Small-sat Ionosphere Exploration at Several Times and Altitudes (SIESTA)

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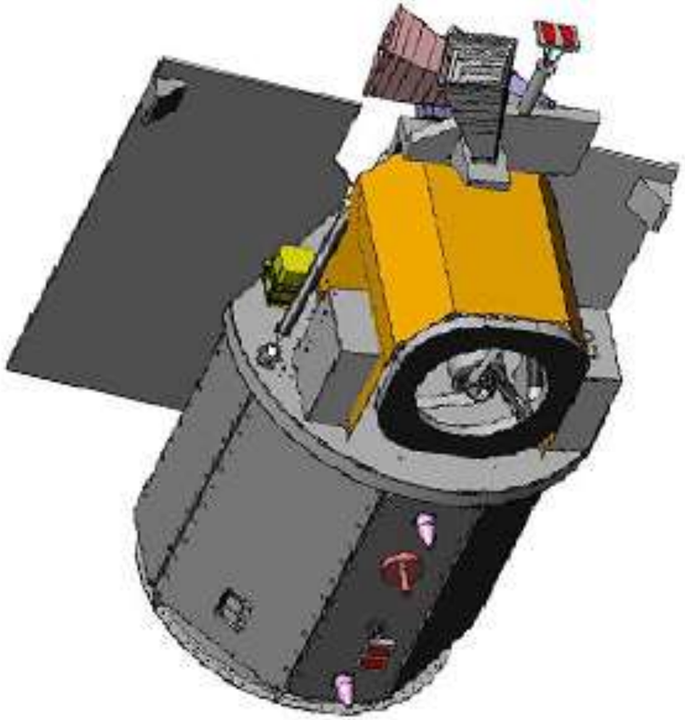
Satellite Overview



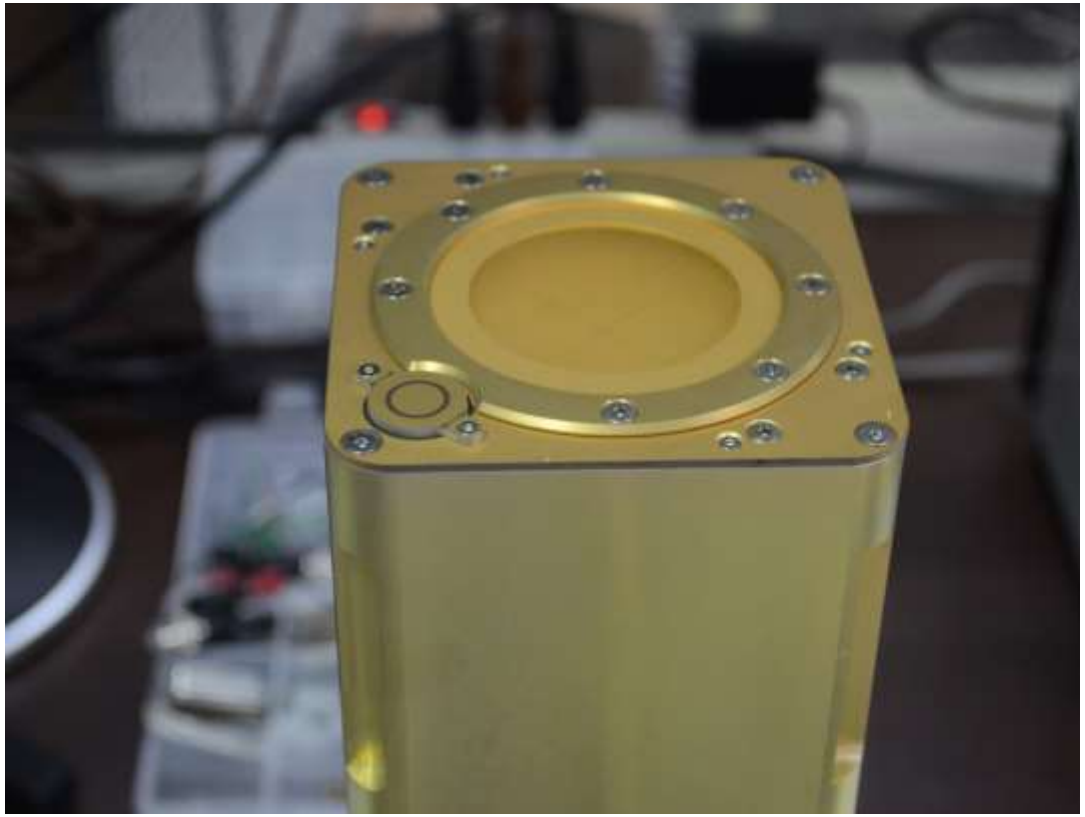
FORMOSAT-5

INSPIRESat/IDEASat

	FORMOSAT-5	INSPIRESat (6U)	IDEASat (3U)
Mass (kg)	475	5	4
Orbit Altitude (km)	720	500	500
Orbit Inclination (deg)	98	45	97
Launch Date	August 24, 2017	November, 2019	2020

