

Investigation of the Coupling between Convective Physics and Catalytic Chemistry in the Stratosphere: A New Observing System

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Summary of the Required Measurement

Molecule

ClO
BrO
ClONO₂
ClOOCl
N₂O
CH₄
CO
CO₂

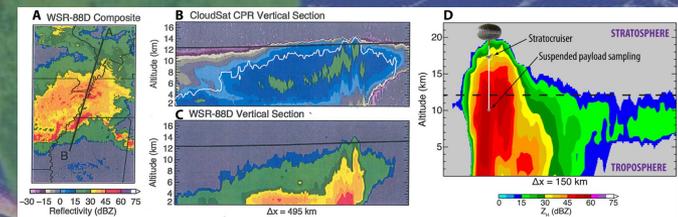
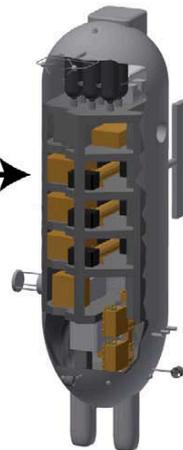
Strato-
cruiser



Molecule

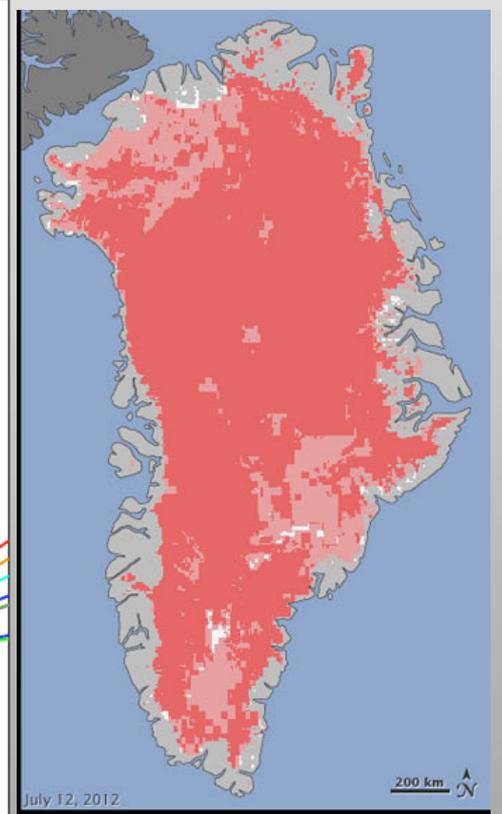
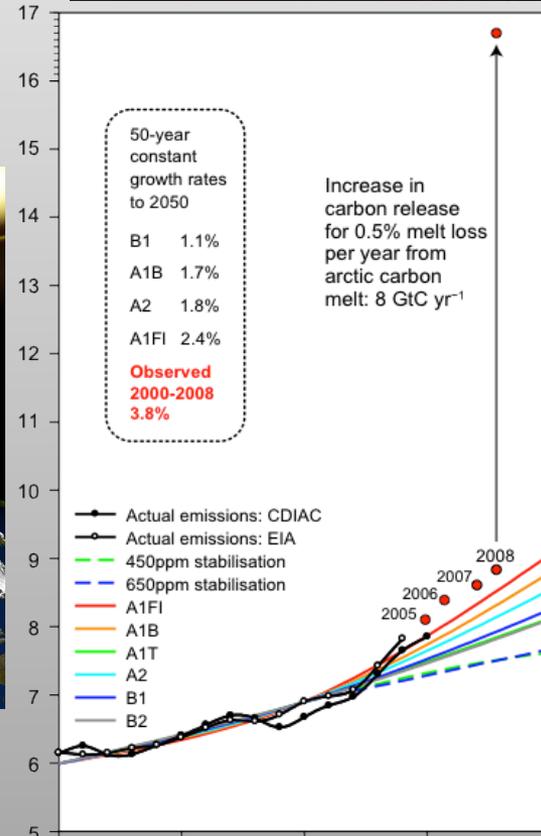
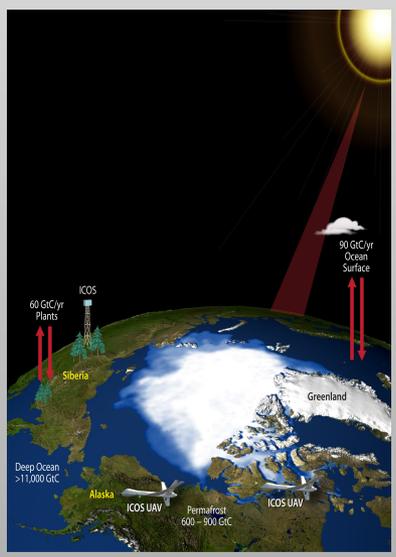
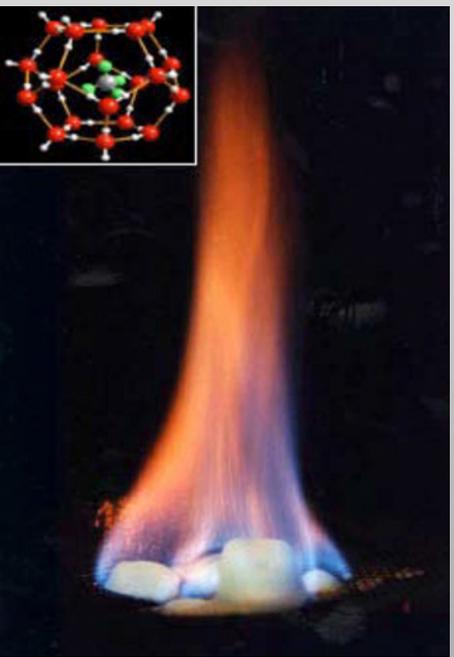
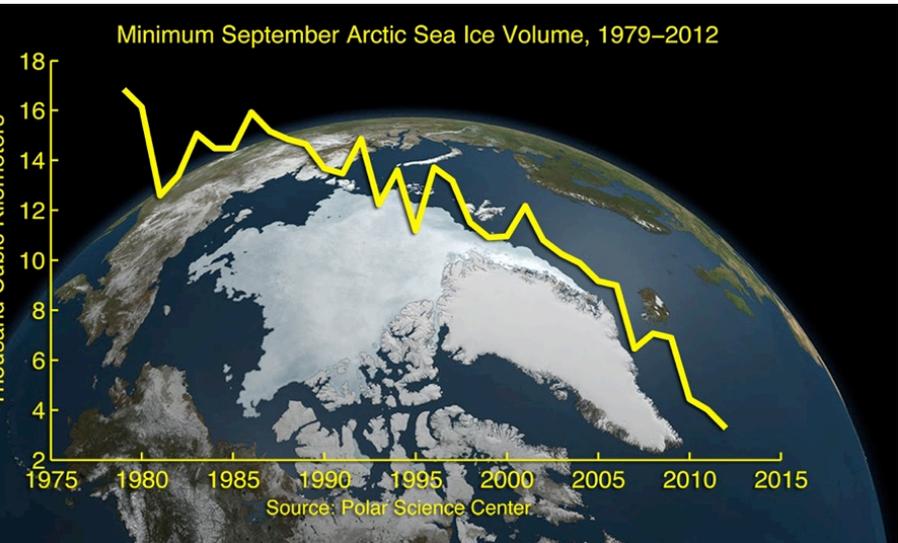
ClO
HCl
NO₂
H₂O
HDO
H₂O total
O₃
N₂O
CH₄
CO
CO₂

