

# Polarimeter to Unify the Corona and Heliosphere (PUNCH)

## Mission Overview

The Polarimeter to Unify the Corona and Heliosphere, or PUNCH, mission will focus directly on the Sun's outer atmosphere, the corona, and how it generates the solar wind. Composed of four suitcase-sized satellites, PUNCH will image and track the solar wind as it leaves the Sun. The spacecraft also will track coronal mass ejections – large eruptions of solar material that can drive large space weather events near Earth – to better understand their evolution and develop new techniques for predicting such eruptions.

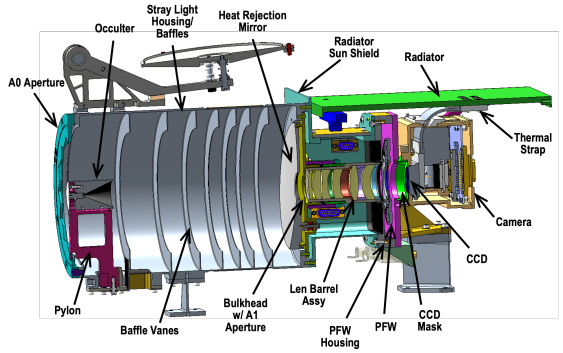
## Science & Technology Objectives

Science Goal: comprehend the cross-scale physical processes – from microscale turbulence to the evolution of global-scale structures – that unify the solar corona and heliosphere.

1. Understand how coronal structures become the ambient solar wind.
2. Understand the dynamic evolution of transient structures in the young solar wind

## Instruments

Narrow Field Imager (NFI) (Naval Research Laboratory)
Wide Field Imager (WFI) (Naval Research Laboratory)
Student Thermal Energetic Activity Module (STEAM (Colorado Space Grant Consortium)




NFI Instrument

## Key Mission Requirements

| | |
|---|---|
| Official Launch Readiness Date | October 2023 |
| Selection Date | July 28, 2017 |
| PI Managed-Mission Cost Cap (PIMCC)($M) | 150.621 |
| Orbit Type | Sun Synchronous Orbit(SSO) |
| Apogee | 620km |
| Perigee | 620km |
| Number of SpaceCrafts Per Mission | 4 |
| Design Life | 24 |

## Project Organization

| | |
|---|---|
| Program Executive: | David J. Cheney (HQ) |
| Program Scientist: | Guhathakurta, Madhulika (HQ-DJ000) |
| Program Office Mission Manager: | Tyrone D. Dillard (GSFC) |
| Project Scientist: | Nicholeen M. Viall-kepko (GSFC) |
| Principal Investigator: | Craig DeForest |
| PI Institution: | Southwest Research Institute in Boulder, Colorado |
| Project Manager: | Tyrone D. Dillard (GSFC) |

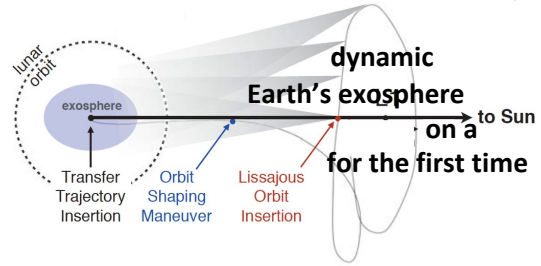
# The Global Lyman-alpha Imager of the Dynamic Exosphere