AIP/CIP Overview

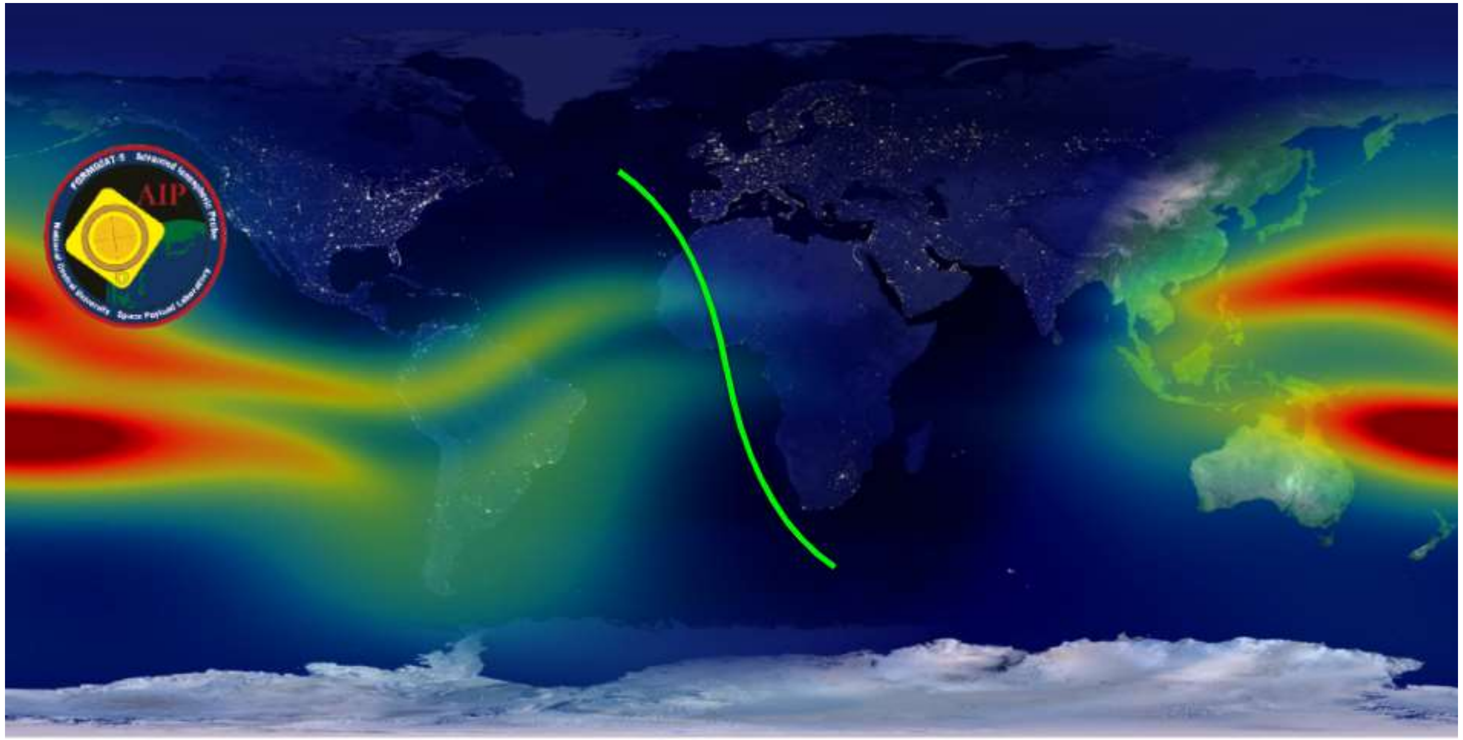
- Advanced/Compact Ionosphere Probe
- Four measurement modes
  - Planar Langmuir Probe (PLP)
  - Retarding Potential Analyzer (RPA)
  - Ion Trap (IT)
  - Ion Drift Meter (IDM)
- With the following measurements
  - Ion density
  - Ion drift velocity
  - Ion and Electron Temperature
  - Ion Composition
- Duty Cycles
  - FORMOSAT-5 – Always On
  - IDEASat/INSPIRESat – Eclipse Only

