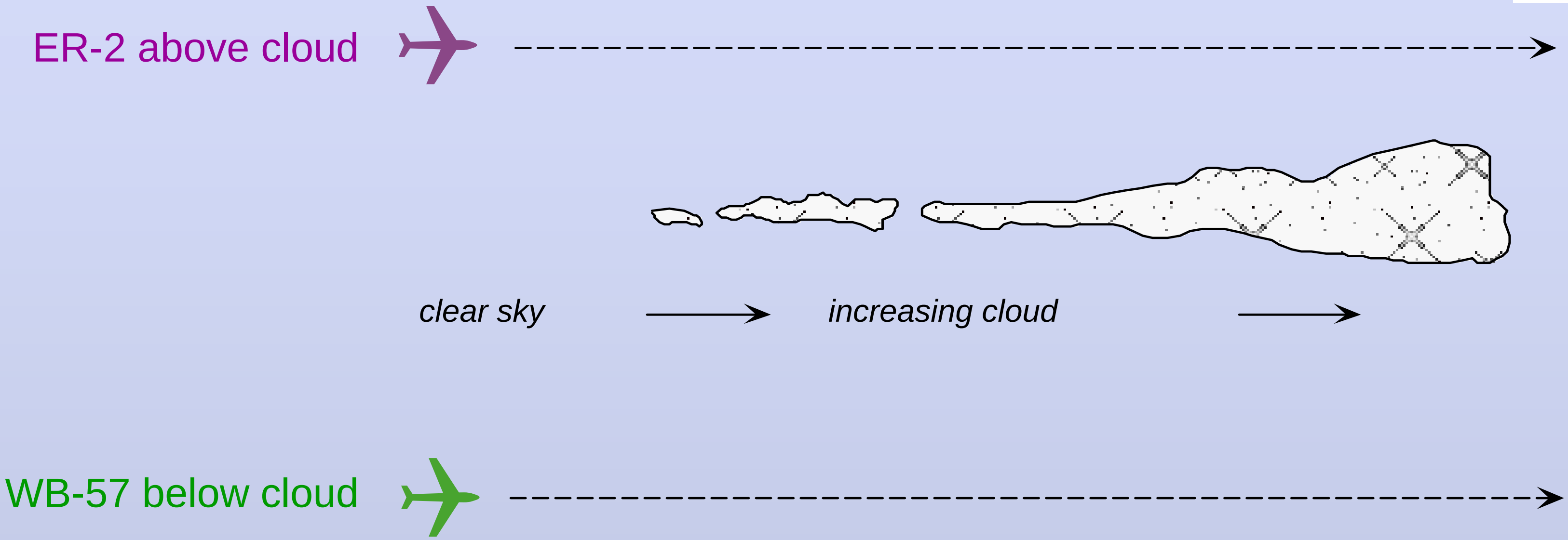
• **total-direct-diffuse radiometers** (**TDDR**s) – up, down fluxes in six 50-nm-wide channels spanning 400 to 700 nm and one 10-nm-wide channel at 500 nm. (Zenith TDDR has shadow-arm so that direct & diffuse components and optical depth can be determined.)

Example of net fluxes measured above and below cloud, during ARESE II in Oklahoma in 2000



Valero et al.

Flight coordination: w/WB-57, matched set of radiometers on each aircraft to measure cloud radiative effects



Science objectives:

•Analyze upwelling and downwelling irradiance data to **determine layer transmittance**, **reflectance**, and **absorptance** using data acquired above, below, and in cloud.

• **C-F instrument synergy**: use **microphysical data** (water vapor concentrations, cloud ice and liquid water measurements) to calculate the expected fluxes and compare them to our observed values.

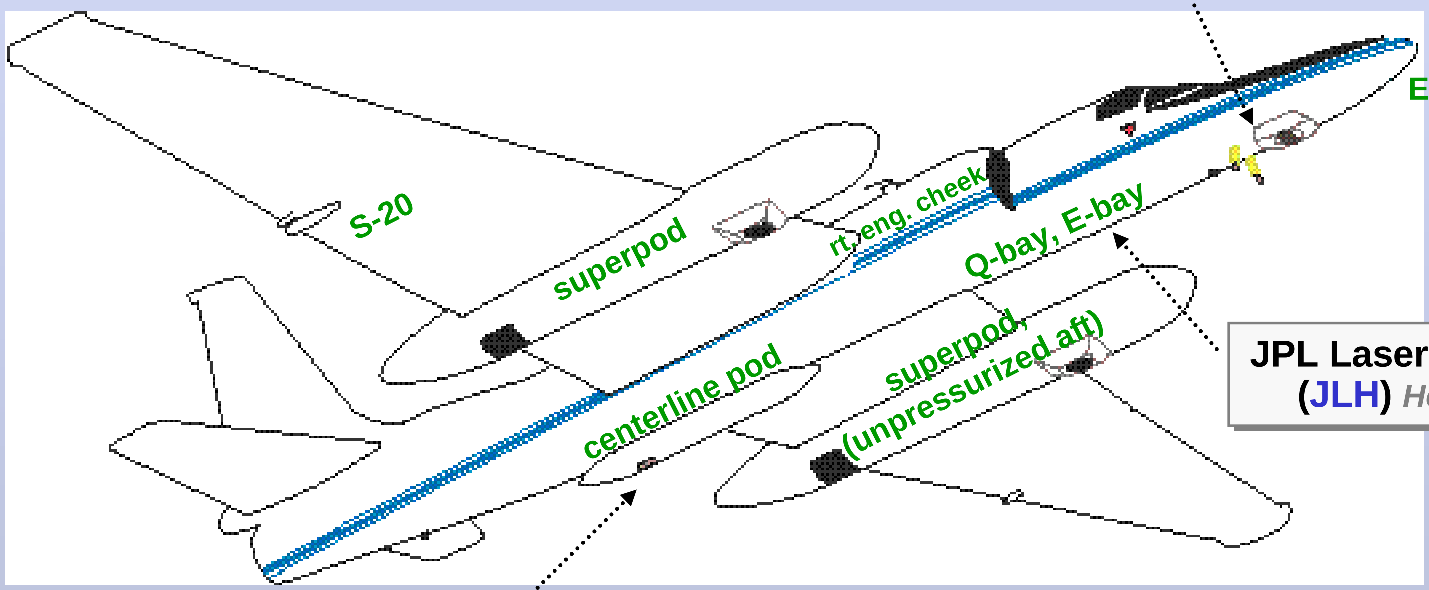
Valero et al.

CRYSTAL-FACE ER-2 Instrument Payload

(exact locations subject to cg analysis, integration, etc.)

In situ meteorology, atmospheric state instruments

Meteorological Meas. System (MMS) *Bui (Ames)*



JPL Laser Hygrometer (JLH) *Herman (JPL)*

Vaisala Dropsonde
Halverson (UMBC), Starr (GSFC)

Advanced Atmospheric Profiling: ER-2 Dropsonde

Jeff Halverson, JCET UMBC, P.I.

Science Objectives:

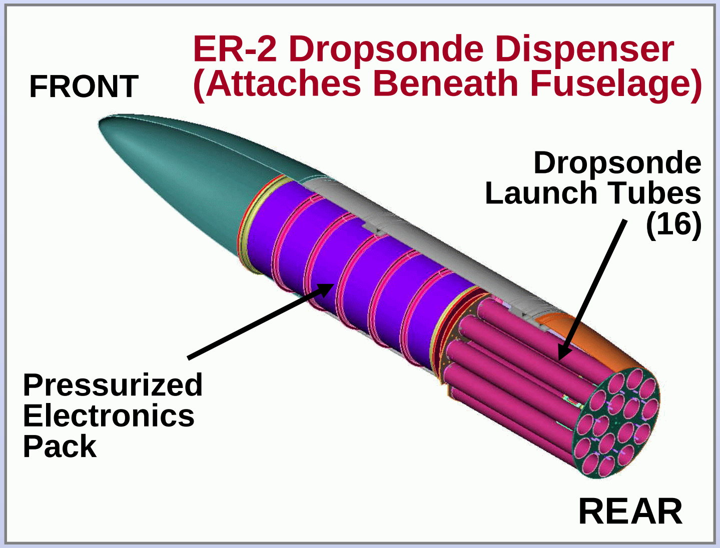
1. Measurement of *in situ* atmospheric thermodynamic and wind profiles within cirrus/cirrostratus anvils;
2. Initialization of numerical prediction models based on targeted observation of marine (undisburbed) inflow regions
3. Elucidation of MCS forcing mechanisms in conjunction with other datasets i.e. radar, satellite

Products in field: *profiles, skewT diagrams, lat/long, ASCII data*

Derived products: *CAPE, CIN, shear, RH /wrt/ ice, theta-e*

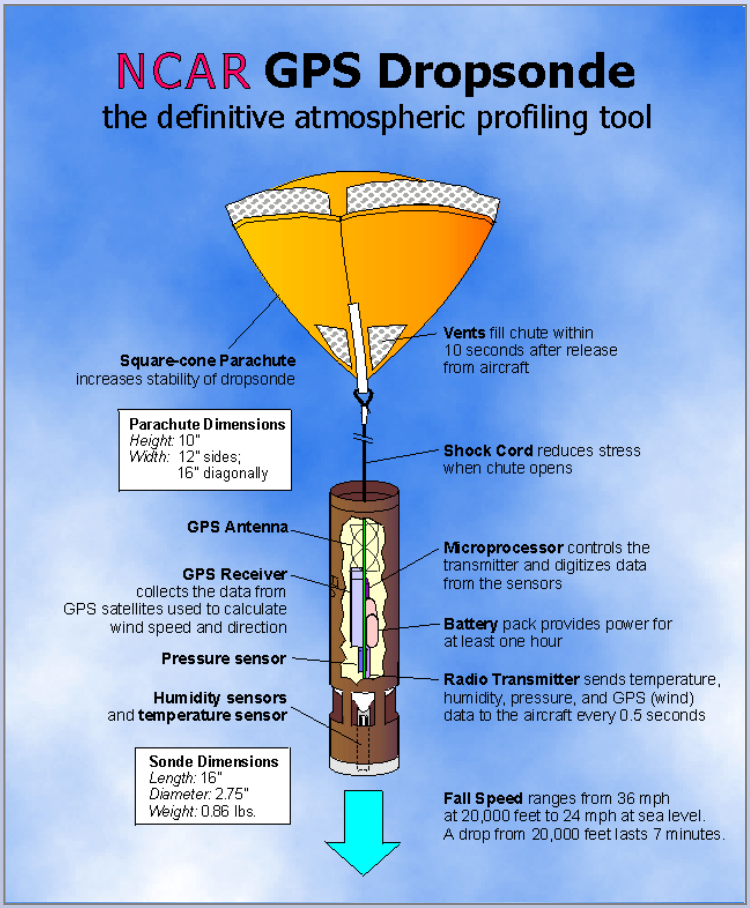
- Developed for ER-2 during 2000-01 by NCAR, DFRC, Vaisala Inc., UMBC
- Deployed during **CAMEX-4**, Aug-Sept 2001
- Successful soundings in Hurricane Erin from FL700 & other tropical cyclones
- 2 Hz *in situ* sampling of *T*, *RH*, *P*, wind components (code correlating GPS)
- **23-25 min for sonde to descend** from FL700
- **4-channel capability** (four sondes simultaneously in the air)
- **16 sonde capacity per mission**
- Data telemetered from sonde to ER-2 computer, downloaded after landing
- Completely autonomous system: single push button for pilot, status lights
- QC filters & algorithms applied to data immediately after landing
- **Caveats: 1) No drops over land or aircraft; 2) Must include in ATC flight plan**

Advanced Atmospheric Profiling: ER-2 Dropsonde



Dropsonde Dispenser Removed from Plane

Anatomy of GPS Dropsonde



Halverson

Meteorological Measurement System

T. Paul Bui, NASA Ames Research Center (ARC)

The Meteorological Measurement System (MMS) is a proven instrument to measure accurate, high resolution *in situ* airborne state measurements. Accurate measurements of these quantities **require judicious choices of sensor locations**, repeated laboratory calibrations, and proper corrections for compressibility, adiabatic heating and flow distortion.