## Science objectives:

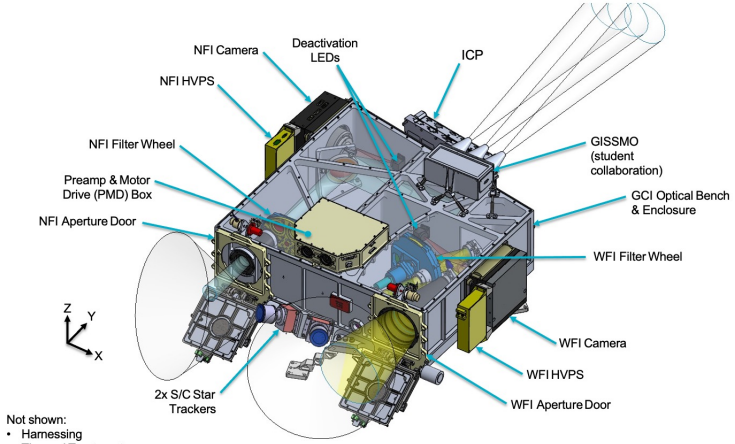
- Earth's exosphere strongly influences the severity and duration of geomagnetic storms through **ion-neutral coupling**
- Earth's exosphere is also the pathway by which thermal evaporation of neutral hydrogen (H) atoms drives permanent **atmospheric evolution** and water loss, much as it did on Mars
- The long-standing lack of comprehensive observations of exospheric structure, energetics, and dynamics have forced a current reliance on oversimplified and unphysical models
- **GLIDE will provide unprecedented measurements of the global, time-dependent distribution of exospheric density,** with the following science objectives:
  1. ***To determine the drivers of the quiet-time exospheric density distribution on regional and global scales.***
  2. ***To determine the nature and origin of transient variability in the exospheric density distribution.***

## Mission concept:

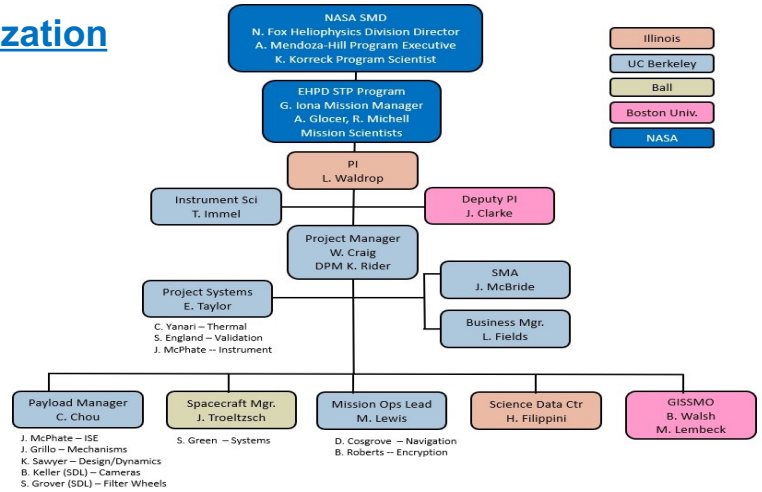
- Rideshare with IMAP offers the unique opportunity to deploy the **ideal instrumentation at the ideal vantage** for global, time-dependent exospheric remote sensing
- Dedicated Earth nadir viewing from halo orbit around the Earth-Sun L1 Lagrange point enables high-cadence UV imaging of exospheric **Lyman-α emission at 121.6 nm**
- GLIDE's 2-year science phase commences in 2025, near solar maximum
- **GLIDE will reveal the dynamic response of Earth's exosphere to geomagnetic storms on a global scale for the first time**