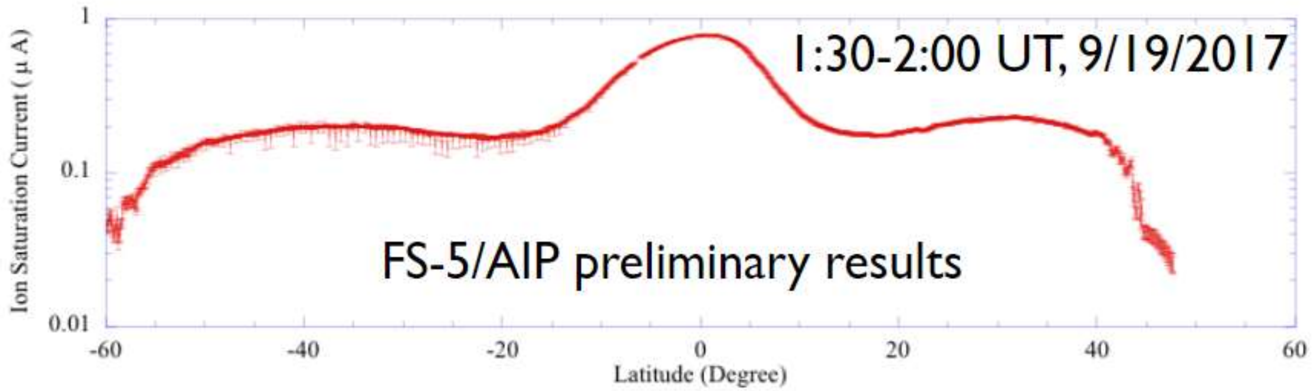


AIP : Photo courtesy of Ya-Chih Mao

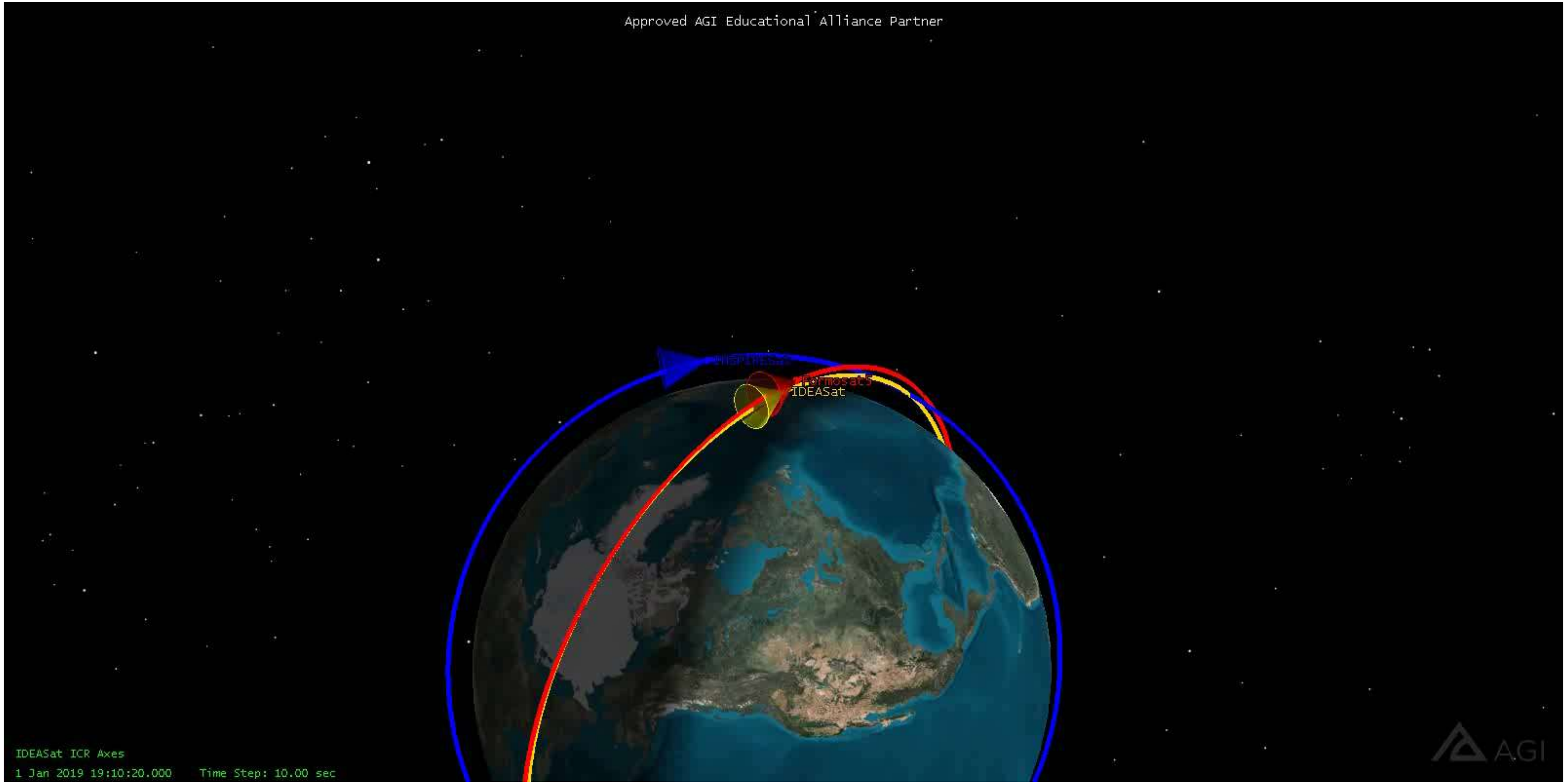
FORMOSAT-5 AIP First Data

- First measurements from the AIP instrument
- Courtesy Dr. Chi-Kuang from NCU
- Vertical axis can be converted to ion density