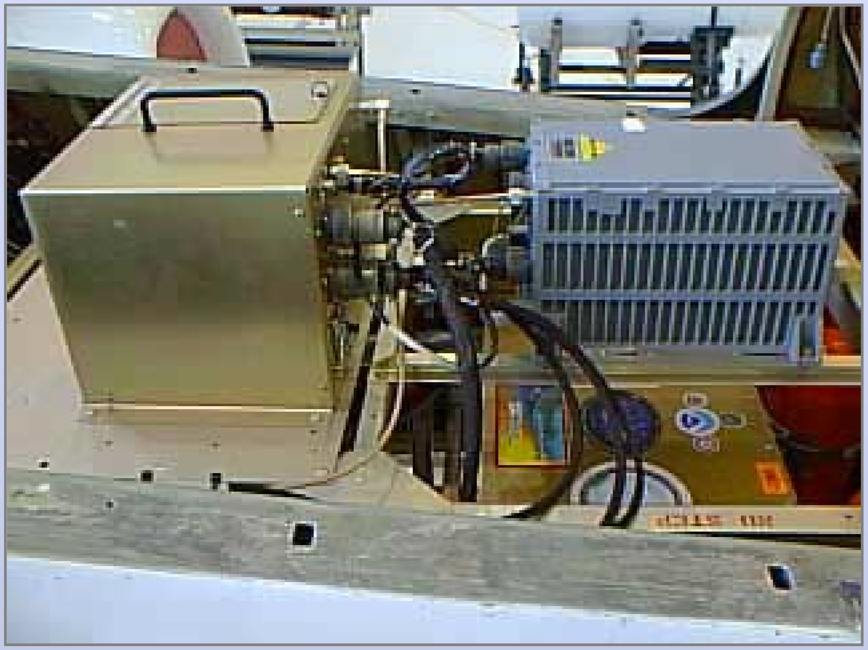
Primary Products @20 Hz	***Typical value***	***Precision***	***Accuracy***	
Pressure	~ 60 mb	0.1 mb	± 0.3 mb	~ 0.5%
Temperature	~ 180 K	0.1 K	± 0.3 K	~ 0.2%
Horizontal Wind	~ 30 m s^{-1}	0.1 m s^{-1}	± 1 m s^{-1}	~ 3.3%
Vertical Wind	< 1 m s^{-1}	0.1 m s^{-1}	time averaged ~ 0.0 ms^{-1}	

Other Products: potential temperature, true-air-speed, turbulence, DGPS positions, velocities, accelerations, pitch, roll, heading, Angle-of-Attack, Angle-of-Sideslip, dynamic & total pressures, total temperatures.

Past Missions: STEP, AAOE, AASE-I, SPADE, AASE-II, ASHOE/MAESA,
(ER-2 & DC-8) STRAT, POLARIS, SOLVE, SUCCESS, SONEX, CAMEX-3/4

Meteorological Measurement System

ER-2 SOLVE Installations



The MMS Data System and ring laser INS mounted in the ER-2 Q-bay

Pitot/Temperature probe on top
Fast Rosemount Temperature probe on side

Modification for ER-2 CRYSTAL-FACE:

1. Integrate with **EDOP nose cone**
2. Increase basic raw data sample rate to 300 Hz
   (power spectra is limited by sensor response and installation)

Bui

JPL Laser Hygrometer on the ER-2

Robert L. Herman
Jet Propulsion Laboratory

Instrument Description:

The JPL Laser Hygrometer (JLH) is a **near-infrared, open-path, tunable diode laser spectrometer** for *in situ* measurements of atmospheric water vapor. To insure measurements in "clean" air and avoid sampling issues, the optical cell is mounted external to the boundary layer of the aircraft. The optical path is folded between two mirrors (**total path = 11.13 m**). Rapid measurements are made by scanning the laser across a single absorption line in the **7300 cm-1 (1.37 μm) water combination band**.

Specifications:

- Detection range: 0.1 to 100 ppmv
- Accuracy: 5%
- Precision: 0.03 ppmv H_2O
- Time-resolution: 1.3 sec
- Mass: 20 lbs.
- Power: 100 W (maximum)
- Voltage: 28 V DC

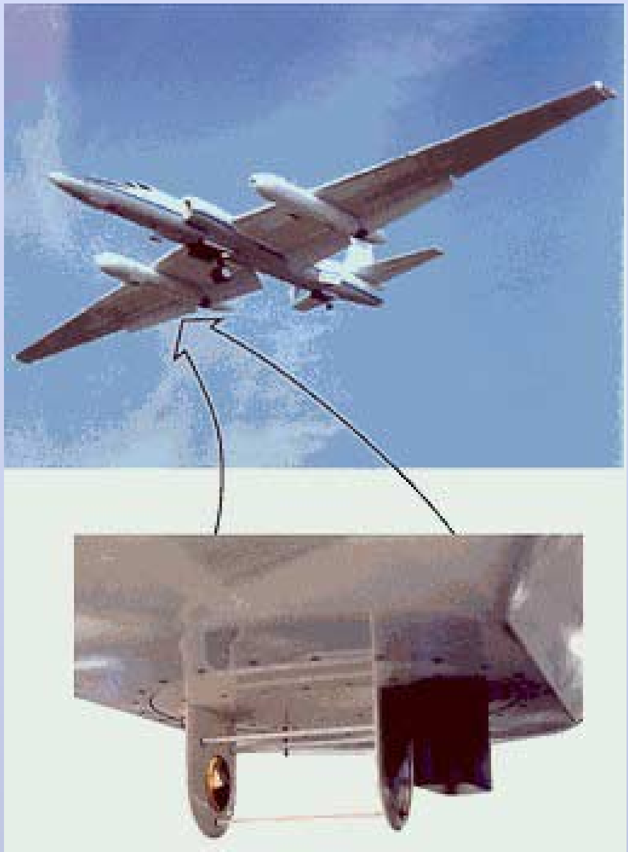
Spectrometers in CRYSTAL-FACE:

- JLH on NASA ER-2 (100-60 hPa)
- JLH on WB57F (150-60 hPa)

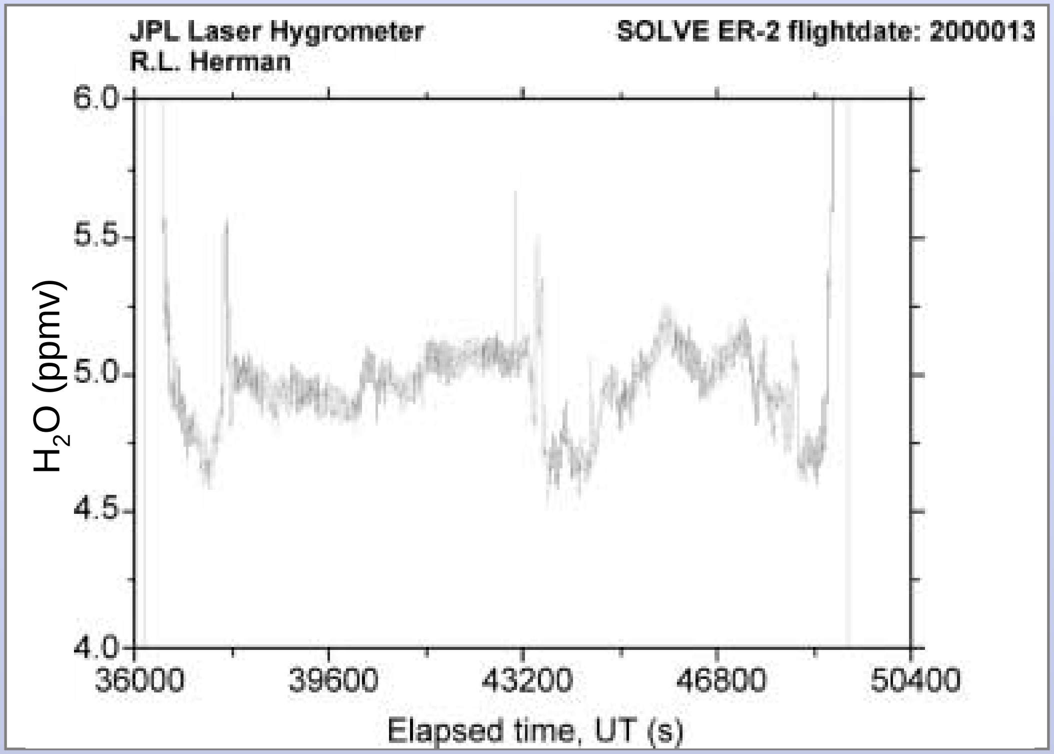
Recent missions:

POLARIS, CAMEX-3 and -4, WAM, ACCENT, SOLVE

JPL Laser Hygrometer on the ER-2



JLH shown mounted on the ER-2. The multipass open-path optical cell is on the left (white) and the laser/detector housing is on the right (blue). For CRYSTAL, JLH will be mounted in the **lower Q-bay** of the ER-2.



Stratospheric water vapor measured by JLH during NASA SOLVE campaign.

R. Herman

JPL Laser Hygrometer on the ER-2

Robert L. Herman
Jet Propulsion Laboratory

Science objectives:

Measure *in situ* water vapor mixing ratios in the stratospheric *middleworld* and *overworld* to study transport and the distribution of water in the atmosphere.

Data products:

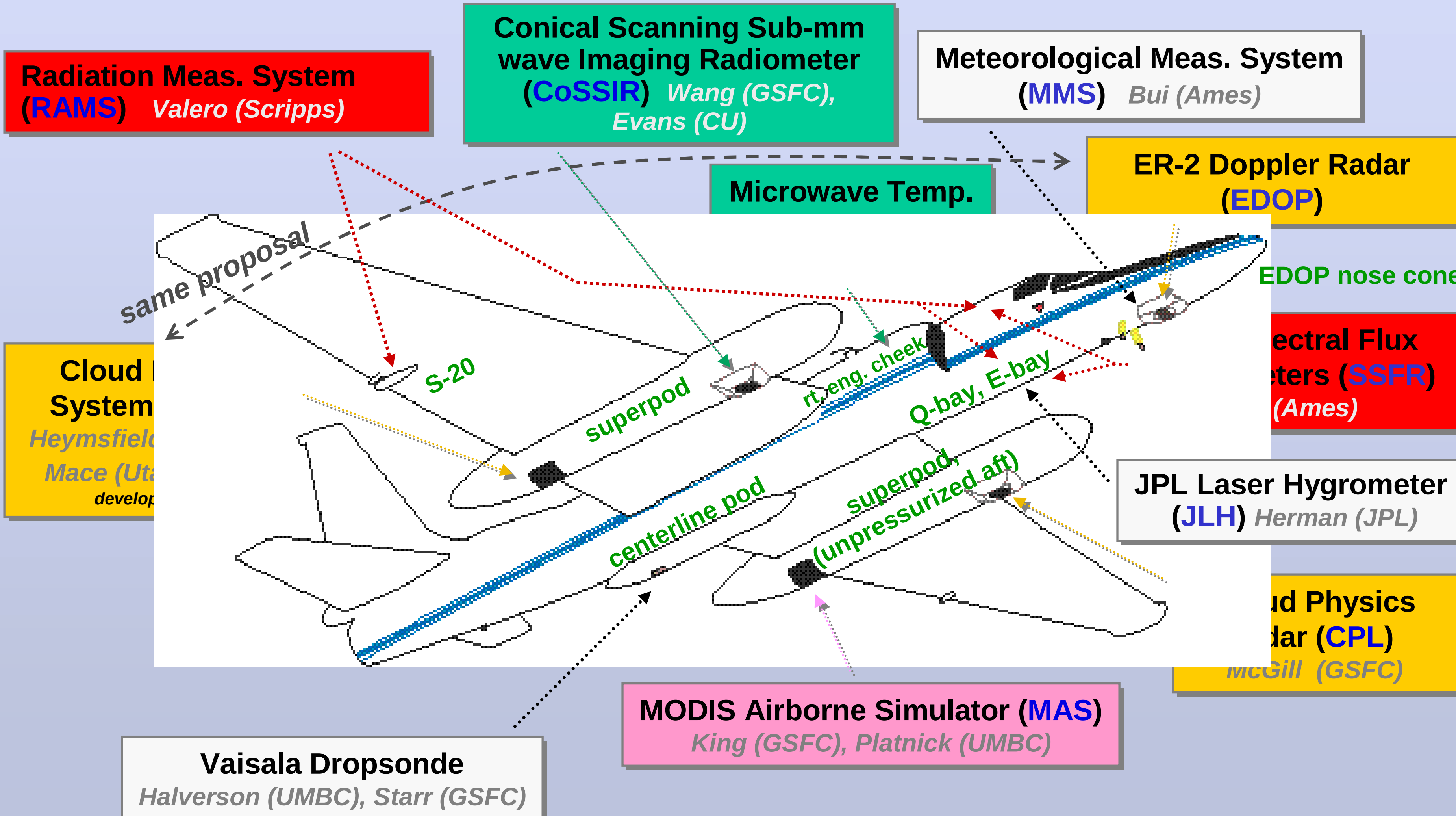
Water vapor mixing ratio, relative humidity, supersaturation (if in clouds), frost point, water partial pressure, and equivalent potential temperature at 0.7 Hz.