## Instruments (GCI and GISSMO Student Collaboration)




## Organization



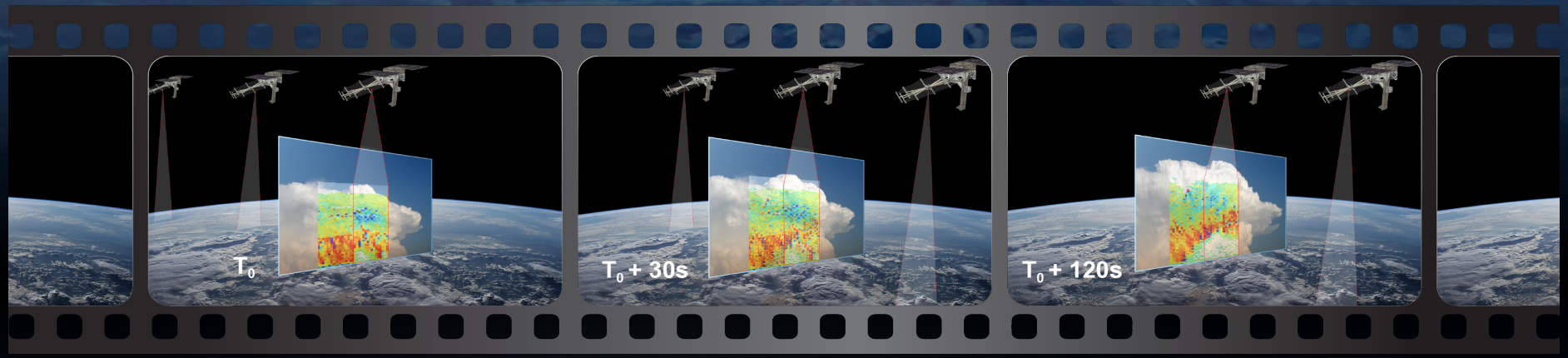

**Status: GLIDE is in Phase B and Mission-PDR held Nov. 16-18**

# INCUS Investigation of Convective Updrafts

*NASA's Storm Chaser*

## INCUS Goal

**To understand why, when and where tropical convective storms form, and why only some storms produce extreme weather.**




*Storms begin with rapidly rising water and air that create towering clouds primed for rain, hail, and lighting. The greater the mass of water and air that is transported upwards, the larger the risk of extreme weather. This vertical transport of air and water, known as convective mass flux (CMF), remains one of the great unknowns in weather and climate. Systematic CMF measurements would improve the representation of storm intensity and constrain high cloud feedbacks in weather and climate models.*

### Science Objectives

*To determine:*

1. The predominant environmental properties controlling CMF in tropical convective storms;
2. The relationship between CMF and high anvil clouds;
3. The relationship between CMF and the type and intensity of the extreme weather produced;

and then evaluate these determined relationships between CMF and environmental factors, high anvil clouds, and extreme weather in weather and climate models.

### The INCUS Baseline Mission:

- Flies 3 SmallSats carrying RainCube-like radars with cross-track scanning and a TEMPEST-D-like radiometer
- Applies a novel time-differencing ($\Delta t$) approach
- Provides the first ever tropics-wide measurements of CMF
- Directly addresses ***"Why do convective storms, heavy precipitation and clouds occur exactly when and where they do? (W-4)"***, one of the questions associated with the most important objectives of the National Academies of Science and Engineering 2017–2027 Decadal Survey.

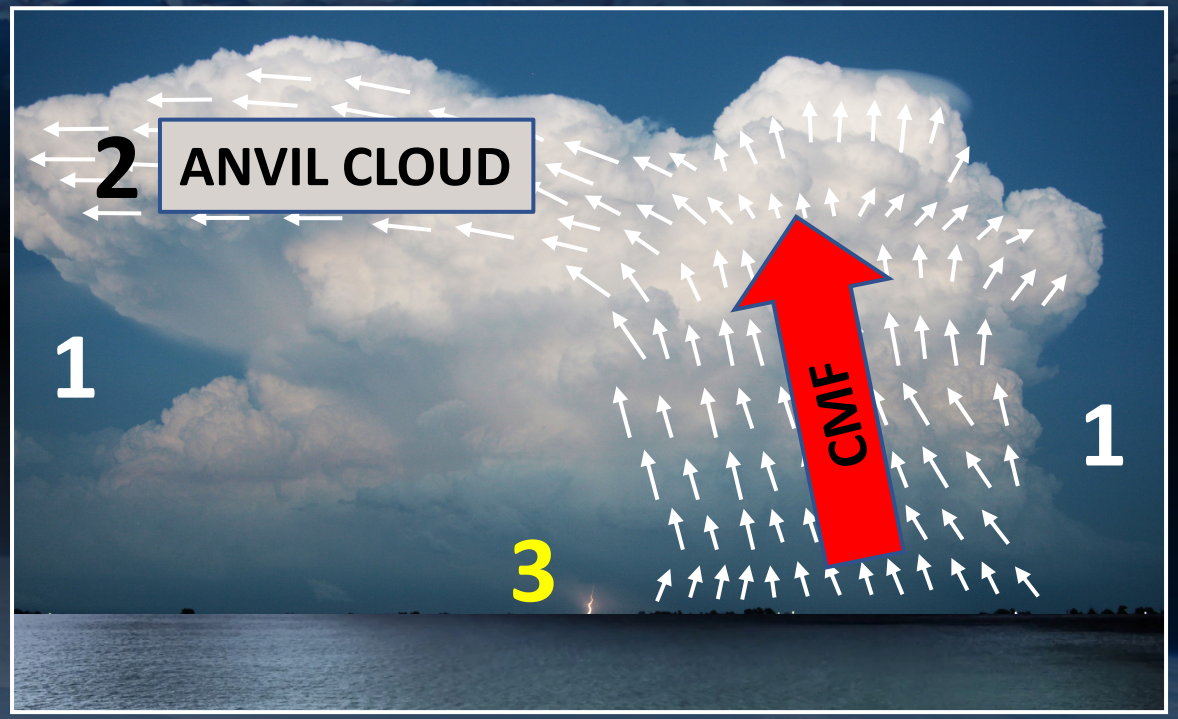
# INCUS Investigation of Convective Updrafts