FORMOSat, INSPIRESat, IDEASat Mission Design



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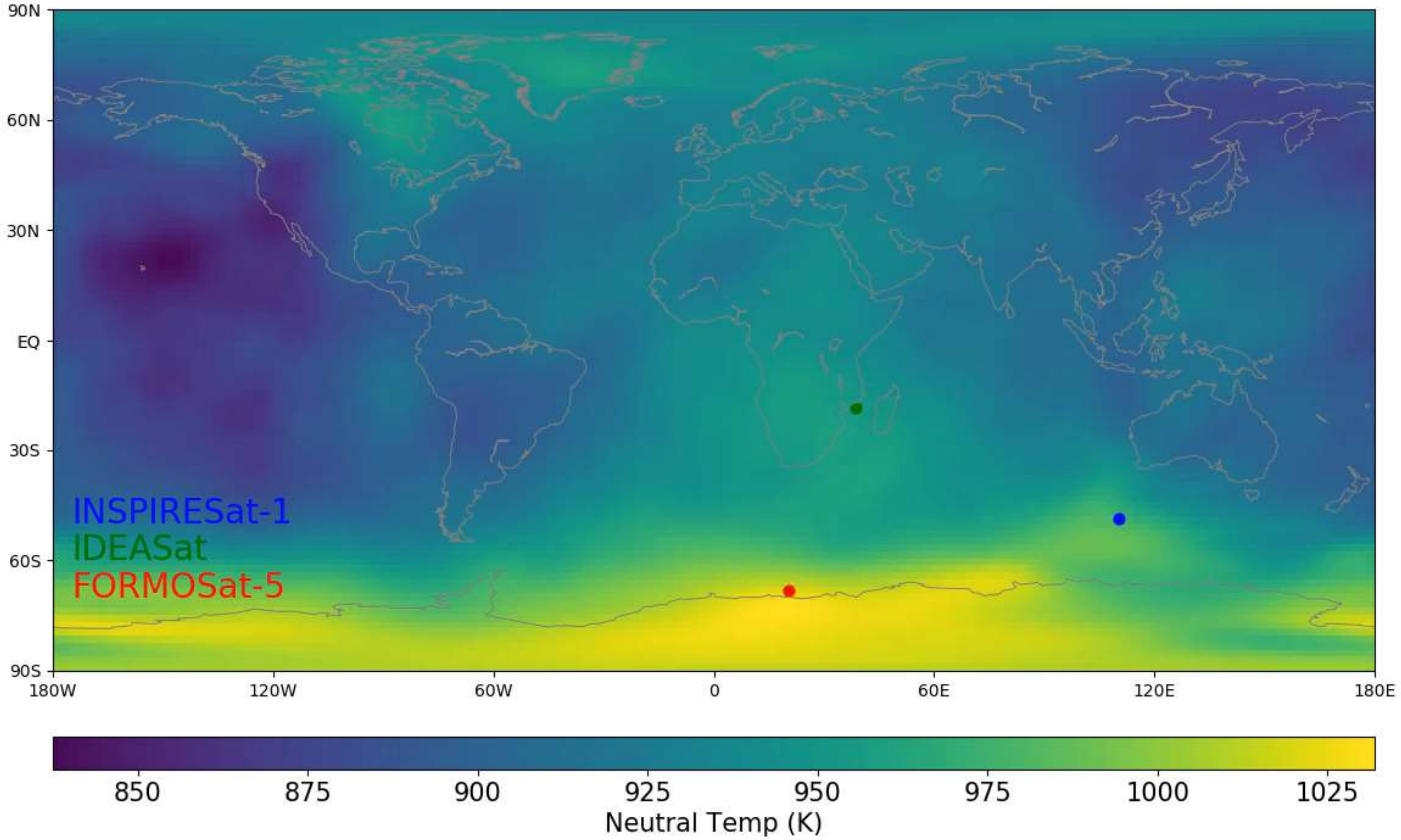
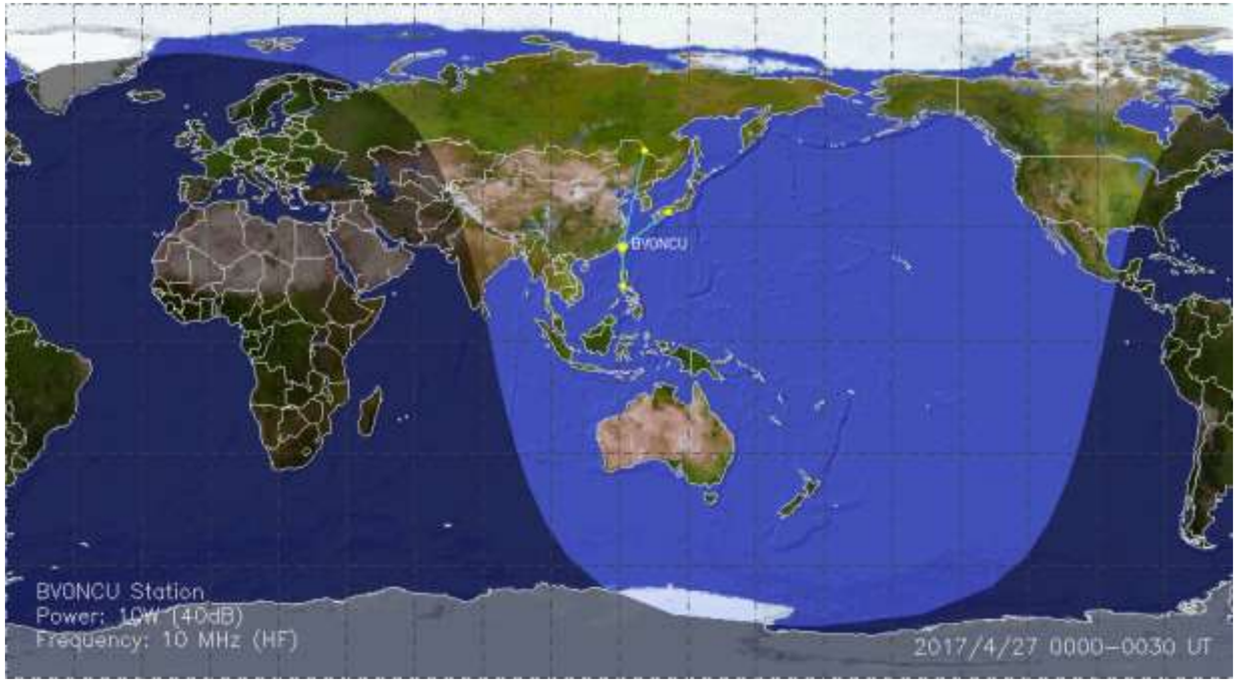