Desired or needed coordination with instruments:

In situ temperature and pressure measurements on board the ER-2 are required (**MMS**). Intercomparison with water instruments on the **WB-57** is highly desired.

CRYSTAL-FACE ER-2 Instrument Payload

(exact locations subject to cg analysis, integration, etc.)



Platnick et al., C-F Science Team Mtg., 30 Jan. 2002

ER-2 measurement summary

Instrument	phase	D_e	IWP	τ_c	flux (spectral, broadband)	vertical structure	state, meteo.
CoSSIR		X	X				$H_2O(z)$
CRS			X			X	v
EDOP			X			X	v
CPL	X			X		X	
MAS	X	X	X	X			
SSFR					X		
RAMS					X		
MTP							$T(z)$
MMS							X
JLH							H_2O
Dropsonde							X

ER-2 flight planning

Objectives: Cb/anvil, thin cirrus studies coupled *with* remote sensing validation (ER-2 vs. other C-F aircraft, all vs. satellite), studies of opportunity

Satellites of interest:

Aqua (18 April 2002, 1330 local): MODIS, CERES, AIRS, AMSR-E

Terra (1030 local): MODIS, CERES, MISR, ASTER

Envisat (March 2002, 1000 local): interest from SCIAMACHY team (also flies AATSR, MERIS)

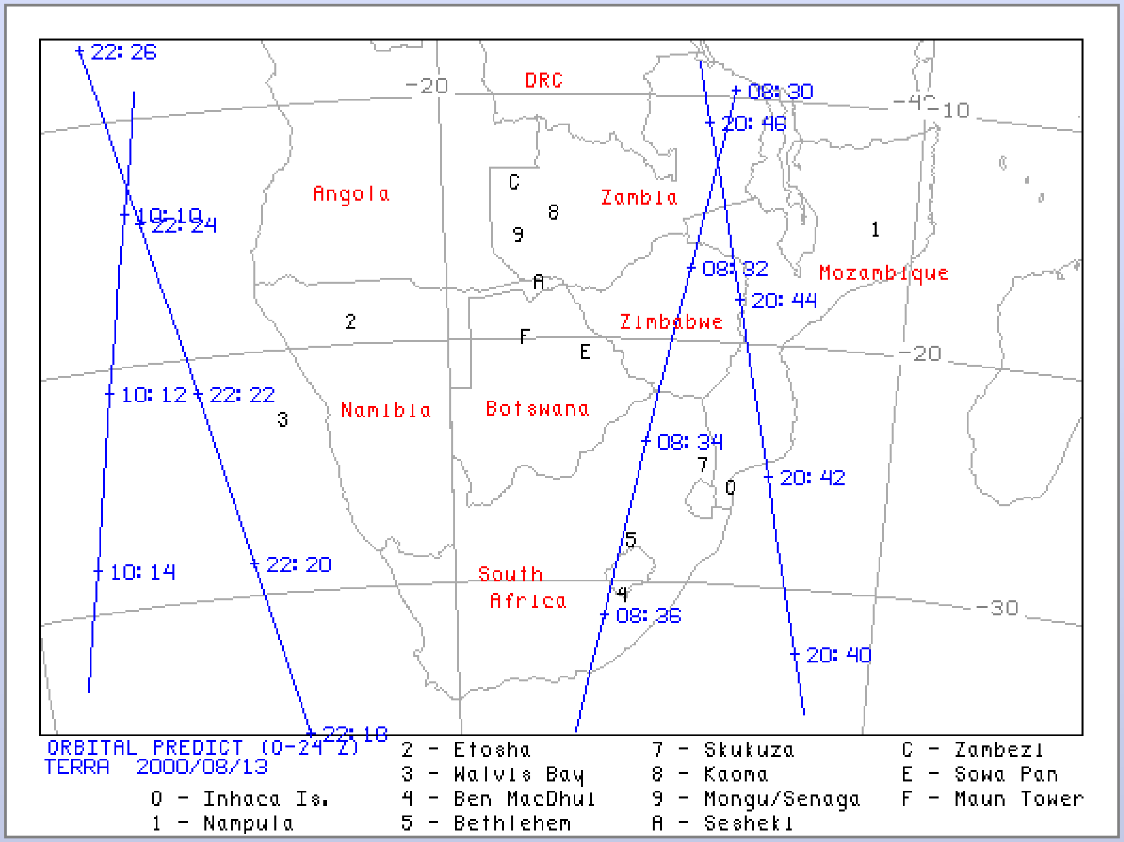
ER-2, Proteus payload is an "A-train" simulator: Aqua (MAS, SSFR, RAMS), CloudSat (CRS), Calipso (CPL), Parasol (POLDER, RSP), …

ER-2 flight planning issues

Coordination with Proteus: preferred solar scattering angles for RSP, POLDER phase, habit retrievals

Satellite coordination: radiometric validation requires similar geometry (e.g., similar heading)

Satellite prediction: Minnis et al. web-based calculations, graphics



Skukuza, space craft is - **TERRA**

lat=-25.02 lon= 31.50 geocen lat= -24.87 lcl rad(km)= 6374.4

gmt yr	mo	da	hr	mn	viewing zenith	sat azm fr. north	relative azimuth	solar zenith	sat heading	satellite direction	dist to site(km)	MODIS (1165km)	MISR (180km)	ASTER (30km)
00	8	13	20	42	24.55	79.07	164.10	159.24	349.07	asce	288.89	+	-	-
00	8	14	21	25	52.87	254.06	36.56	166.63	344.06	asce	777.62	+	-	-
00	8	15	8	22	2.55	111.60	77.75	45.35	201.60	d	30.43	+	+	-

ER-2 flight planning issues, cont.

General Cb/anvil strategy issues:

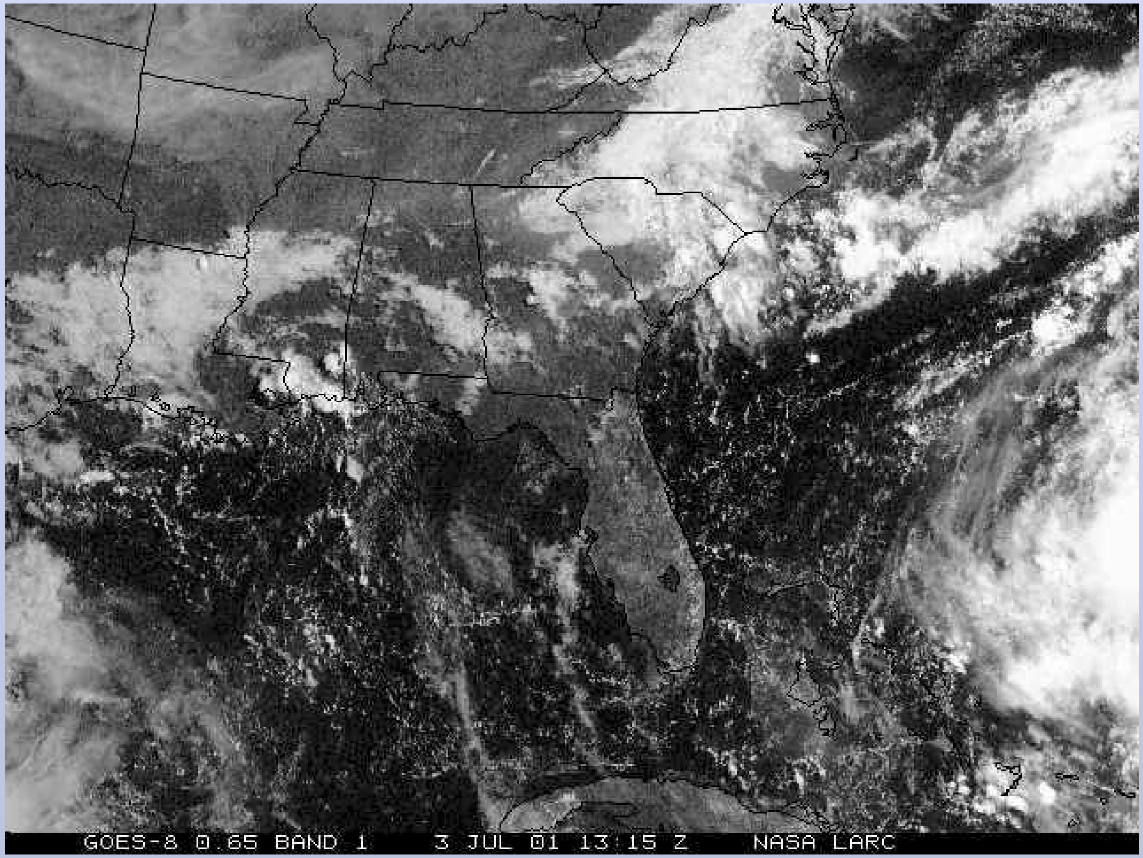
Cross-anvil legs, along-anvil legs? Ability to predict anvil axis? Dealing with rapidly changing systems? In-flight updates of ER-2 waypoints? Dealing with single cell Cb/anvils vs. multicell?