Suspended
Payload

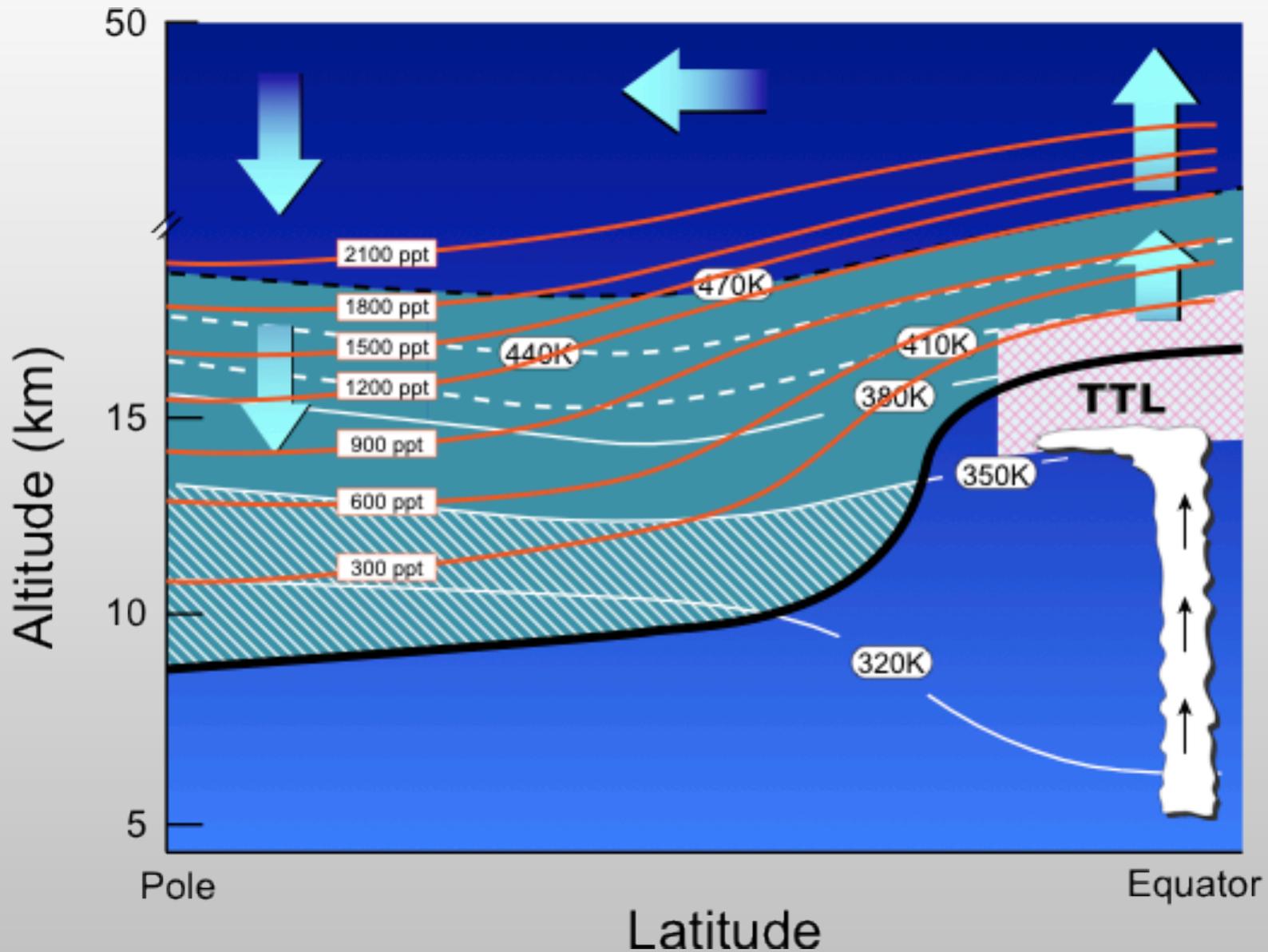


Background Points: Climate is changing far more rapidly than we thought even five years ago:

- Loss of permanent floating ice volume has decreased by 80% since 1980
- Greenland is undergoing remarkable changes in both surface melt and glacial structure
- The warming of the Arctic basin brings both a decrease in the temperature gradient between midlatitudes and the polar region
- Warming of the Arctic exposes the sequestered clathrates and permafrost that contain major carbon stores
- These structural changes are linked directly to feedbacks in the climate system that set the time scale for irreversible change