SIESTA Science Objectives

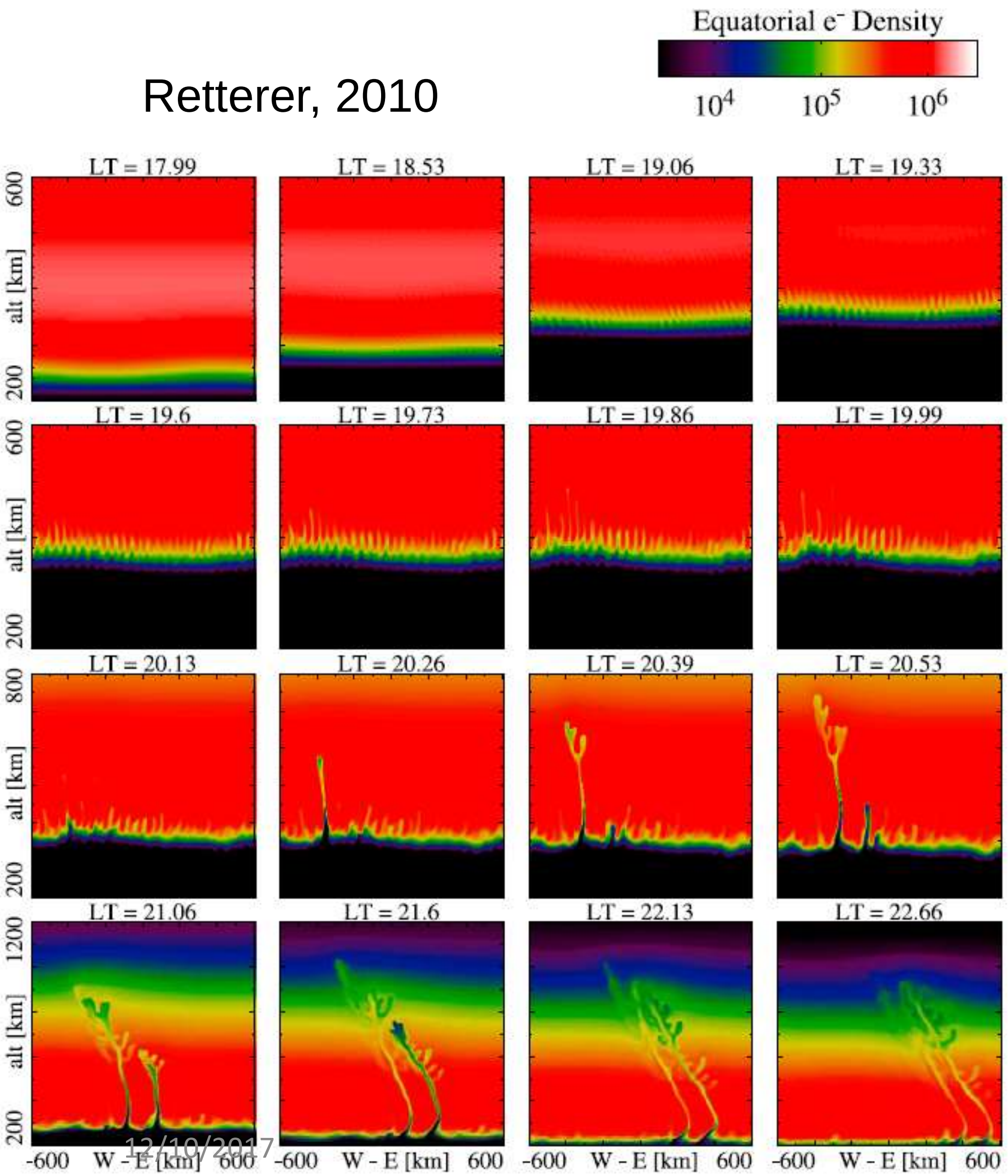
1. What are the occurrence rates and characteristics of plasma irregularities at low and mid latitudes?
2. What are the spatial and temporal variations of the midnight temperature maximum (MTM)?
3. How do the ionospheric density and electric field respond to the MTM thermospheric dynamics?



GIF courtesy of Chi-Ting Liao

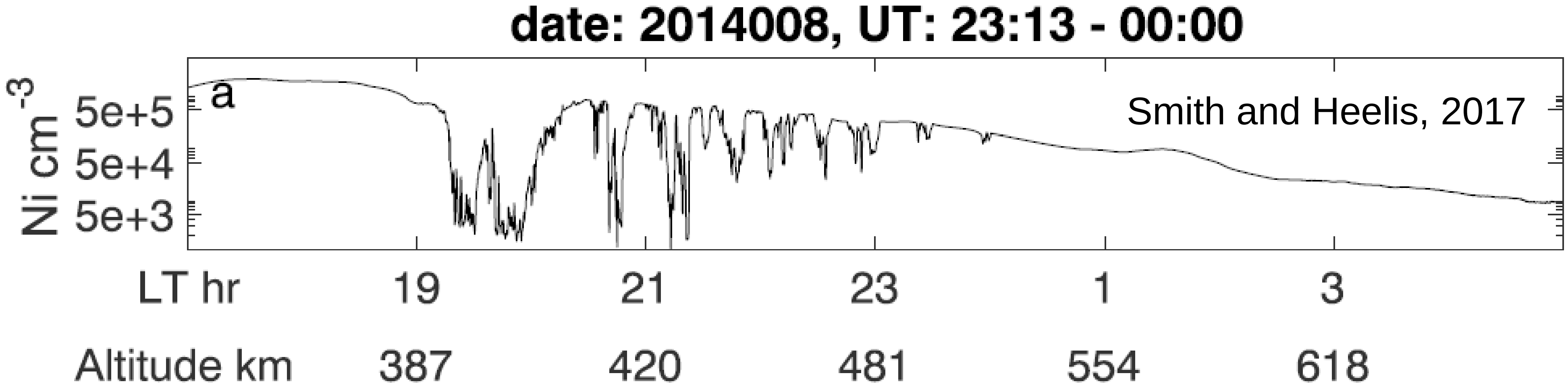
Plasma Bubbles

Retterer, 2010



- Plasma bubbles form around the magnetic equator in the early evening where there is a density gradient and magnetic field lines don't extend to upper parts of the ionosphere (Kil, 2015)
- Bubbles propagate along magnetic field lines allowing the bubble to expand to latitudes far from their initiation site (Sultan, 1996).
- Bubbles can be hundreds of kilometers across (in longitude) and extend hundreds of kilometers up in altitude above the F-layer (>150 km)(Kil, 2015)
- Bubbles can cause communications disruptions via scintillation (large drops in signal intensity and a shift in phase)