*NASA's Storm Chaser*

## INCUS Goal

**To understand why, when and where tropical convective storms form, and why only some storms produce extreme weather.**

- *Storms begin with rapidly rising water and air that create towering clouds primed for rain, hail, and lighting.*
- *The greater the mass of water and air that is transported upwards, the larger the risk of extreme weather.*
- *This vertical transport of air and water, known as convective mass flux (CMF), remains one of the great unknowns in weather and climate.*
- *Systematic CMF measurements would improve the representation of storm intensity and constrain high cloud feedbacks in weather and climate models.*

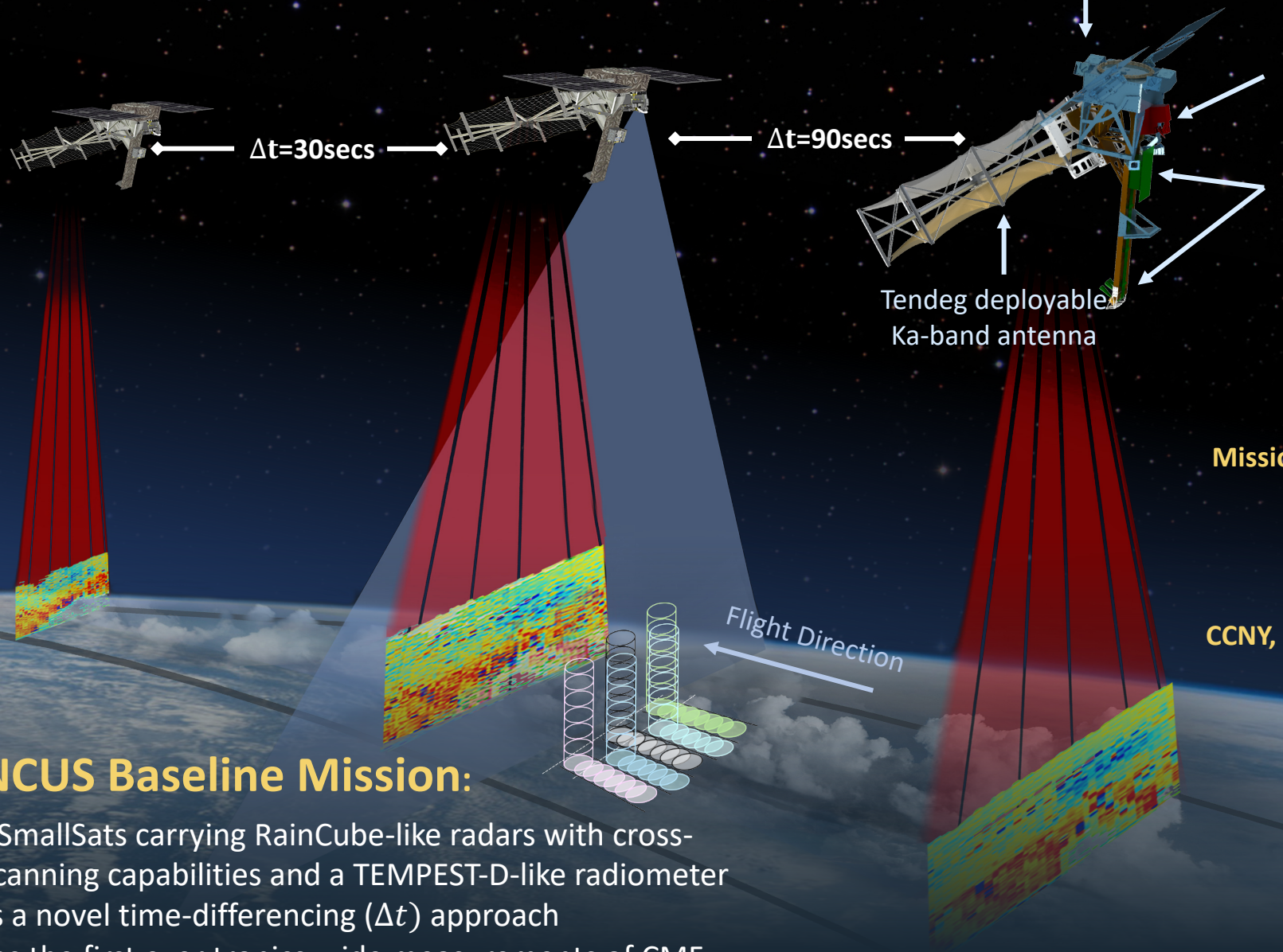



## Science Objectives

*To determine:*

1. The predominant environmental properties (RH, temperature, wind shear) controlling CMF in tropical convective storms;
2. The relationship between CMF and high anvil clouds (critical to cloud-climate feedbacks);
3. The relationship between CMF and the type (lightning, rainfall) and intensity of the extreme weather produced; and
4. Evaluate these observationally determined relationships between CMF and environmental factors, high anvil clouds, and extreme weather in weather and climate models.

# INCUS Investigation of Convective Updrafts




Blue Canyon Technologies X-SAT
Venus commercial bus

JPL cross-track scanning microwave radiometer (middle spacecraft only) (TEMPEST-D heritage)