Personal opinion:

- *cross-anvil for remote sensing platforms*
- *along-anvil for in situ platforms*

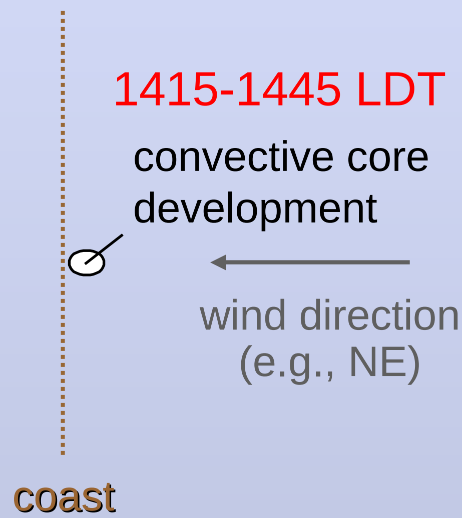
cross-track strategy for remote sensing platforms can maximize likelihood that nadir instruments will observe anvil, provide more in situ validation opportunities

GOES-8 loop, 3 July 2001, 0915-1845 EDT from Langley CLAMS web site

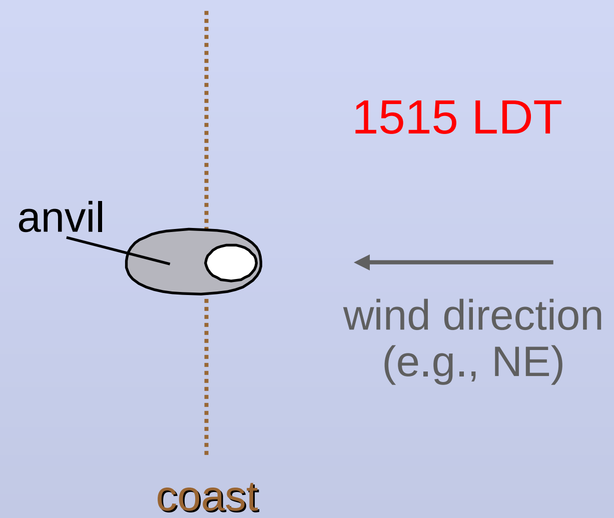


schematic Cb/anvil scenario
w/remote sensing validation
(*greatly simplified*)