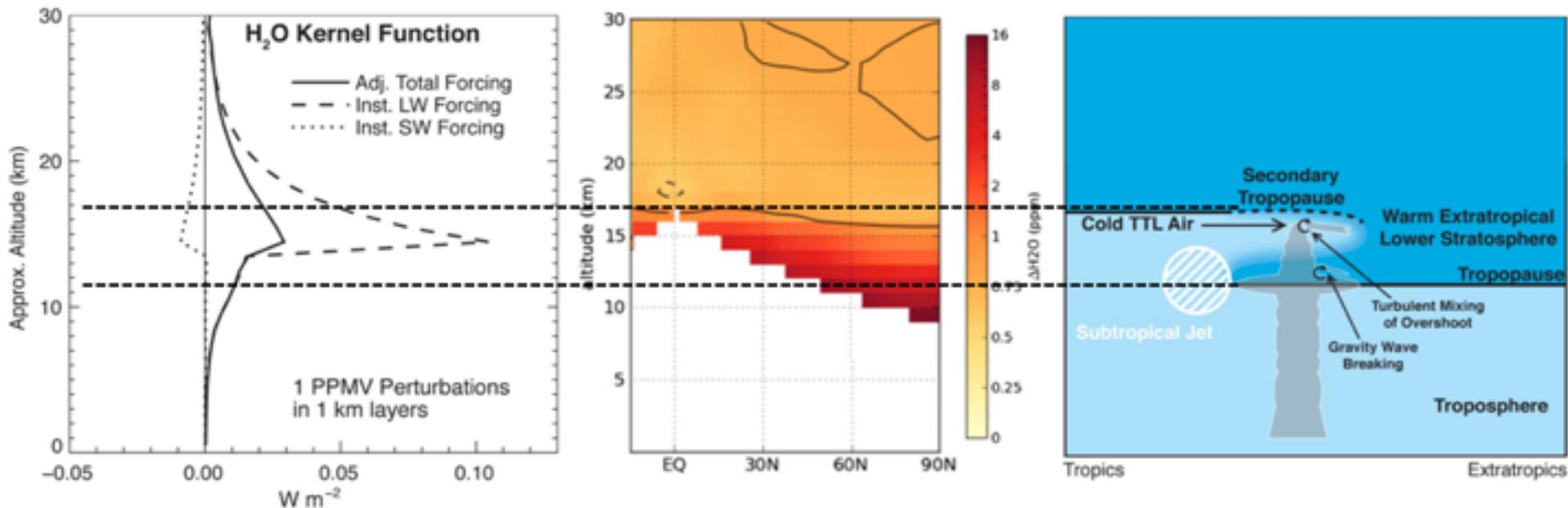


Focus on Convection



Scientific Motivation I

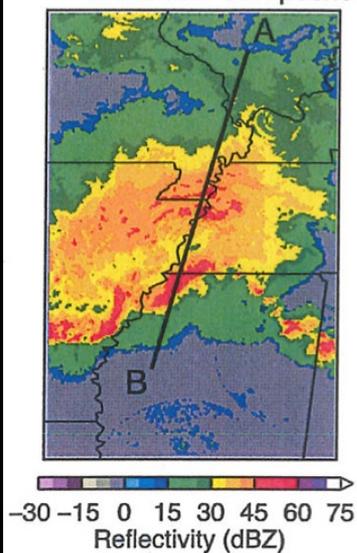
Water Vapor, Radiative Forcing & Climate Feedback



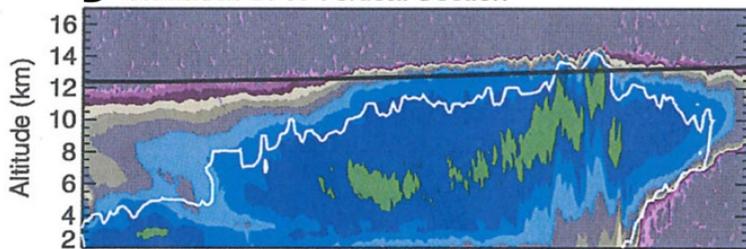
- ❖ Radiative impact significant even for ~1 ppmv changes in strat. H₂O
- ❖ As temperatures rise, water vapor in UT/LS increases --> +Feedback
- ❖ Convective contribution least well understood
- ❖ **How will mechanisms that determine UT/LS H₂O change in response to climate forcing?**