C/NOFS Plasma Bubble Study



- Smith and Heelis (2017) used C/NOFS data to plot plasma density through local time to try and identify plasma bubbles in the data
- Smith and Heelis (2017) found that bubbles were present in all longitude sectors both post midnight and post sunset with post midnight preferred in low solar activity conditions

The Midnight Temperature Maximum (MTM)

- The MTM is a neutral temperature peak and characteristic wind pattern around midnight local time.
- Individual black lines are single days in a month of the Whole Atmosphere Model with clear ΔT peaks in both summer (bottom) and winter (top) with stronger peaks in the former.
- The MTM is a feature likely driven by migrating tides whose contribution by zonal wave number can be seen by the green and blue lines.

Akmaev, 2009

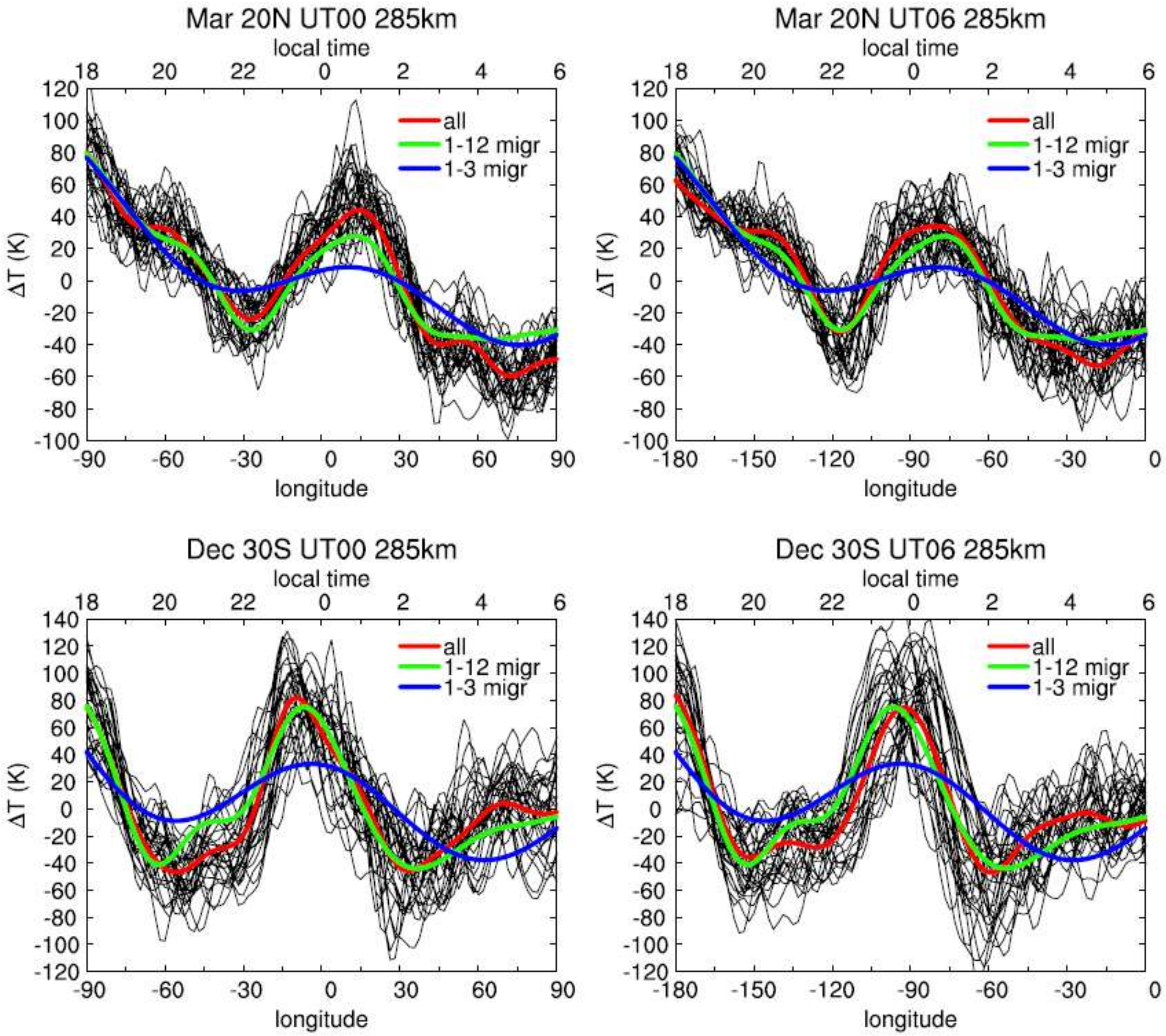


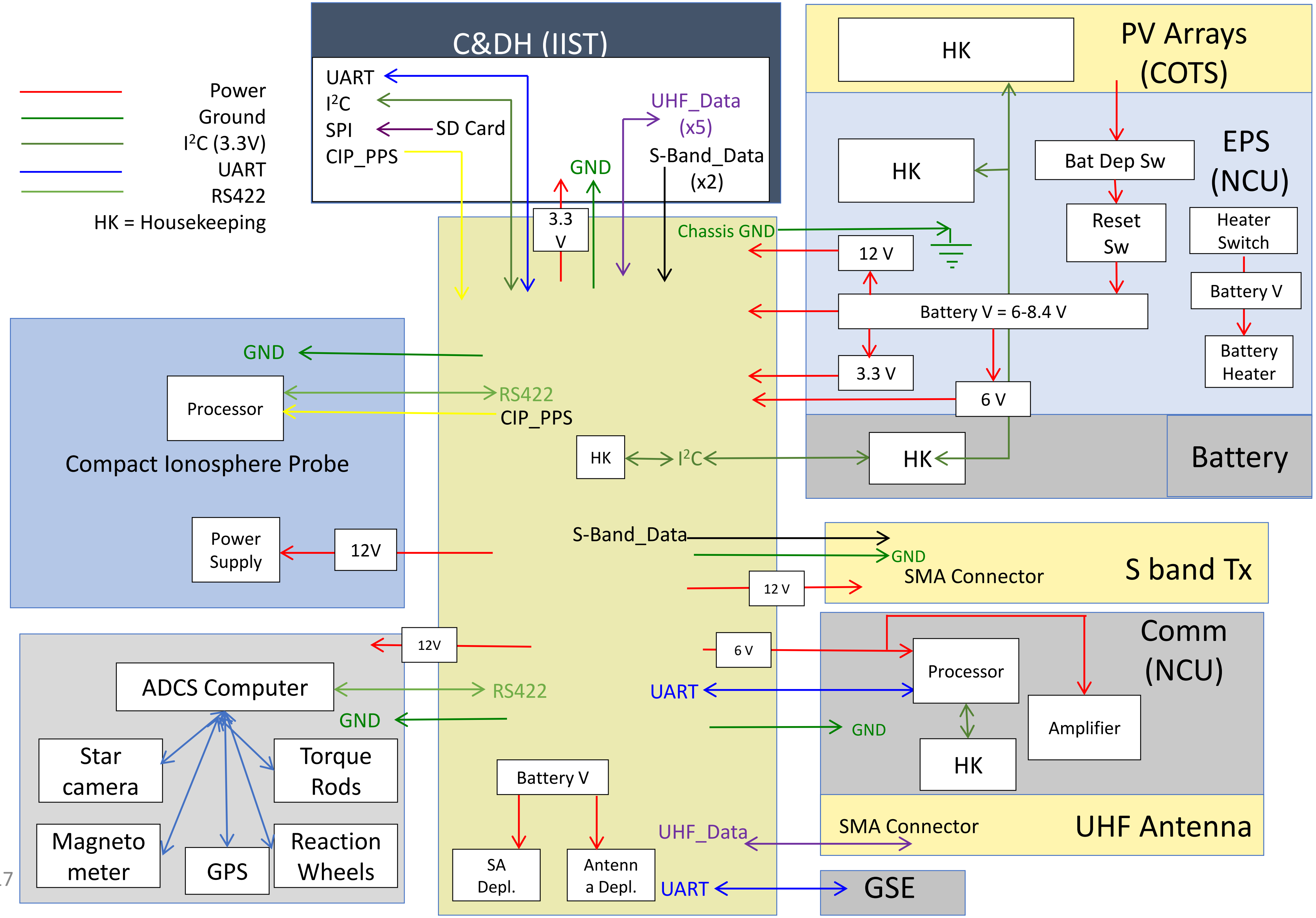