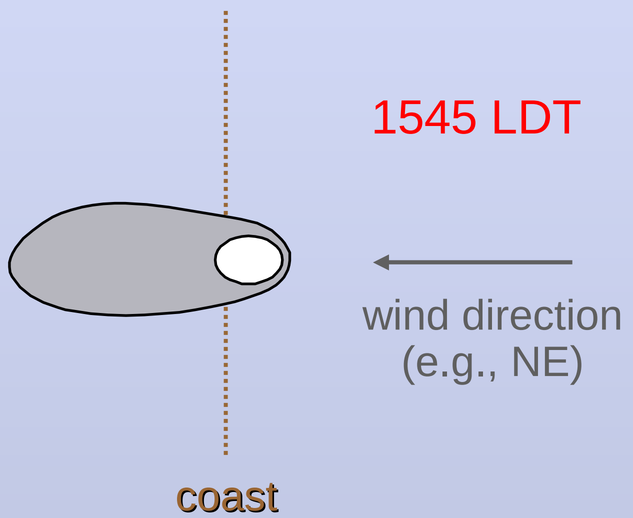
schematic Cb/anvil scenario



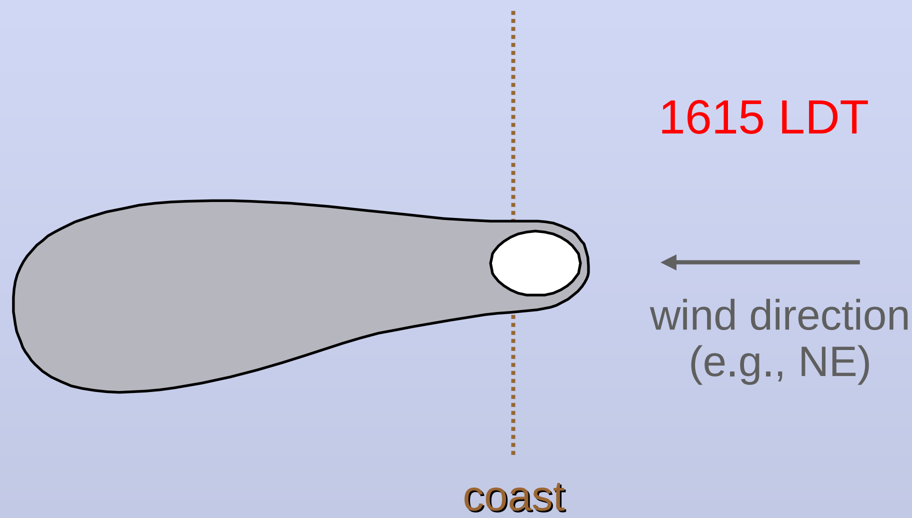
schematic Cb/anvil scenario



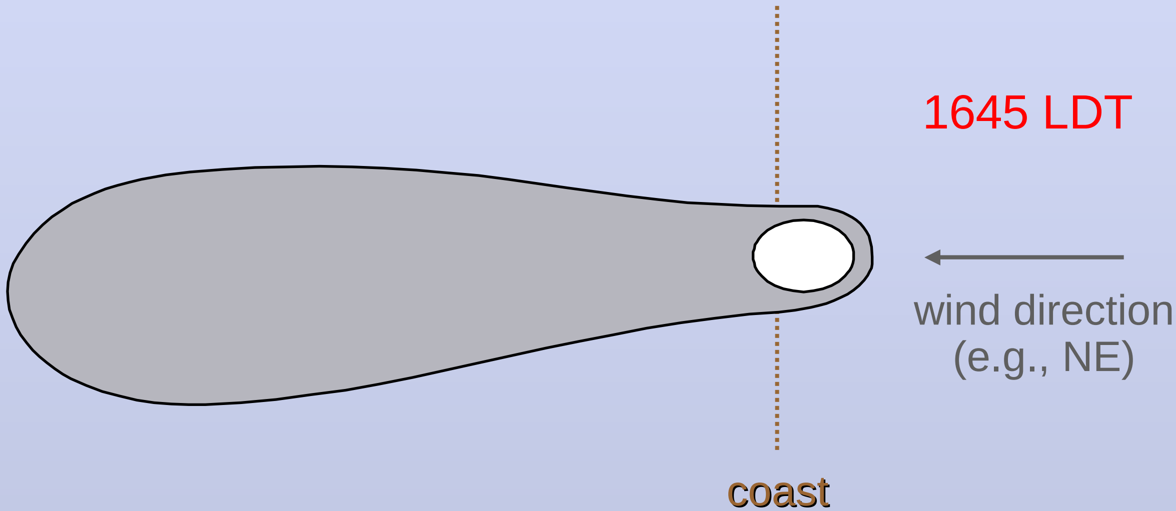
schematic Cb/anvil scenario



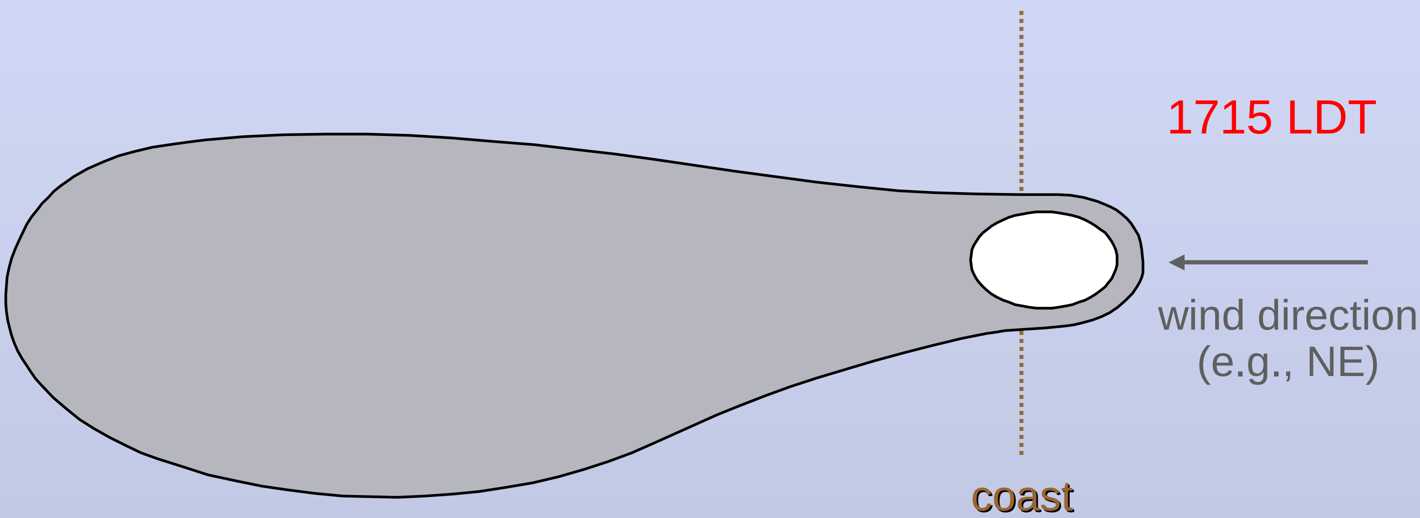
schematic Cb/anvil scenario



schematic Cb/anvil scenario



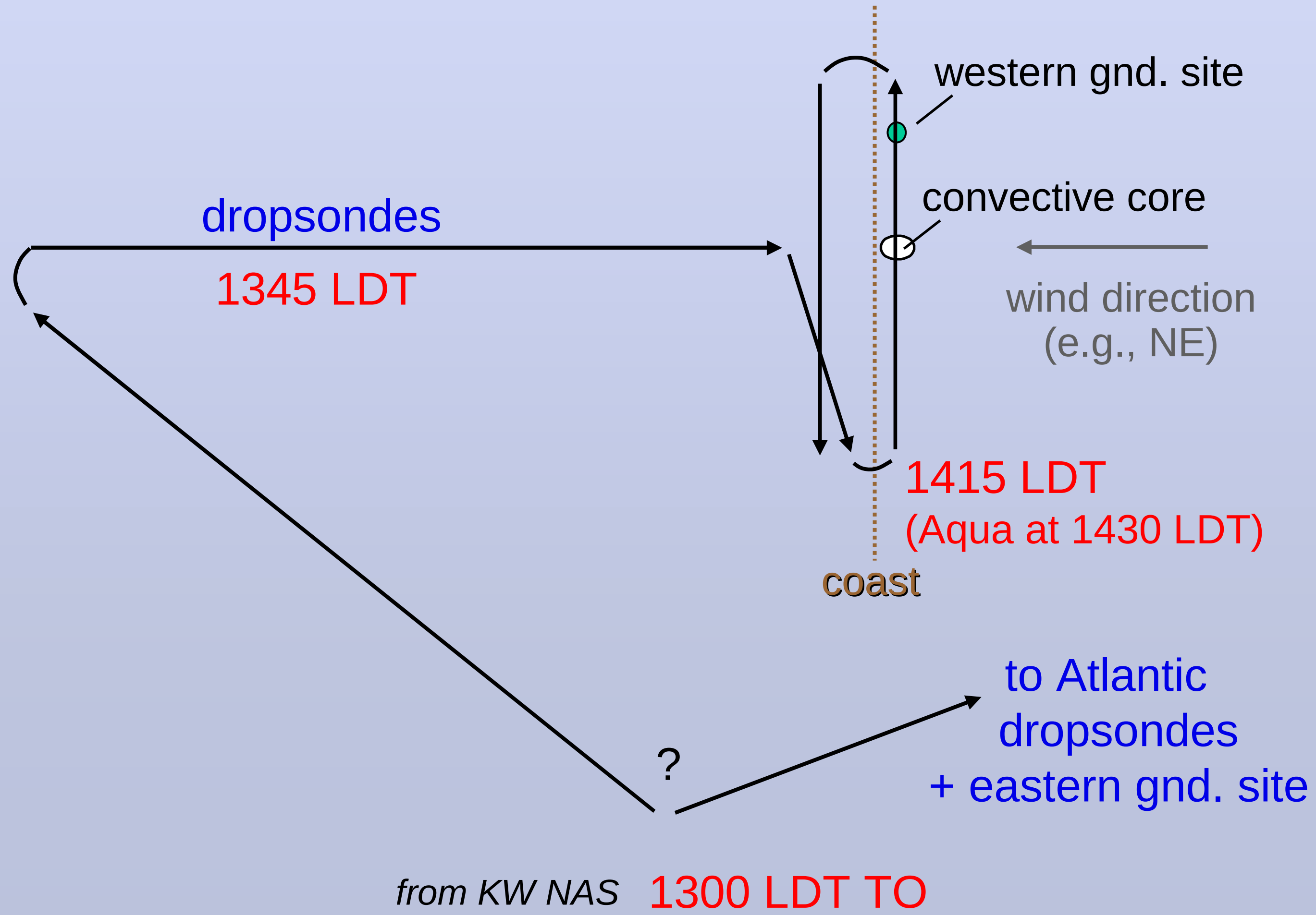
schematic Cb/anvil scenario



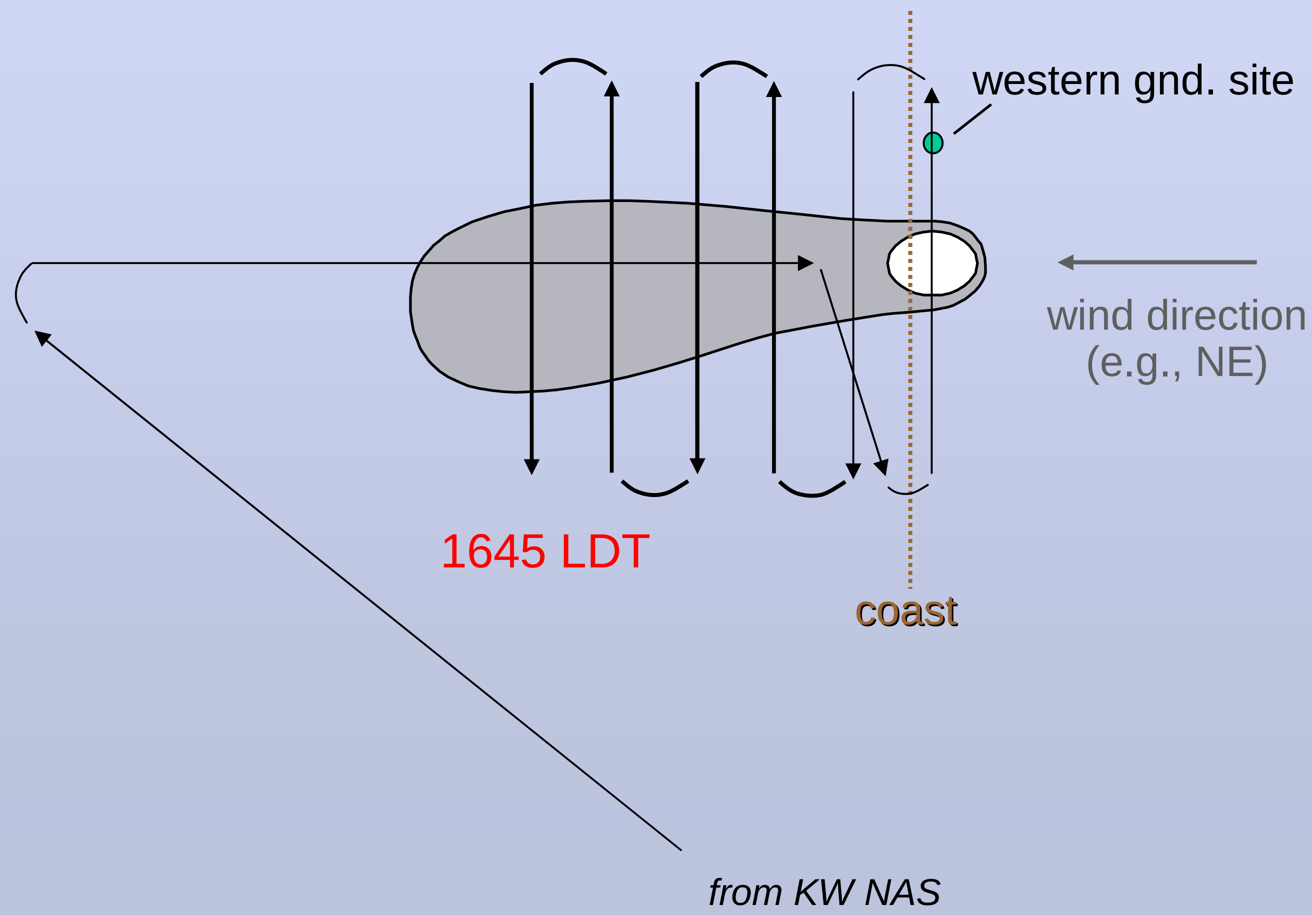
example flight plan for Cb/anvil scenario (not to scale)

philosophy: keep it simple,
allow more flexible aircraft to make adjustments

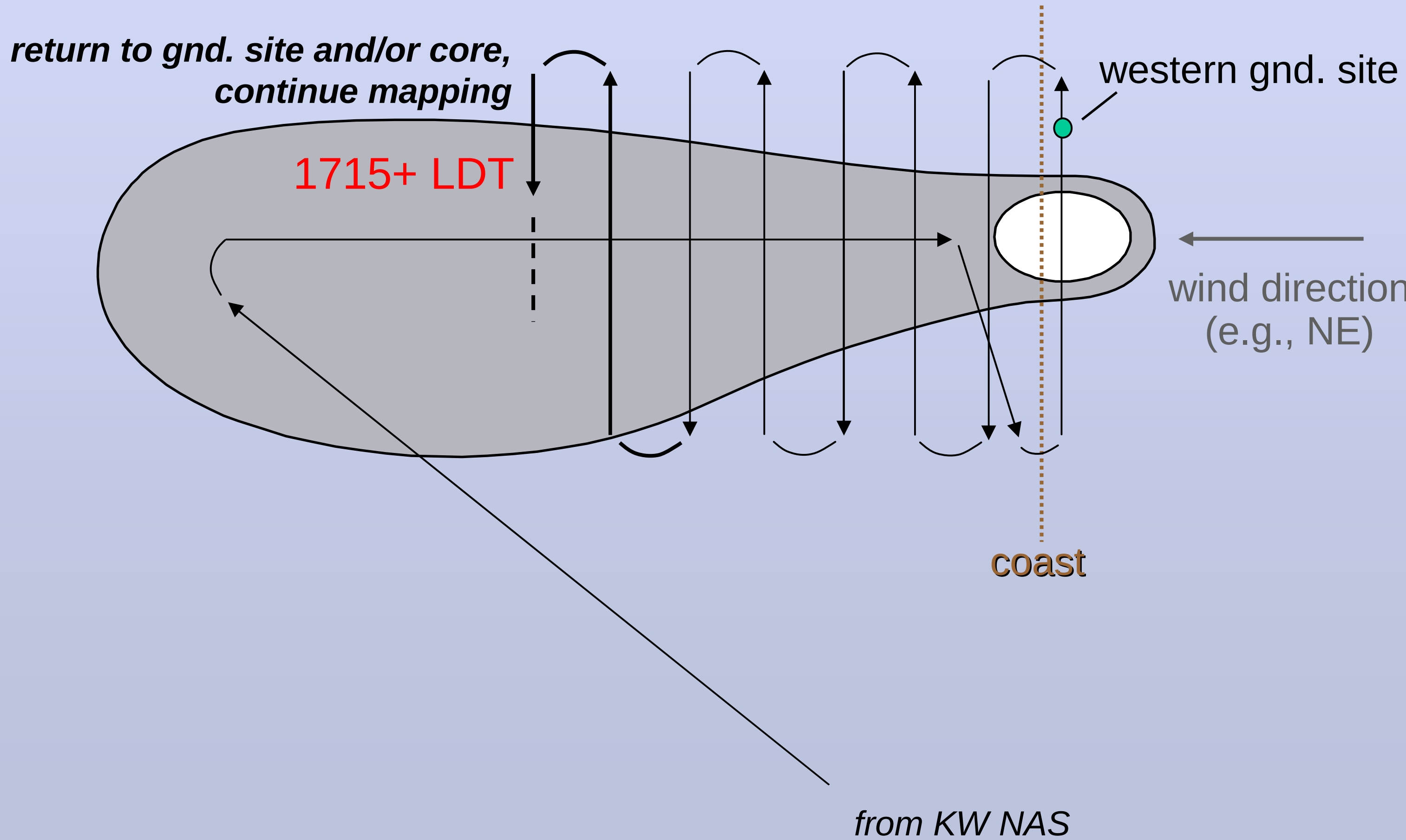
example flight plan for Cb/anvil scenario (not to scale)



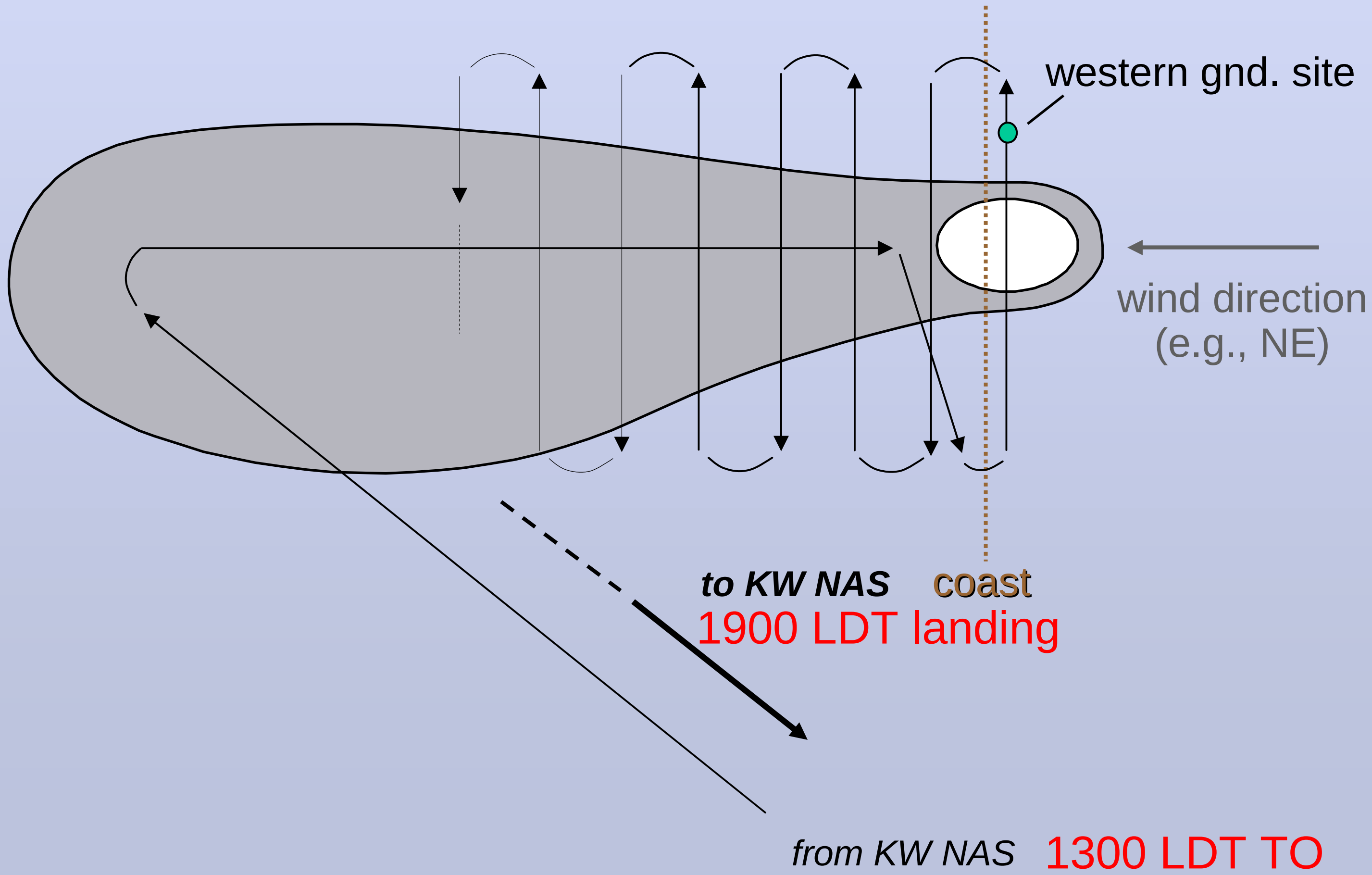
example flight plan for Cb/anvil scenario (not to scale)



example flight plan for Cb/anvil scenario (not to scale)

