Observing Hurricanes and Severe Storms with the GeoSTAR-PATH Mission

National Aeronautics and Space Administration

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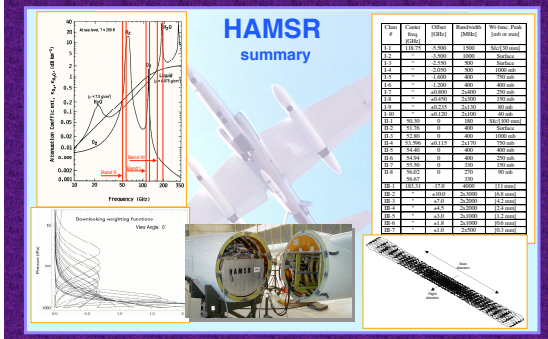
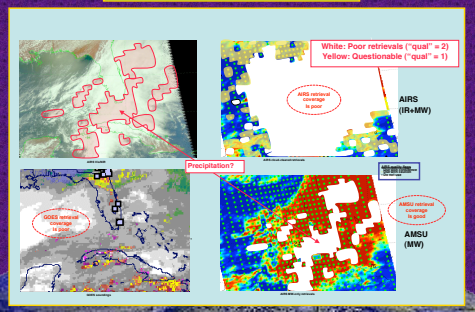
PATH will provide a number of measurements that are crucial for the monitoring and prediction of hurricanes and severe storms – including hemispheric 3-dimensional temperature, humidity and cloud liquid water fields, rain rates and totals, tropospheric wind vectors, sea surface temperature, and parameters associated with deep convection and atmospheric instability everywhere and all the time, even in the presence of clouds. These observations will be available as a continuous stream of 2-D "synoptic snapshots" covering the entire visible disc. With these capabilities, GeoSTAR would become the prime hurricane sensor, in addition to providing the basic sounding functions required by the National Weather Service and other operational agencies for regional weather prediction and will in addition provide key observations needed for studies related to the hydrologic cycle. In particular, with GeoSTAR the diurnal cycle can be fully resolved, and atmospheric processes related to cloud dynamics and convection can be studied without diurnal temporal sampling biases. As has been demonstrated in LEO, microwave sounders are excellent tools for climate applications, with their superior stability and lack of sampling bias. Much of the technology risk of this new measurement concept has been retired with the prototype, but additional technology development as well as application studies are under way, funded by NASA and NOAA.

Analysis of aircraft data from hurricane field campaigns



Chan #	Center freq (GHz)	Offset (GHz)	Bandwidth (MHz)	Wt-func. Peak (mb or mm)
1-1	118.75	5.500	1000	60x(30 mm)
1-2	"	±3.500	1000	Surface
1-3	"	±2.550	500	Surface
1-4	"	±1.650	300	1000 mb
1-5	"	±1.000	400	750 mb
1-6	"	±.320	400	400 mb
1-7	"	±0.0800	2x600	250 mb
1-8	"	±0.450	2x300	150 mb
1-9	"	±0.215	2x130	80 mb
1-10	"	±0.120	2x100	40 mb
H-1	90.30	0	180	5x(100 mm)
H-2	91.70	0	400	Surface
H-3	62.80	0	400	1000 mb
H-4	53.590	±0.115	2x170	750 mb
H-5	54.40	0	400	400 mb
H-6	54.94	0	400	250 mb
H-7	55.50	0	330	150 mb
H-8	56.02	0	270	90 mb
	56.67		330	
H-1	183.31	27.0	4000	[11 mm]
H-2	"	±010	2x3000	[6.8 mm]
H-3	"	±7.0	2x2000	[4.2 mm]
H-4	"	±4.5	2x2000	[2.4 mm]
H-5	"	±3.0	2x1000	[1.2 mm]
H-6	"	±2.0	2x1000	[0.6 mm]
H-7	"	±1.0	2x500	[0.3 mm]

Why do we need microwave?

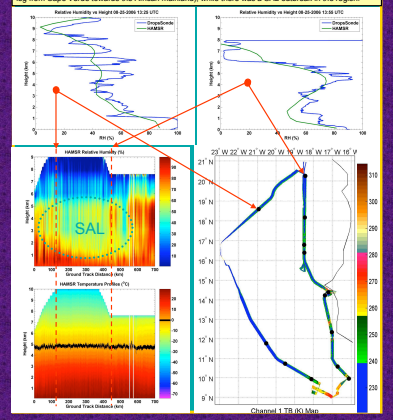


NAMMA campaign (2006, Cape Verde)

Saharan Air Layer (SAL) 08/25/2006

In the NAMMA field campaign HAMSR was mounted in the cargo bay of the NASA DC-8. The purpose of this campaign was to observe the early stages of transitions from African Easterly Waves to tropical cyclone and the influence of the SAL on this process.

