Stratospheric Global Winds on Titan at the Time of Huygens Descent

HIPWAC at Subaru Nasmyth Focus
Jan. 14-15, 2005

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Goals of HIPWAC Investigations on Subaru

Primary Goals on Titan:

- Directly measure *Wind Direction* and *Magnitude*
- Study atmospheric dynamics of slowly rotating bodies
- Measure atmospheric ethane ($C_2H_6$) abundance
- Constrain Stratospheric Temperature
- Support the Cassini-Huygens Mission
- Coordinate with other observers during Huygens descent into Titan

Discover and Investigate Any Unexpected Phenomena
IR Heterodyne Spectroscopy

Performance Parameters

• $S/N = 2 \sqrt{B \tau / \Delta (e^{hv/kT} - 1)}$
• $\lambda / \Delta \lambda > 10^7$
• 9–12 $\mu$m CO$_2$ laser LO
• $\pm 3$ GHz for HgCdTe mixer
• 1:10$^8$ Frequency Determination
• $\theta \sim \lambda / D$ (Diffraction Limited)

• MEASURES TRUE LINE SHAPES
• VELOCITY TO $\sim 1$ m/s

Source $\nu \sim 10^{13}$ Hz

Local Oscillator (LO) $\nu \sim 10^{13}$ Hz

Difference Frequency $\nu \sim 10^9$ Hz
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Heterodyne Instrument for Planetary Wind And Composition
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Laser Side

Mixer Side
HIPWAC/Subaru Wind Measurements on Titan

Ethane (C₂H₆) Emission Near 11.74 µm

Wind Prograde 190 ±90 m/s; h~230 km

Titan 0.89 arcs
IR FOV ~ 0.4 arcs

Kostiuk et al.

15 Jan2005 (25 MHz)

Kostiuk et al.

IR FOV ~0.6 arcs
Altitudes Probed by Ethane Line Profile

No Wind Information Can Be Retrieved Above ~120 km Altitude
Below 120 km best retrieved Winds are prograde ~60 ± 65 m/s
Wind Altitude Profile on Titan

- **Troposphere**
- **Mesosphere**
- **Stratopause**
- **Stratosphere**
- **Troposphere**

The graph shows the wind profile with altitude, indicating the pressure and temperature changes across different atmospheric layers of Titan.
Difference Between Titan Spectra from 2003 and 2005

Dec. 18, 2003  E-W Average

Jan. 15, 2005 E-W Average

Different Line Shapes of C$_2$H$_6$ ($851.5051$ cm$^{-1}$) lines suggests change in Titan’s atmosphere
Evidence of Mesosphere and Large $\text{C}_2\text{H}_6$ Abundance

$\text{C}_2\text{H}_6$ Abundance Above 300 km is 10 times higher ($Q \approx 1.5 \times 10^{-4}$)
Possible Wind Shear

Differences in Wind Velocity Change the measured Line Shape
(~100 m/s change stratosphere vs. mesosphere shown)
Conclusions

• Helped generate the first *Wind Altitude Profile* on Titan
• E – W spectra imply high ethane mole fraction above stratopause (~10 x) - *Not Expected*
• Spectral changes and wind retrievals both suggest *Variability* in Titan’s atmosphere - *Not Expected*
• Detected evidence of Titan’s Mesosphere
• Possible detection of Wind Shear near stratopause
• HIPWAC Results are Complementary to Cassini/Huygens Investigations

Possible Future HIPWAC Observations

• Titan’s Mesosphere, positive Measure Wind Shear, detection of minor constituents (e.g. C$_3$H$_4$) and spatial and temporal Variability

• Envelopes of Infrared Stars their composition and their velocity structure

We welcome future collaborations from the entire astronomy community

We thank Dr. H. Karoji and the Subaru staff for their excellent support of our investigation and wish them all a happy holiday and a successful New Year
Happy New Year from
NASA Goddard Space Flight Center HIPWAC Team at Subaru

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