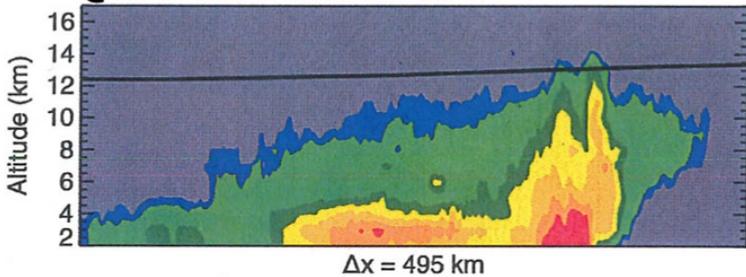
A WSR-88D Composite



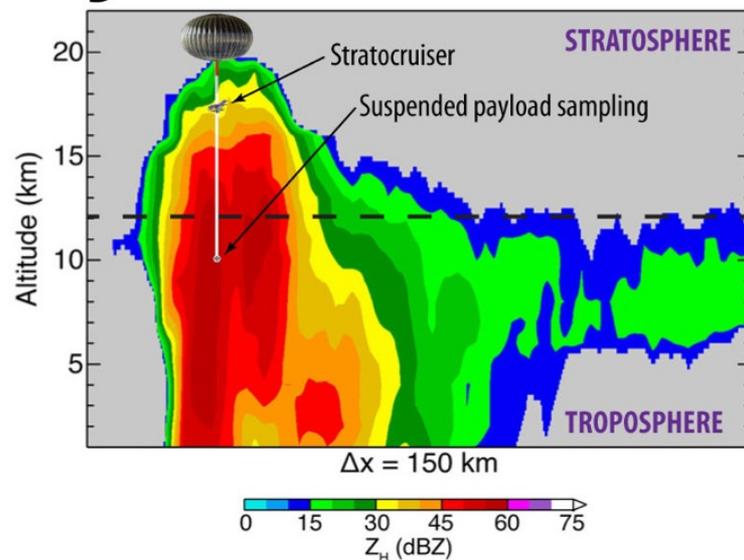
B CloudSat CPR Vertical Section



C WSR-88D Vertical Section

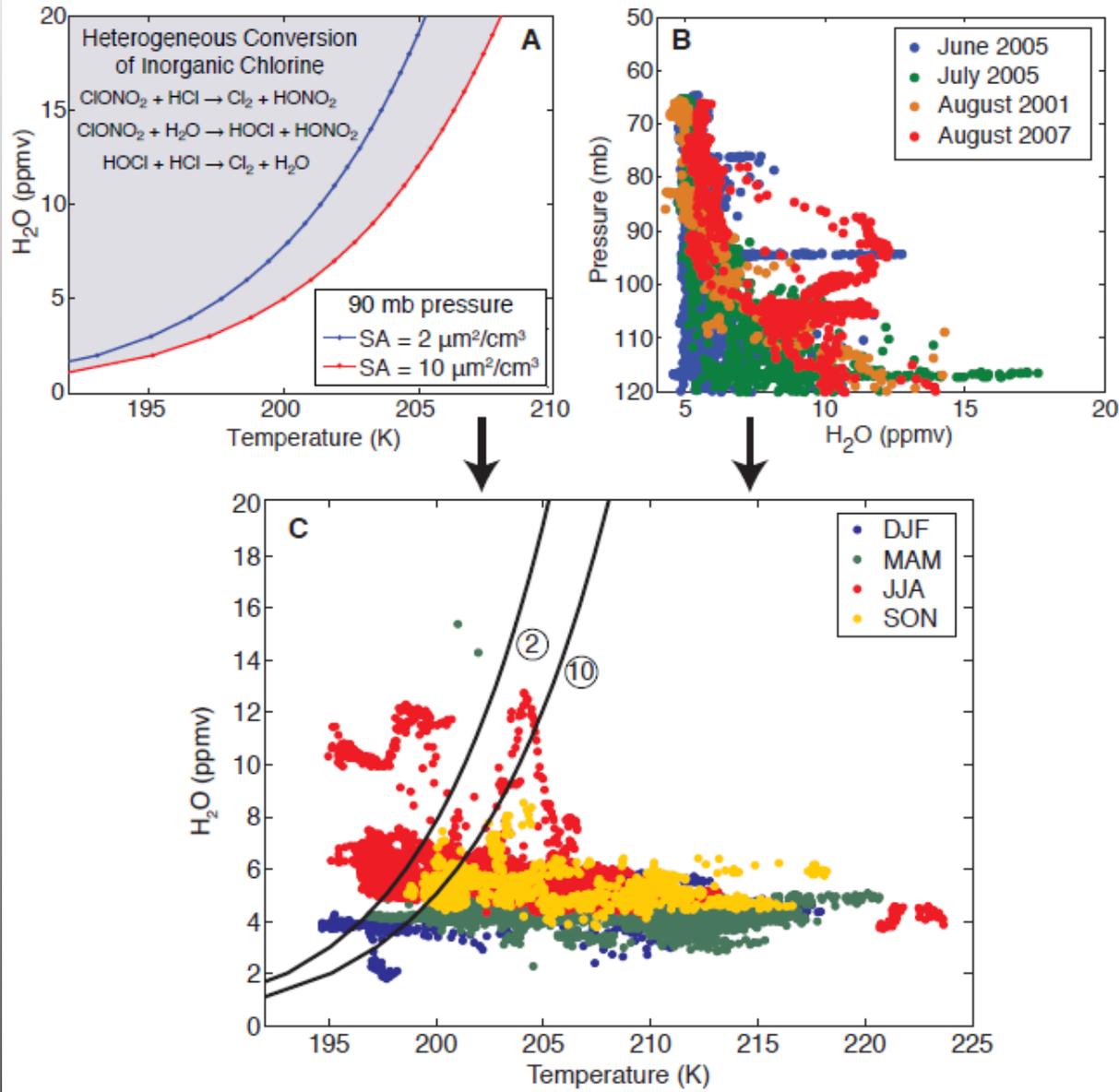