During the August 25 flight (as well as in several others) HAMSR measured the dry air associated with the SAL. The figures below show observations from a segment of this flight (the initial north-easterly leg from Cape Verde towards the African mainland), while there was a SAL outbreak in the region.

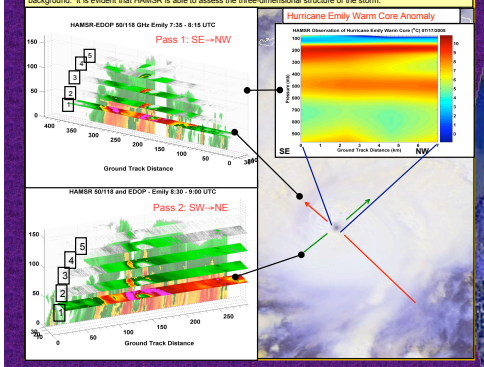


TCSP campaign (2005, Costa Rica)

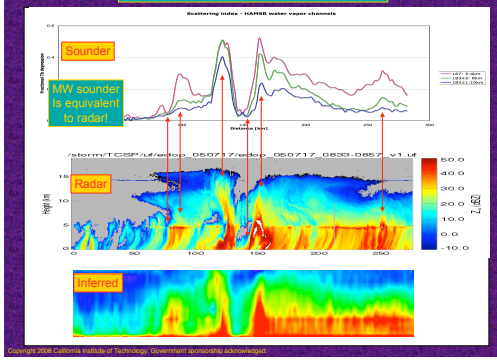
Hurricane Emily 07/17/2005

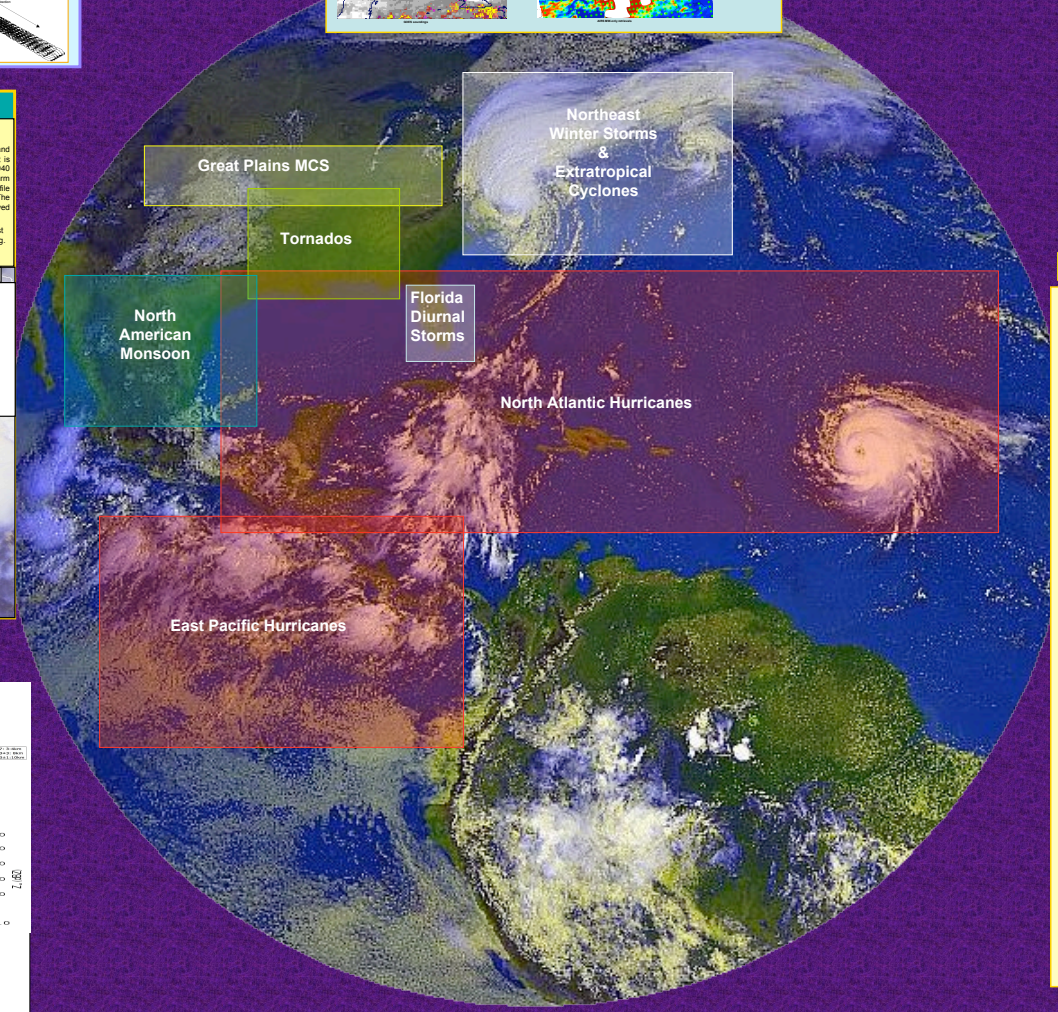
HAMSR observed Hurricane Emily from the ER-2 on July 17, 2005. Emily became a tropical depression on July 10 and reached Category 5 status briefly around 0 UTC on July 17th before weakening to Category 4 status on July 18th. It is estimated that the surface pressure and maximum sustained winds at the time of the ER-2 overflights (7-12 UTC) were 940 mb and 135 kts, respectively (NHC Tropical Cycle Report). A direct fly over of the eye allowed HAMSR to retrieve the warm core anomaly, which is shown along track below. The warm core anomaly is computed by subtracting the temperature profile retrieved in the eye, to an environmental profiled retrieved on the approach to the storm, > 600 km from the eye. The maximum magnitude of the warm anomaly peaks near 11-12 °C between 150-250 mb. A second peak near 8°C is observed around 500 mb.