JPL Ka-band radar with 5 beams (RainCube heritage)

Tendeg deployable Ka-band antenna

**PI:** Susan van den Heever, CSU
**Deputy PI:** Ziad Haddad, JPL
**Project Scientist:** Simone Tanelli, JPL

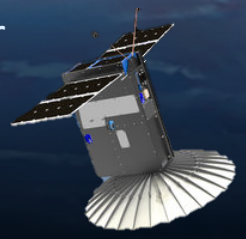
**Mission Management & Participating Organizations**
**CSU:** PI Org, Science Data Processing
**JPL:** Instruments & Mission Management
**Tendeg:** Deployable Antennas
**BCT:** Spacecraft, Mission Ops
**CCNY, GSFC, MSFC, NOAA, SBU, TAMU:** Science Co-Is

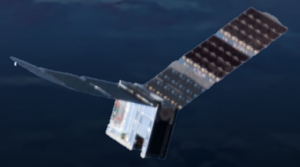
Colorado State University
Jet Propulsion Laboratory
California Institute of Technology

## The INCUS Baseline Mission:

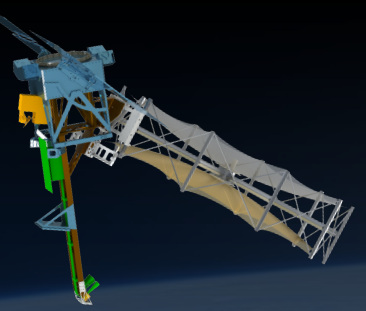
- Flies 3 SmallSats carrying RainCube-like radars with cross-track scanning capabilities and a TEMPEST-D-like radiometer
- Applies a novel time-differencing ($\Delta t$) approach
- Provides the first ever tropics-wide measurements of CMF

RainCube Ka-band radar + TEMPEST-D mm-wave radiometer





# INCUS



**INCUS draws on the strengths of BOTH RainCube and TEMPEST-D to provide unprecedented vertical and horizontal views of storm structure and processes.**

Figures and animations by Simone Tanelli, Shannon Brown and Steve Reising

(Right) On September 28, 2018, TEMPEST-D and RainCube overflew Typhoon Trami < 5 minutes apart

(Bottom) Correlated storm measurements from RainCube radar and TEMPEST-D radiometer over Texas, Mexico and Pacific Ocean