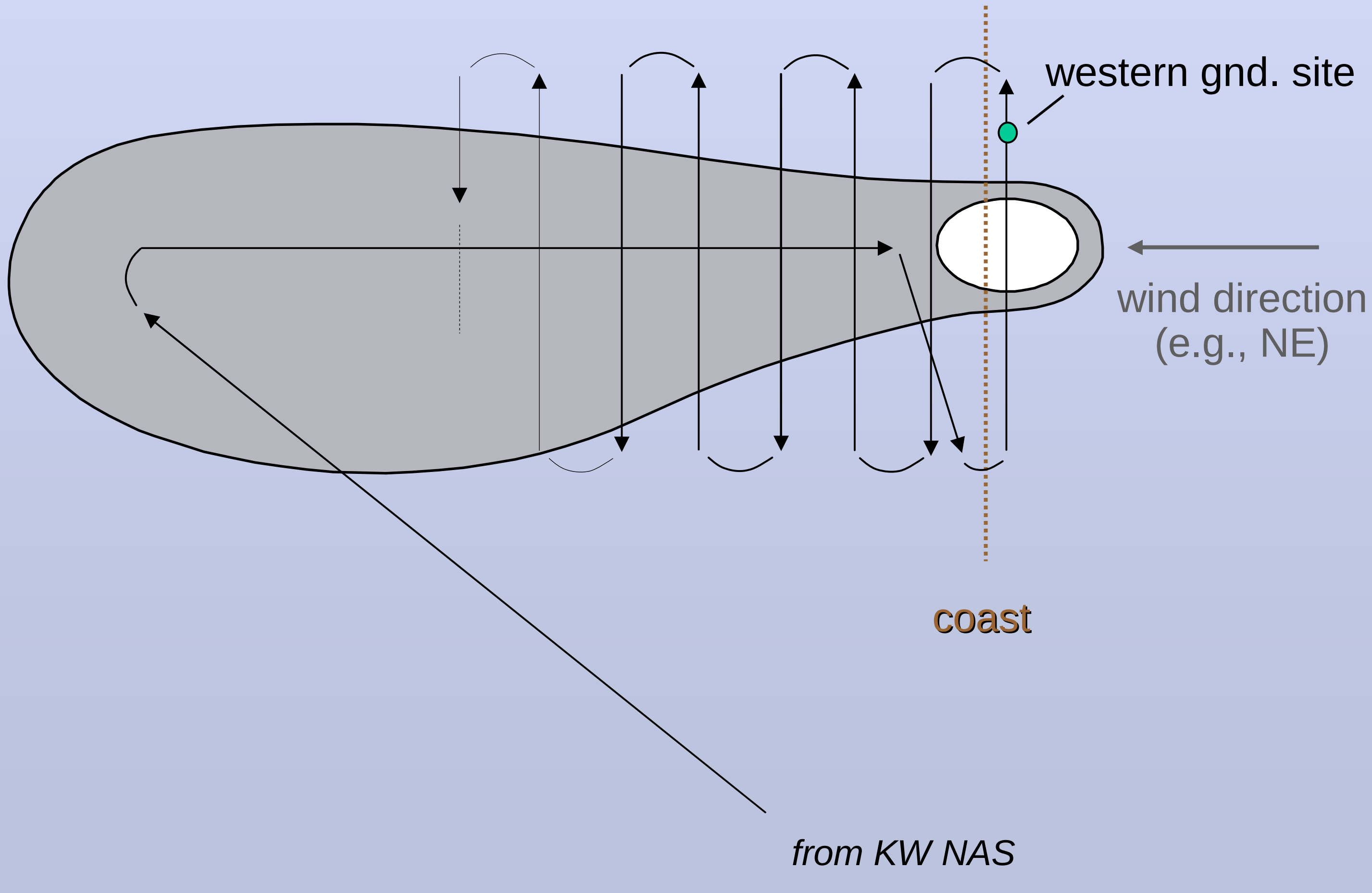


example flight plan for Cb/anvil scenario (not to scale)



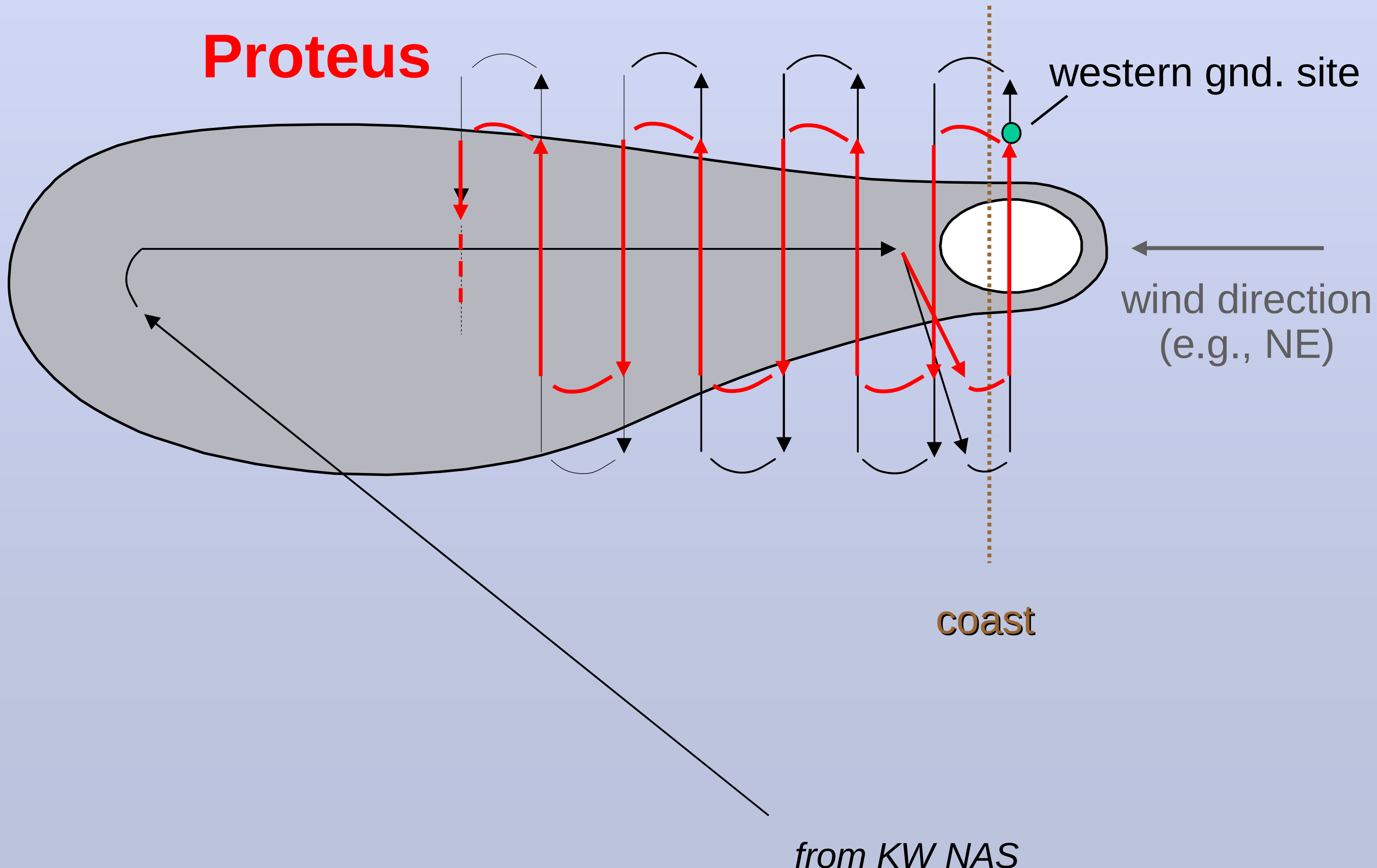
example flight plan for Cb/anvil scenario (not to scale)

Example coordination with other aircraft



example flight plan for Cb/anvil scenario (not to scale)

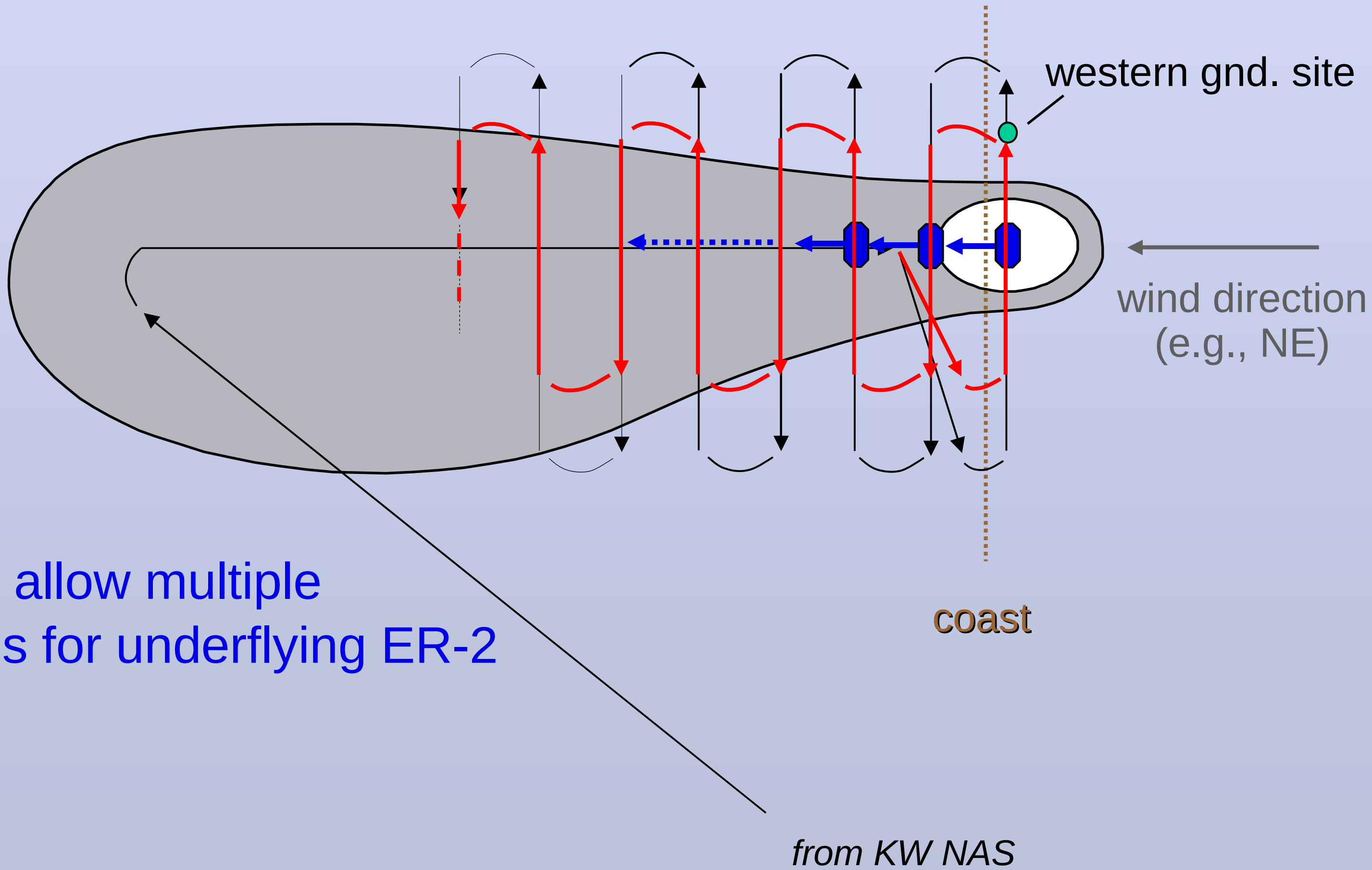
Example coordination with other aircraft



Platnick et al., C-F Science Team Mtg., 30 Jan. 2002

example flight plan for Cb/anvil scenario (not to scale)