HAMSR "cloud slices" reveal intense convection in the eyewall region, with storm tops reaching above 15 km on North-West side of the eyewall. Two transits across the eye wall are shown, the first in a N-W heading and the second in a N-E heading. The 5 HAMSR cloud slicing levels are shown with the nadir ER-2 Doppler Radar (EDOP) X-band reflectivity profile in the background. It is evident that HAMSR is able to assess the three-dimensional structure of the storm.



MW sounder ≈ precip radar!





"PATH" Products, Applications and Synergies

Legacy products
- Temperature, water vapor & liquid water profiles
- Total precipitable water
- Cloud liquid water
- SST
- Clear and cloudy conditions
- GEO: Continuously for entire hemisphere

Emerging products
- Rain rates & vertical precipitation profile
- Snow-fall rates
- Ice water path & vertical ice profile
- Convective intensity, vertically resolved
- Wind vector vertical profiles

Hurricane & storm applications
- 55-GHz warm core anomaly -> Surface pressure anomaly = Intensity
- Equivalent radar reflectivity -> Intesification/weakeneing, microphysics
- Diurnal-cycle observations -> Model improvements
- Real-time atmospheric stability indices -> Severe storm warnings
- AMV-inferred wind vectors -> Improved forecasts

Synergistic applications
- Complement GEO IR sounders: cloud clearing
- Complement LEO sounders: swath-gap & temporal-gap filling
- Complement GEO imagers: resolution enhancement of MW
- Global Precipitation Mission: provide spatio-temporal continuity
  - PATH = key component of "super constellation"

Applications
- Numerical weather prediction
  - —Assimilation of radiances; 4DVAR applications
- Hurricane now-casting
  - —Intensity assessment, detect rapid intensification/weakening
  - —Observation of internal dynamics, kinematics & microphysics
- Severe storm development
  - —Atmospheric stability (CAPE, LI, etc.) in cloudy regions
  - —Detect/assess tornado precursor conditions
- Weather hazard assessment
  - —Life cycle storm observations; total rainfall
  - —Predict/observe flood conditions
- Climate studies
  - —Continuous time series; diurnal cycle fully resolved
  - —Basin-scale inter-seasonal to interannual analyses
  - —Cross-calibration of LEO climate sensors & data series

This work was carried out at the Jet Propulsion Laboratory, California Institute of Technology under a contract with the National Aeronautics and Space Administration.

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