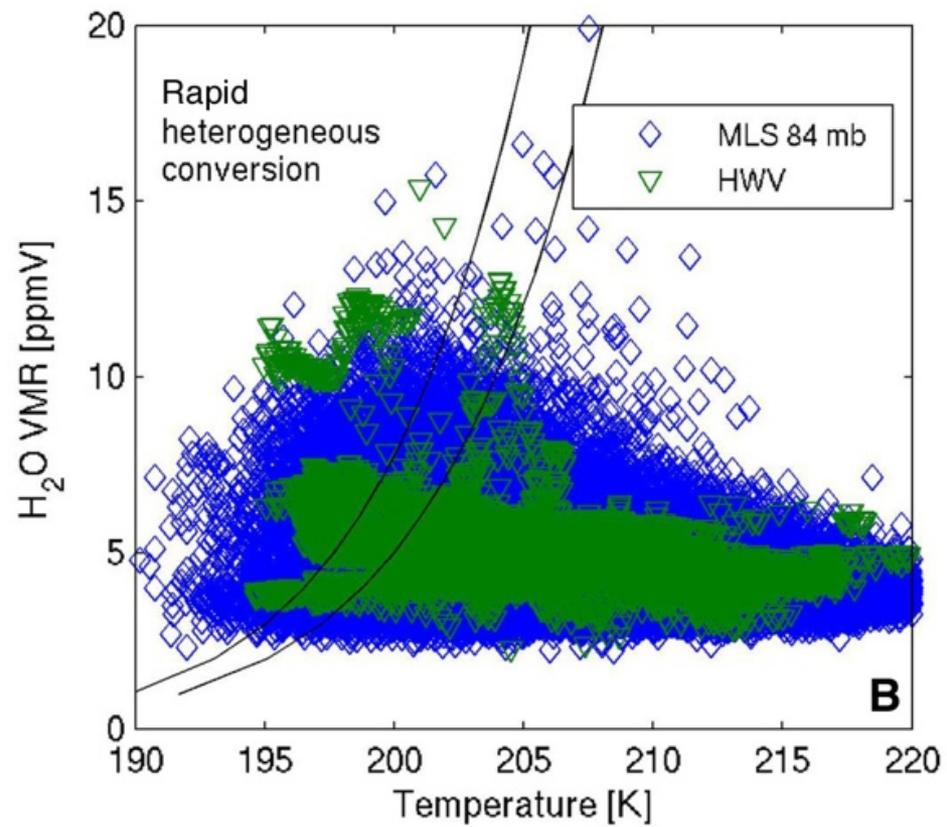
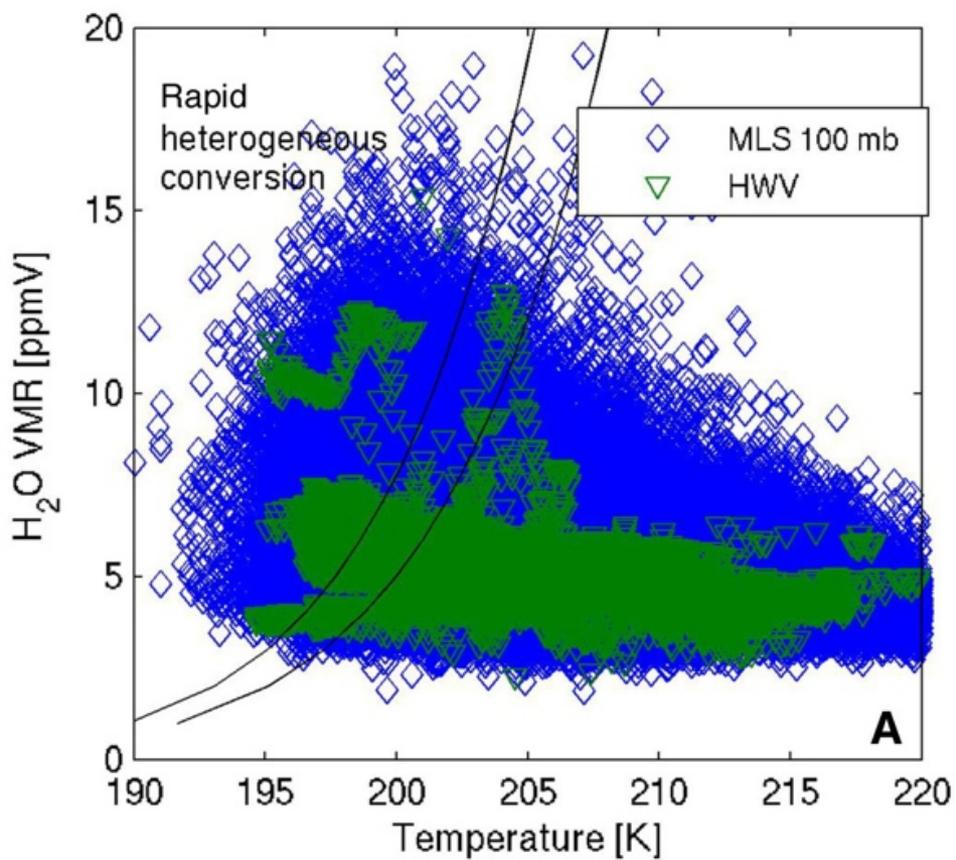
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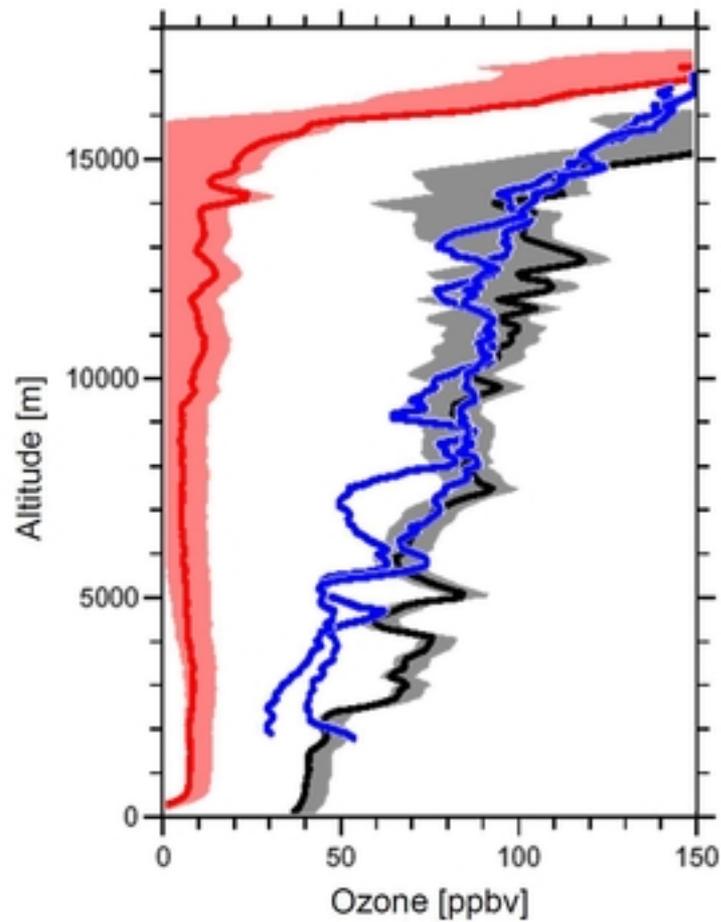
Scientific Motivation II