Figure 1. Temperature deviation from the zonal mean near 285 km in (top) March at 20°N and (bottom) December at 30°S at (left) UT = 0:00 and (right) UT = 6:00. See text for details.

The INSPIRESat-1 at PDR

Components of the INSPIRESat-1

Subsystem	Components used
C&DH	Custom design
EPS	Custom design
ADCS	Blue Canyon Technology XACT
CIP-Payload	Custom design
UHF Rx	SpaceQuest TRXU
UHF Tx	SpaceQuest TRXU
S-Band Tx	SpaceQuest TX2400

INSPIRESat-1 Functional Block Diagram



INSPIRESat-1 Margins

Subsystem	Mass 3U (kg)	Nominal Power (W)	Volume 3U (mm^3)
CIP	0.61	2.13	600
ADCS	0.91	2.97	1000
COMM	0.21	1.02	111.4
C&DH	0.09	0.91	98.5
Structure	0.96	-	433.75
Power	0.10	1.83	98.5
Battery	0.22	-	300
Solar Arrays	0.51	-	54.43
Total	3.60	8.86	2696.58
Allocated	10	12.38	3000
Margin (%)	153	40	10

Sequence of Operations

Enter Orbit:
Phoenix Mode →

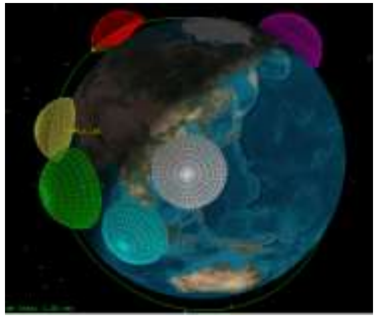
Sun pointing to gain
battery charge.
Safe mode ⇄