Example coordination with other aircraft

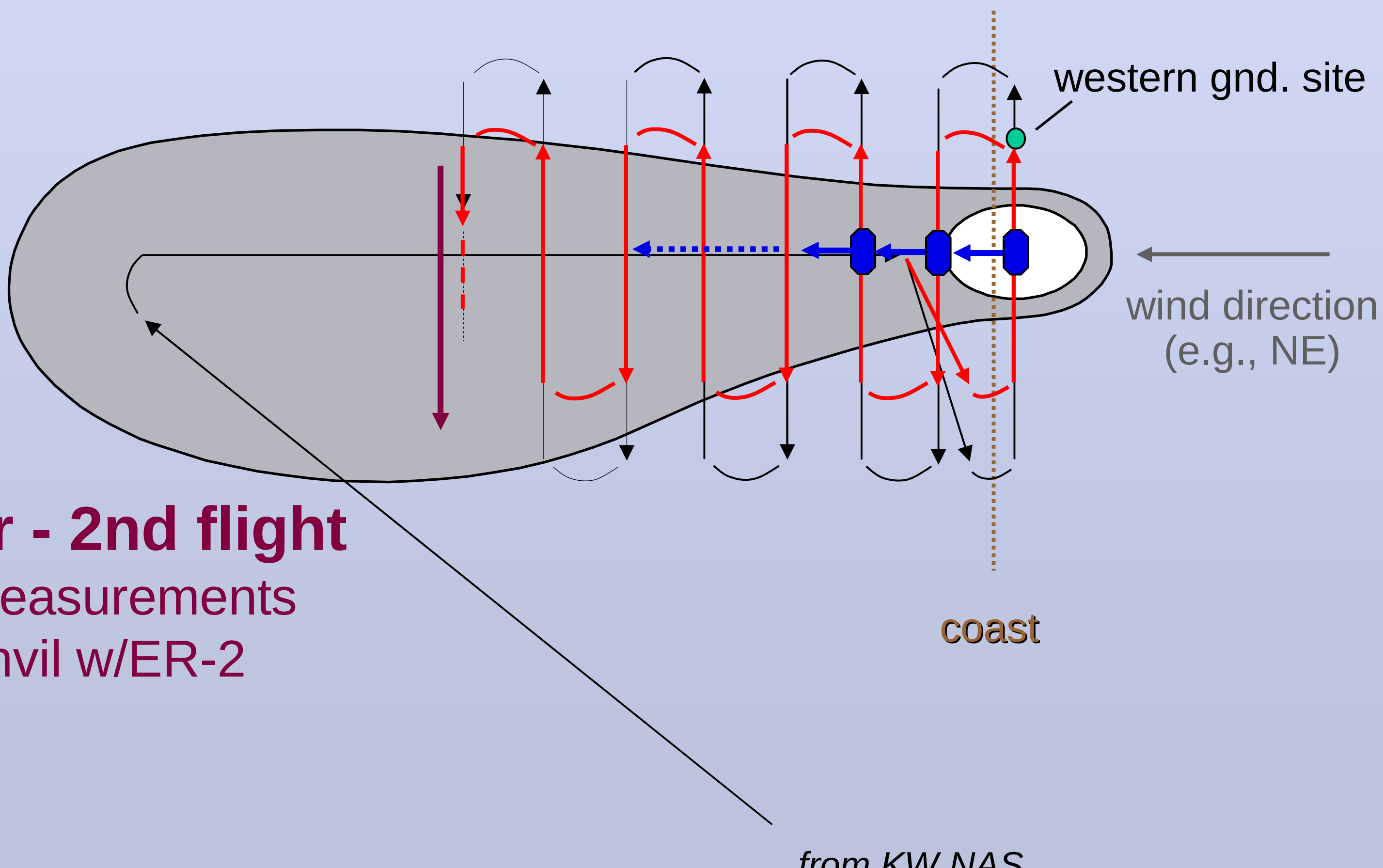


in situ

along-anvil: allow multiple opportunities for underflying ER-2

example flight plan for Cb/anvil scenario (not to scale)

Example coordination with other aircraft



Twin Otter - 2nd flight

radiation measurements
under anvil w/ER-2

Platnick et al., C-F Science Team Mtg., 30 Jan. 2002

Integration & Test

February:

CoSMIR being tested (CoSSIR only involves scan head change)

March, April test period: (using ER-2 #809)

priority 1: CRS (ready in March/early April), CoSSIR (end of April),MMS, RAMS

- ➜ MMS tests require EDOP nose cone, ballast needed in absence of EDOP

priority 2: CPL (March), JLH, MTP

June Integration: all

Estimated Flight Hour Allocation

Total: 120

March/April Tests: 18

June Integration: 10 (2 + 4 + 4)

Ferry (round trip): 10

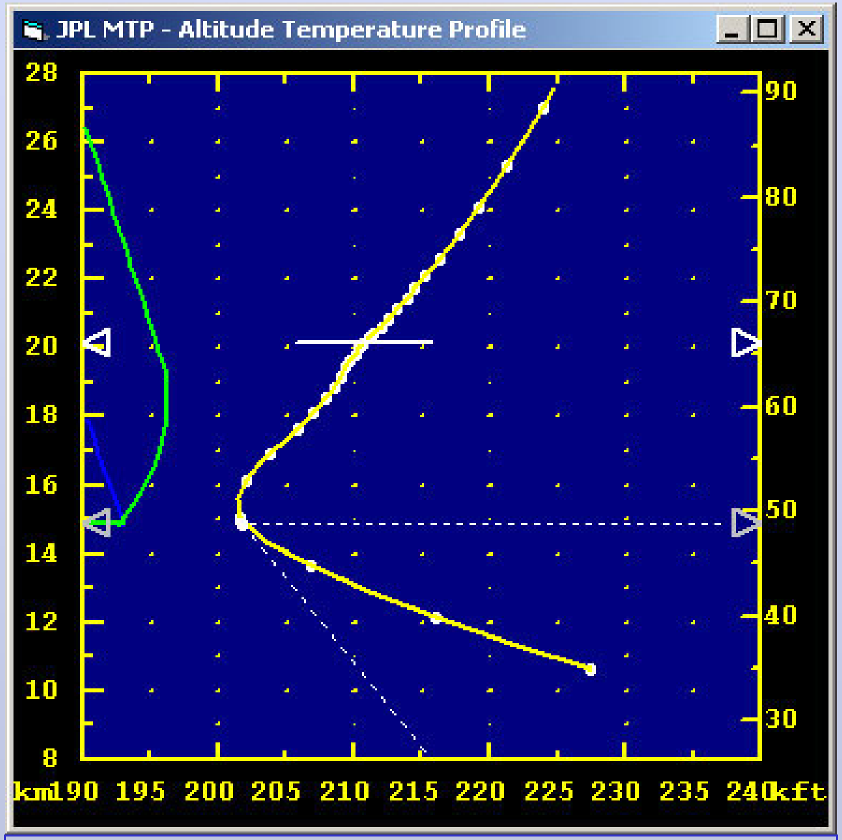
Science hours: 82

- Operational flight period: 3-31July
- Flying every 2-3 days ~ 10 flights x 6 hrs = 60 hrs
  every other day ~ 14 flights x 6 hrs = 84 hrs
- 8 hrs flights may be needed on a few occassions

extras

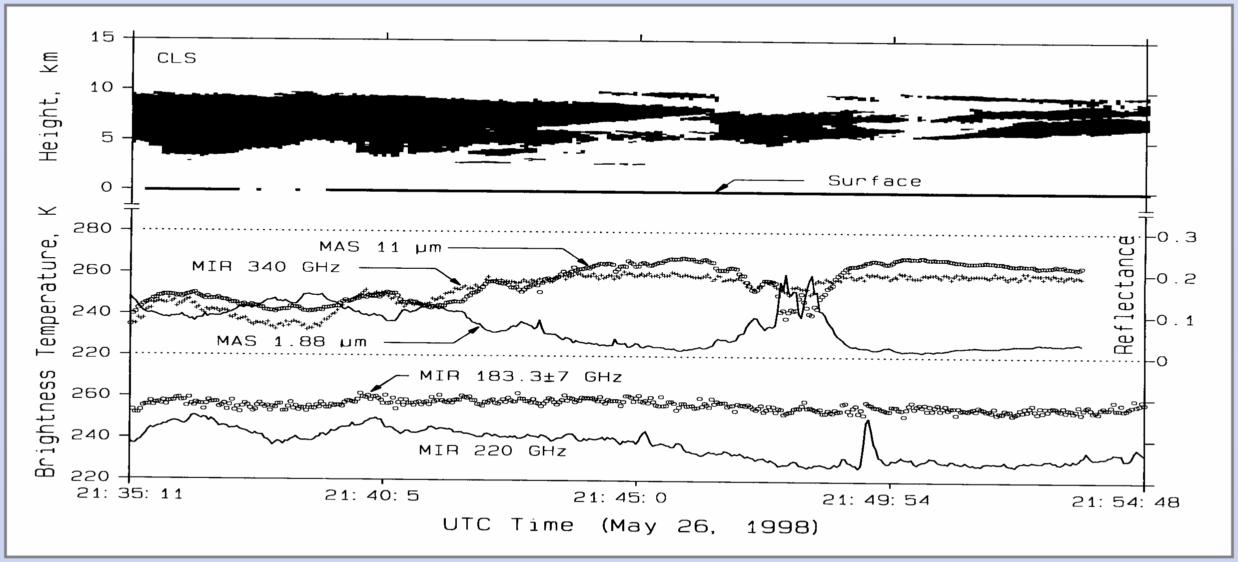
ER-2 Microwave Temperature Profiler (MTP)

- Derived geophysical products:
  - Temperature profile/curtain along the ER-2 flight track
  - Tropopause altitude
  - Isentrope (θ) surfaces
- Science objectives
  - Provide mesoscale meteorological context for *in situ* measurements
  - Use derived isentrope surfaces to study dynamical phenomena
- Data availability and analysis plan
  - Within <1 hour after data taken from a/c
  - Final data within 6 months of end of deployment



An example of an altitude temperature profile (yellow trace) from 8-28 km (left) or 28-91 kft (right), with the temperature in Kelvin along the bottom. The ER-2 altitude is the horizontal white line at 20 km and the tropopause altitude is dashed white line at 15 km. The 2 K/km WMO criteria is also shown descending below the tropopause.

Mahoney



Heritage:

- **MIR** (Millimeter-wave Imaging Radiometer, 89-340 GHz) – SUCCESS, FIRE-ACE
- Response to moderate cirrus at 340 GHz (~2148 UTC above, in the Arctic region). At frequencies ≤ 220 GHz, MIR responds to intense cirrus only (CLS surface signals totally attenuated).
- **CoSSIR will be more sensitive** to cirrus than MIR, excellent complement to visible-IR measurements.

Data Products:

- Preliminary water vapor profiles and cirrus parameters (IWP and D_{me}) available ~ 2 days after flights. Refined data products archived about 6 months later.
- ER-2 instrument synergy: retrieved products based on combined data of CoSSIR and other instruments (e.g., CRS, FIRSC, MODIS, and CPL) will be made available; schedule depends on availability of data from other sensors.

Flight Coordination:

- Coordination with FIRSC (Proteus) and in-situ sensors (WB-57)

Wang et al.

The ARM-UAV Pyrgeometer Sensor

- Modified by **Sandia National Laboratory** for Aircraft use
- Designed for high altitude and harsh environments
- Excellent dome/body thermal coupling
- Entire sensor tracks ambient air temperature
- Integrated miniature data system, RS-232 output
- Outputs Manufacture Serial number in data stream
- Platinum RTD temperature sensors for Repeatability and stability

Specifications:

- Modified Kipp & Zonen CG-4 Pyrgeometer
- Spectral Range: 4.5 to 42 µm
- Field of View: 180° field of view, good cosine response
- Temperature: -70C to +60C
- Power: +5VDC @ 50mA
- Weight: ~1 LBS.
- Dimnesions: 2.9” Dia. X 2” H
- Data rates: DC to 10Hz
- Data output: RS-232, 20 bytes per measurement (Scan)
- Data system: 16 Bit, 4 Channel, Detector, Detector, Electronics and Case Temperature

Pilewskie et al.