Convection, Water Vapor & Potential for Ozone Loss



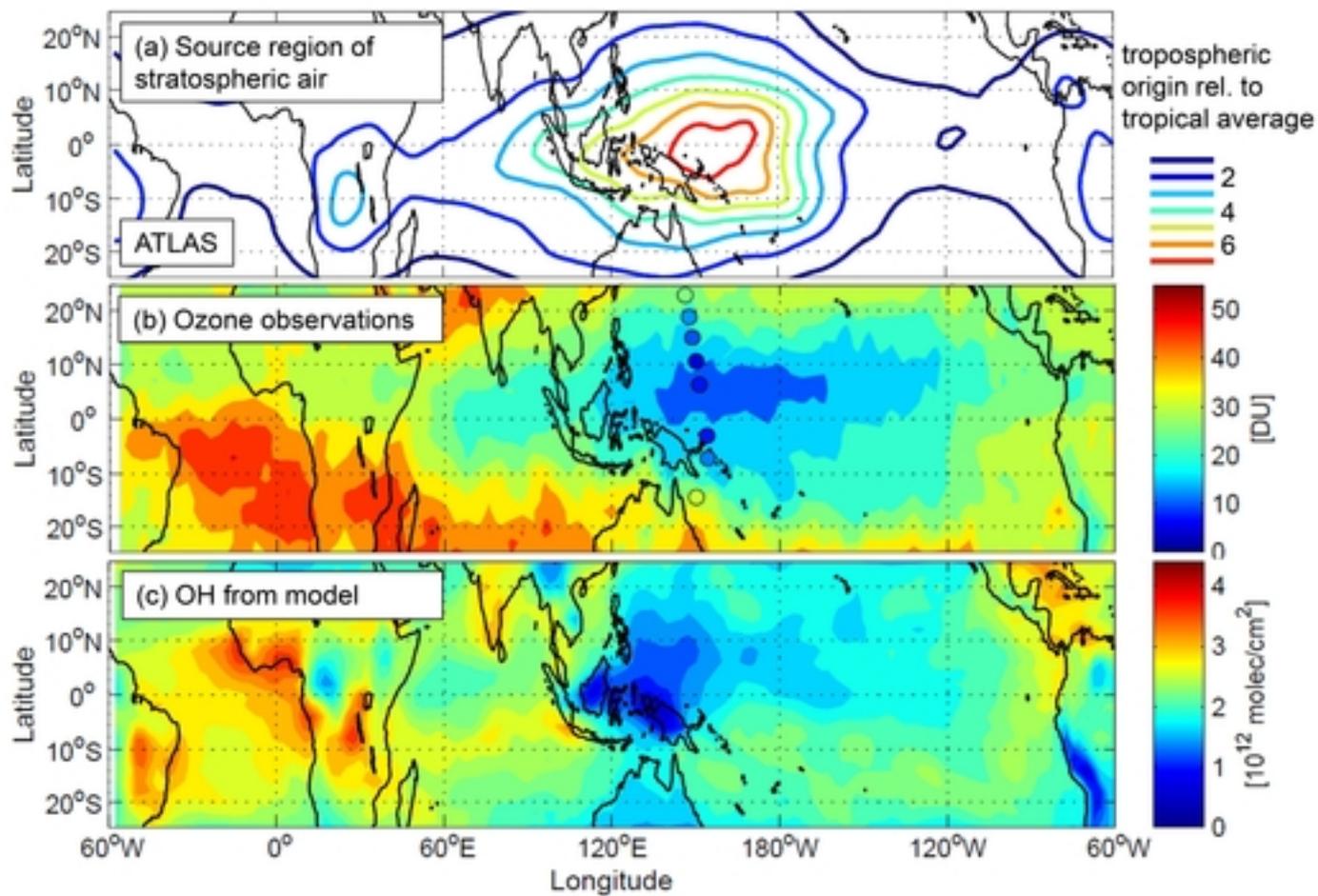






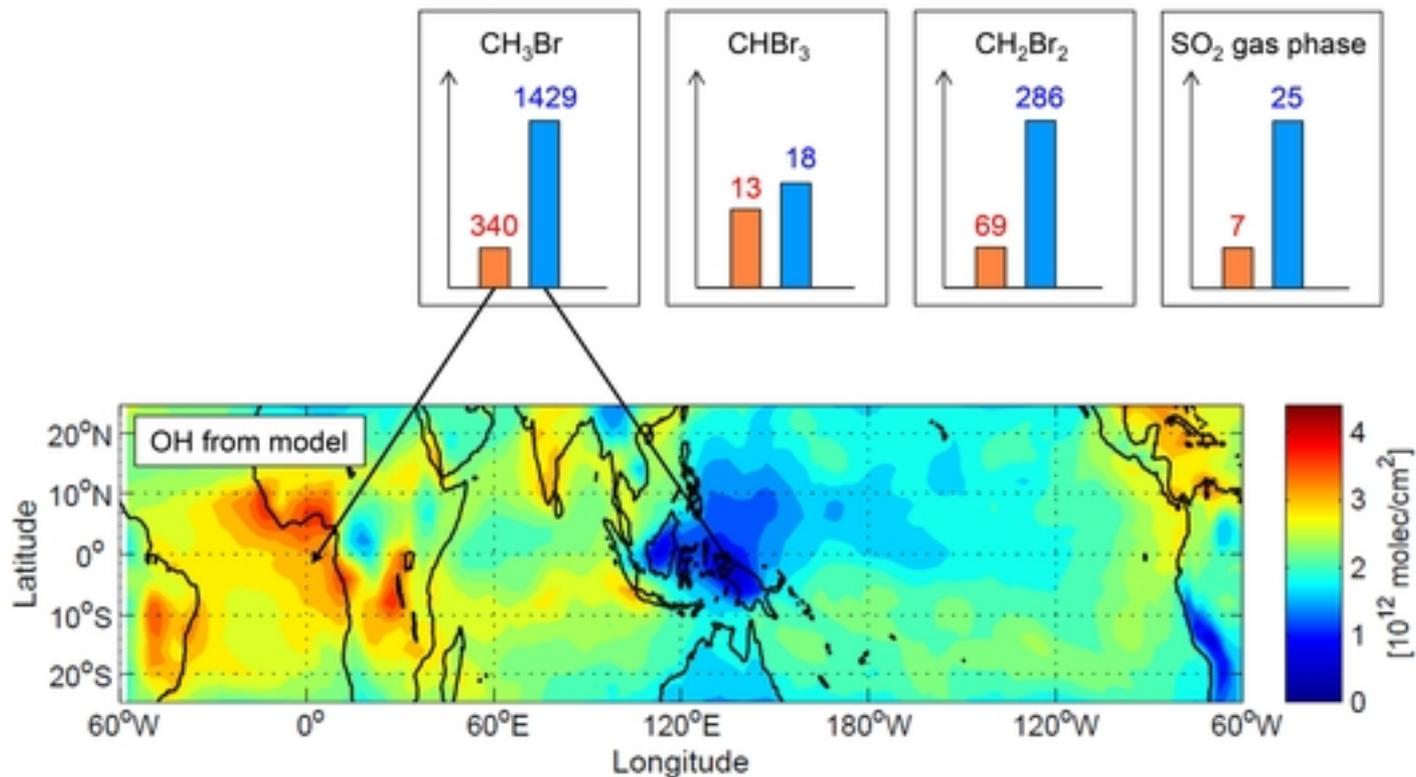
Ozone profiles in the West Pacific

- Extratropical
West Pacific ~30°
- Tropical Atlantic
- Tropical
West Pacific



Lifetimes of key species for stratospheric composition

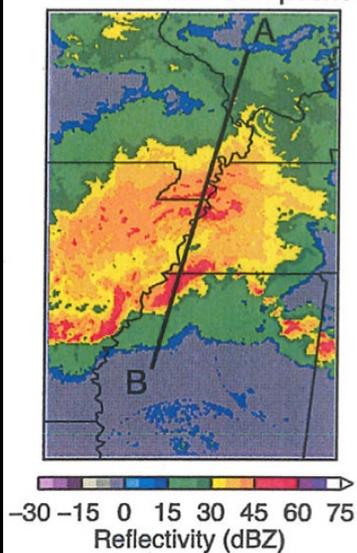
In days: ■ "standard OH" ■ "OH hole"



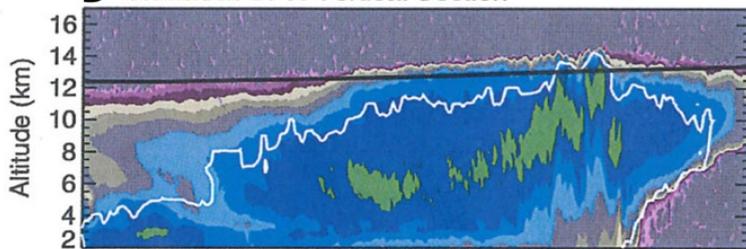
Summary Points:

- It is now established Through a combination of aircraft, NEXGEN radar network, and satellite observations that convection into the summertime stratosphere over the US is a common occurrence.
- The relationship between severe storms and penetration of convection into the stratosphere has developed to the point where knowledge of the relationship between CAPE generation , convective penetration and climate forcing has become a major unsolved scientific question.
- Lack of knowledge of the dynamical and chemical structure of the convective injection into the stratosphere has emerged as a major limitation to our understanding of severe storms, climate feedback and climate forcing. Both aircraft and satellites have observed the steep gradient in inorganic chlorine with respect to both altitude and latitude.
- Skin cancer is the most common for of cancer, the most rapidly growing category, and 5% drop in column ozone equates to ~ 15% fractional increase in incidence of skin cancer.