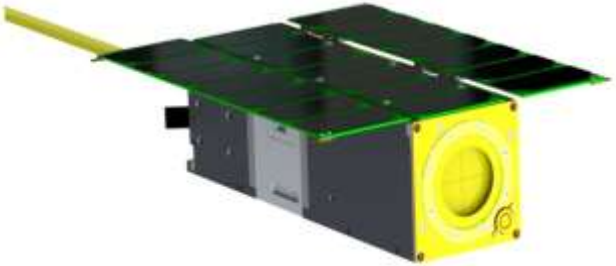
SUNLIT period
Charge mode,
Payload off

↕

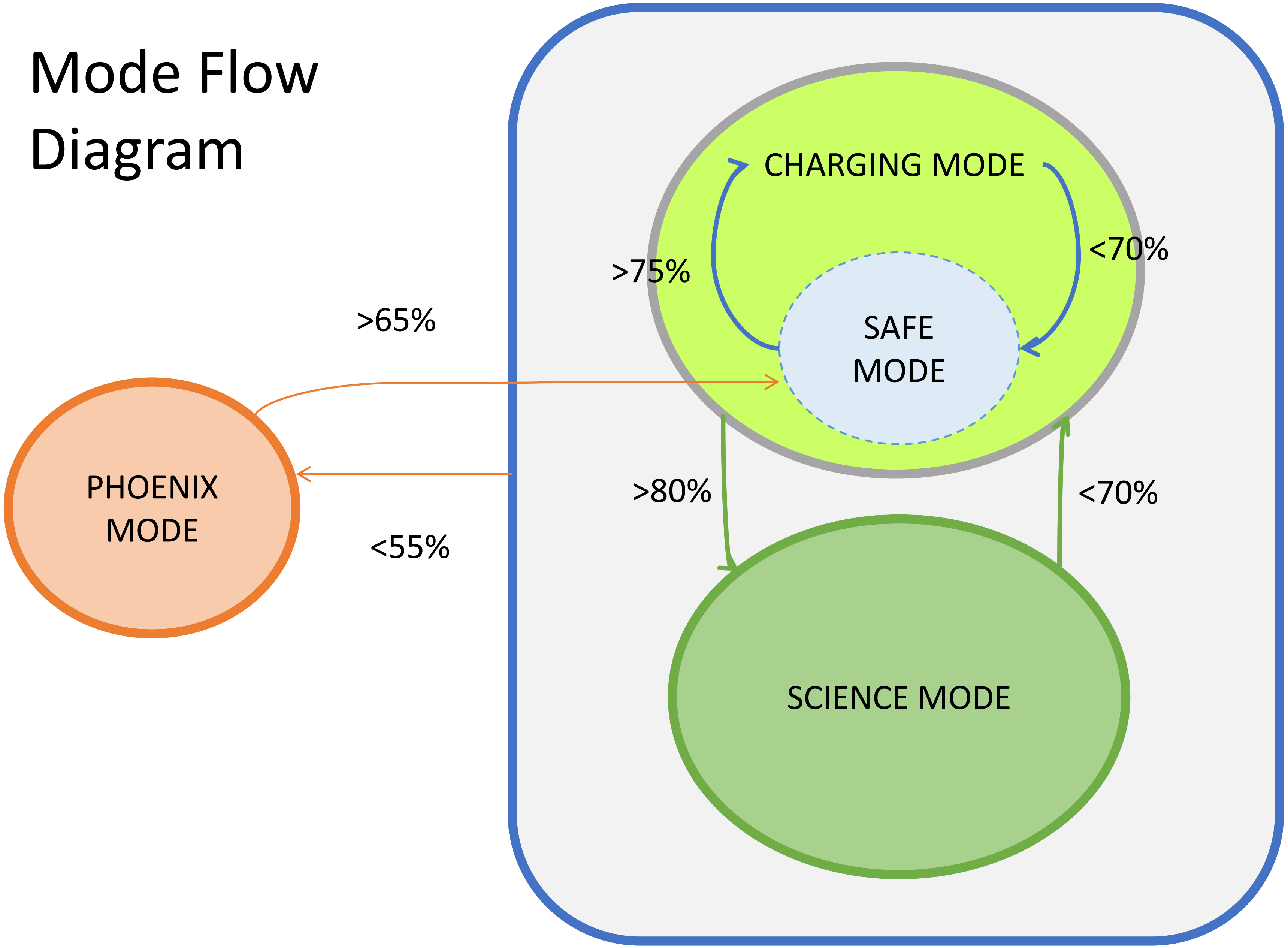
ECLIPSE period
Science Mode
Payload on

→ Send data
down to ground
during access





Mode Flow Diagram



Spacecraft Modes

Subsystem	EMERGENCY MODES		NOMINAL MODES	
	Phoenix	Safe	Charging	Science
C&DH	ON	ON		ON
EPS	ON	ON		ON
ADCS	OFF	Coarse ref. Sun	Fine ref. Sun	Fine Reference in Ram direction
CIP-Payload	OFF	Stand By		ON
UHF Rx	ON	ON		ON
UHF Tx	OFF	Beacon	As required	As Required
S-Band Tx	Beacon	Beacon	As required	As Required
Battery Heater	As Required	As required		As Required

Summary

- Three platforms flying the same instrument provides a depth of data not normally seen in space science
- The goal of the SIESTA concept is to characterize small-scale plasma irregularities and the MTM
- The INSPIRESat-1 is heading for CDR and the IDEASat is using lessons learned to improve upon the INSPIRE programs first satellite

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References

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Questions?