ARESE-II, 29 March 2000, Sc deck

Sandia Twin-Otter

Upwelling retrieval:

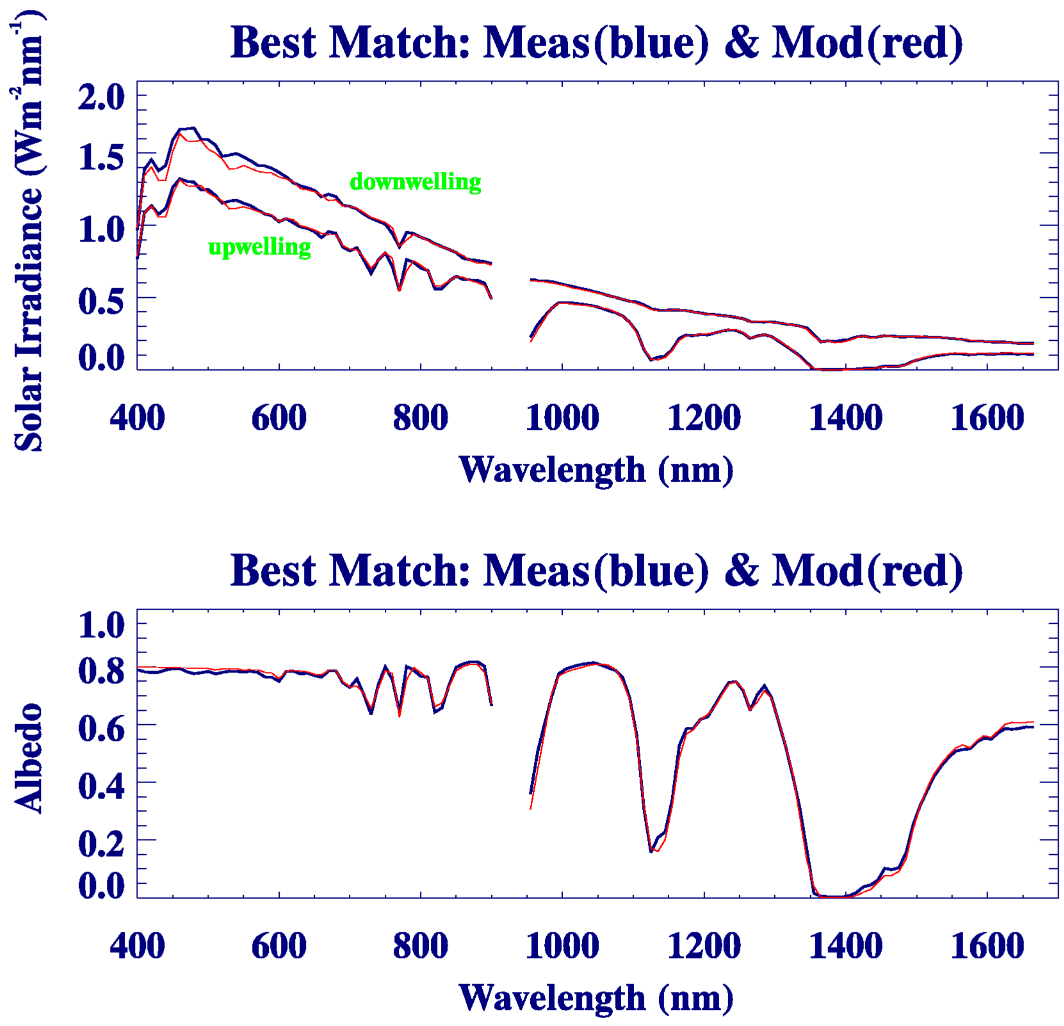
r_e =8.7 µm

τ =45

Albedo retrieval:

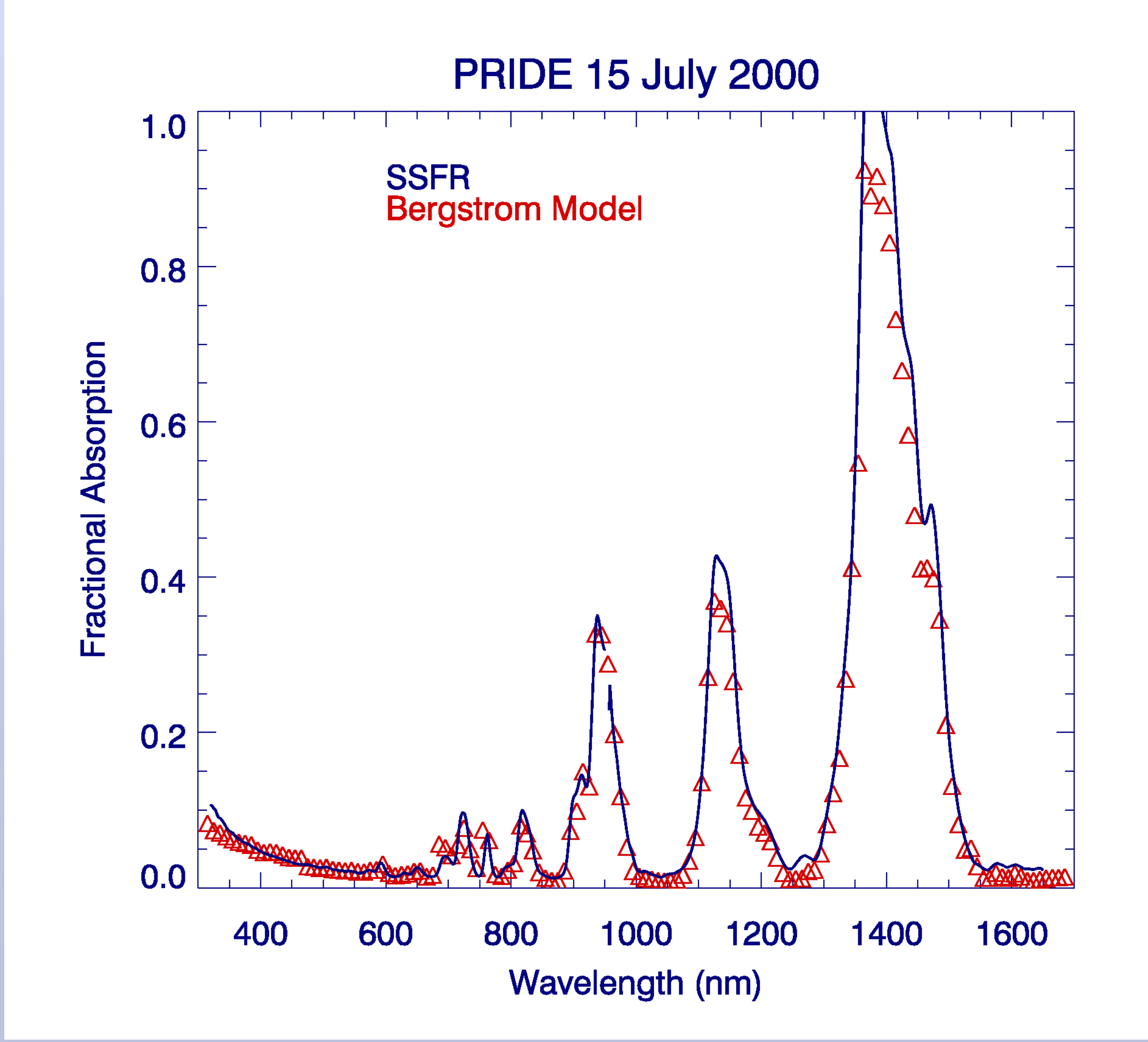
r_e =9.5 µm

τ =43

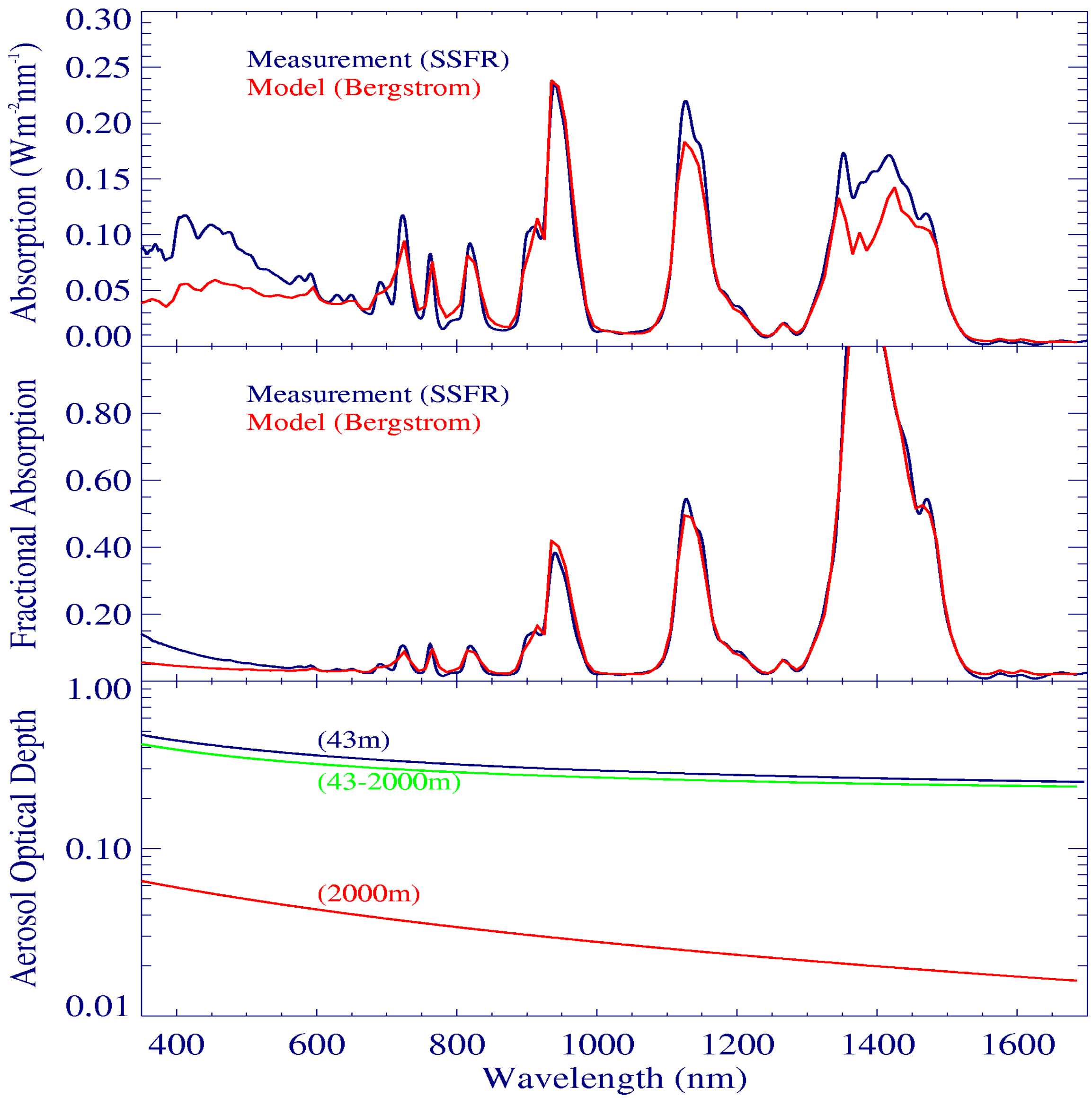


Pilewskie et al.

Puerto Rico Dust Experiment



ACE-Asia



Measurement (SSFR)
Model (Bergstrom)
Absorption (Wm⁻²nm⁻¹)
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Measurement (SSFR)
Model (Bergstrom)
Fractional Absorption
0.80
0.60
0.40
0.20
1.00
(43m)
(43-2000m)
(2000m)
Aerosol Optical Depth
0.10
0.01
400
600
800
1000
1200
1400
1600
Wavelength (nm)