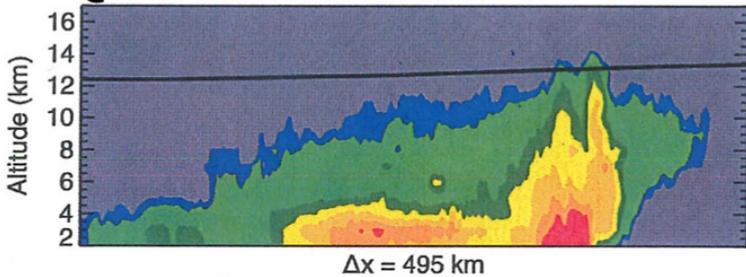
A WSR-88D Composite



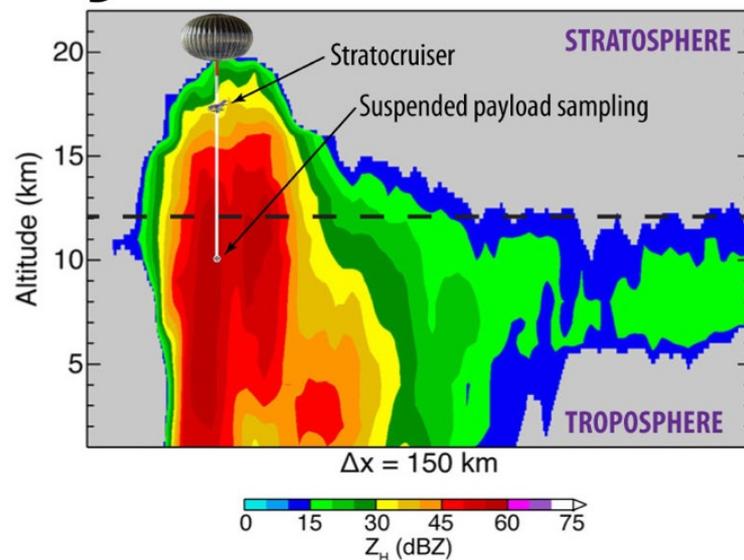
B CloudSat CPR Vertical Section



C WSR-88D Vertical Section



D



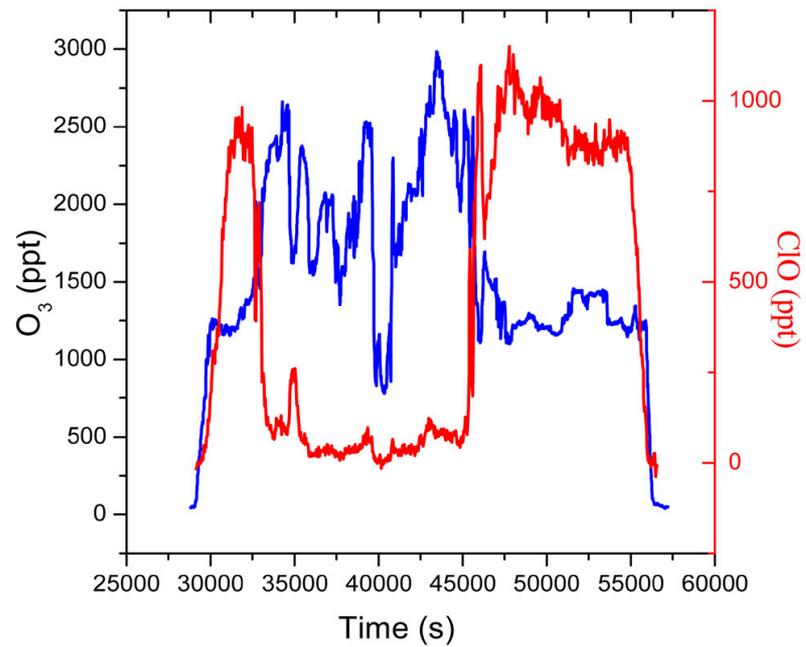
What is not known from the CloudSat/ NEXRAD Observations:

- The structure of the 3D velocity fields within the storm structure in the stratosphere.
- The structure of the wave breaking events associated with the convective intrusion.
- The concentration of species co-injected with water by the convective event.
- Both the vapor phase and condensed phase H₂O and HDO concentrations injected by the storm.
- The concentrations of (a) the reactive chemical precursors that are normally removed by photolysis or oxidation in the troposphere, and (b) chemical tracers brought in by the storm or drawn in by the perturbation associated with convection.
- The subsequent fate of the convectively injected chemical cocktail in the stratosphere in the hours and days following the convective injection.

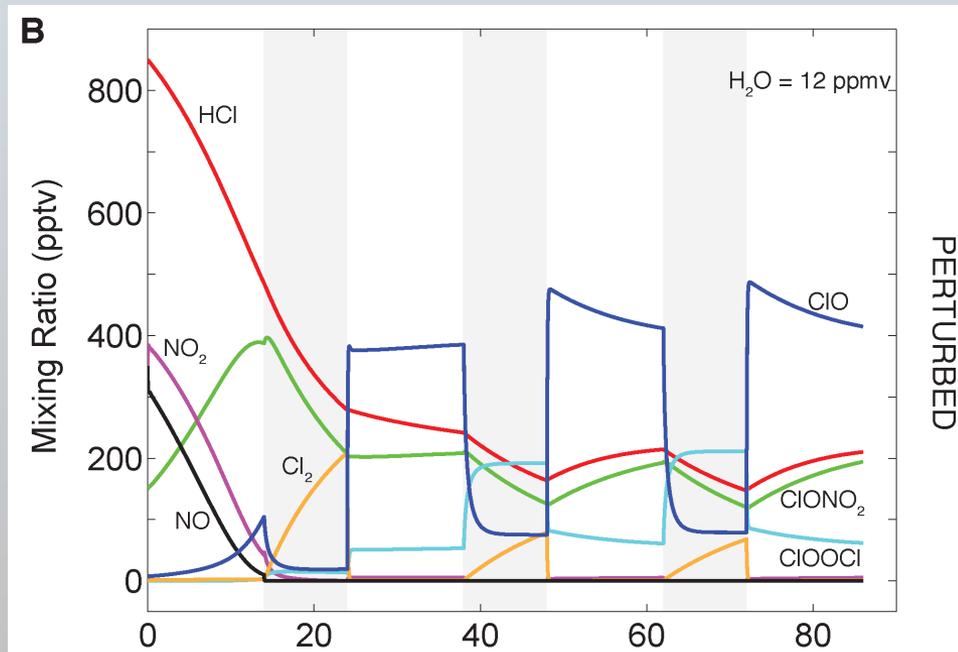
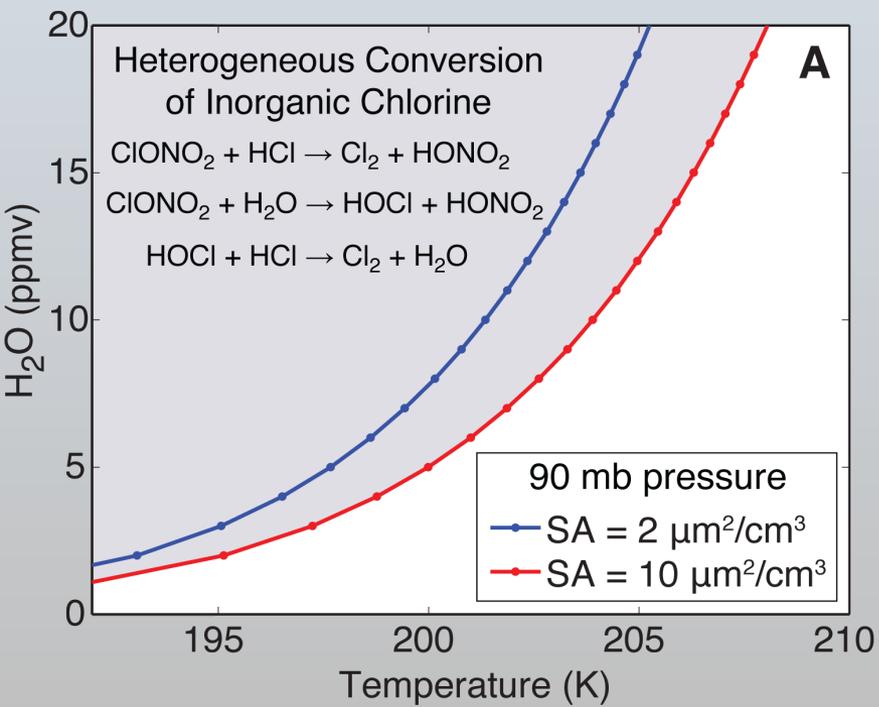
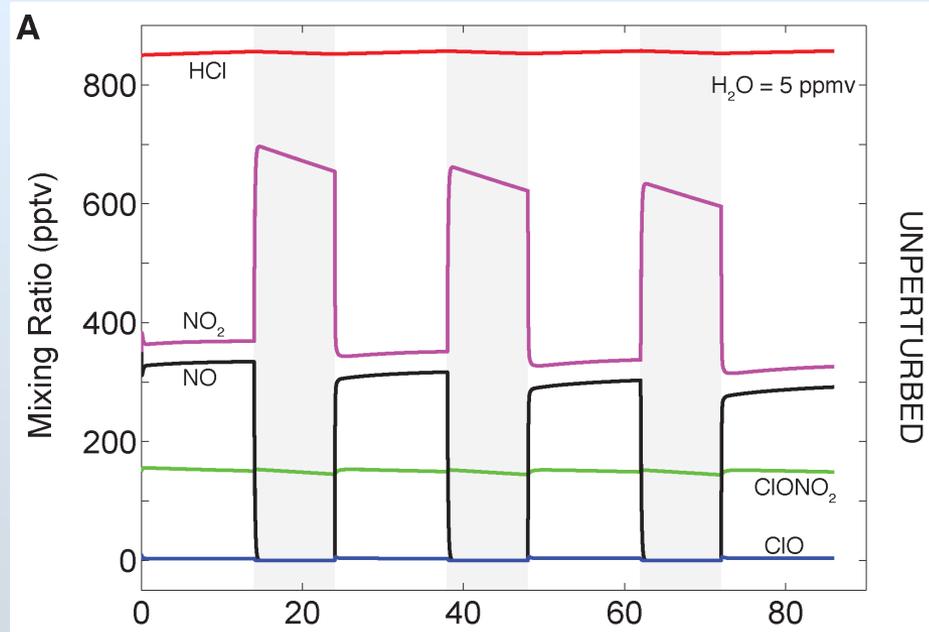
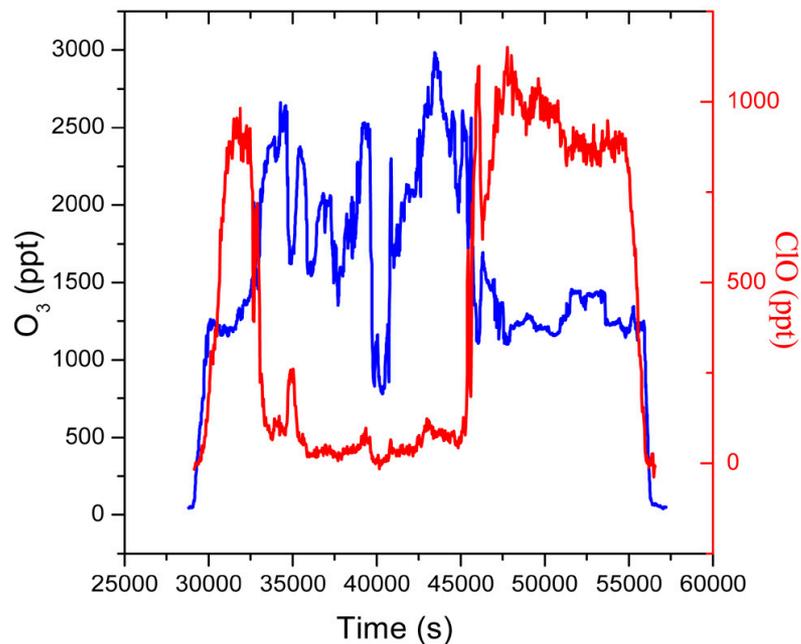
So how does this link with what we know about catalytic destruction of ozone in the lower stratosphere?

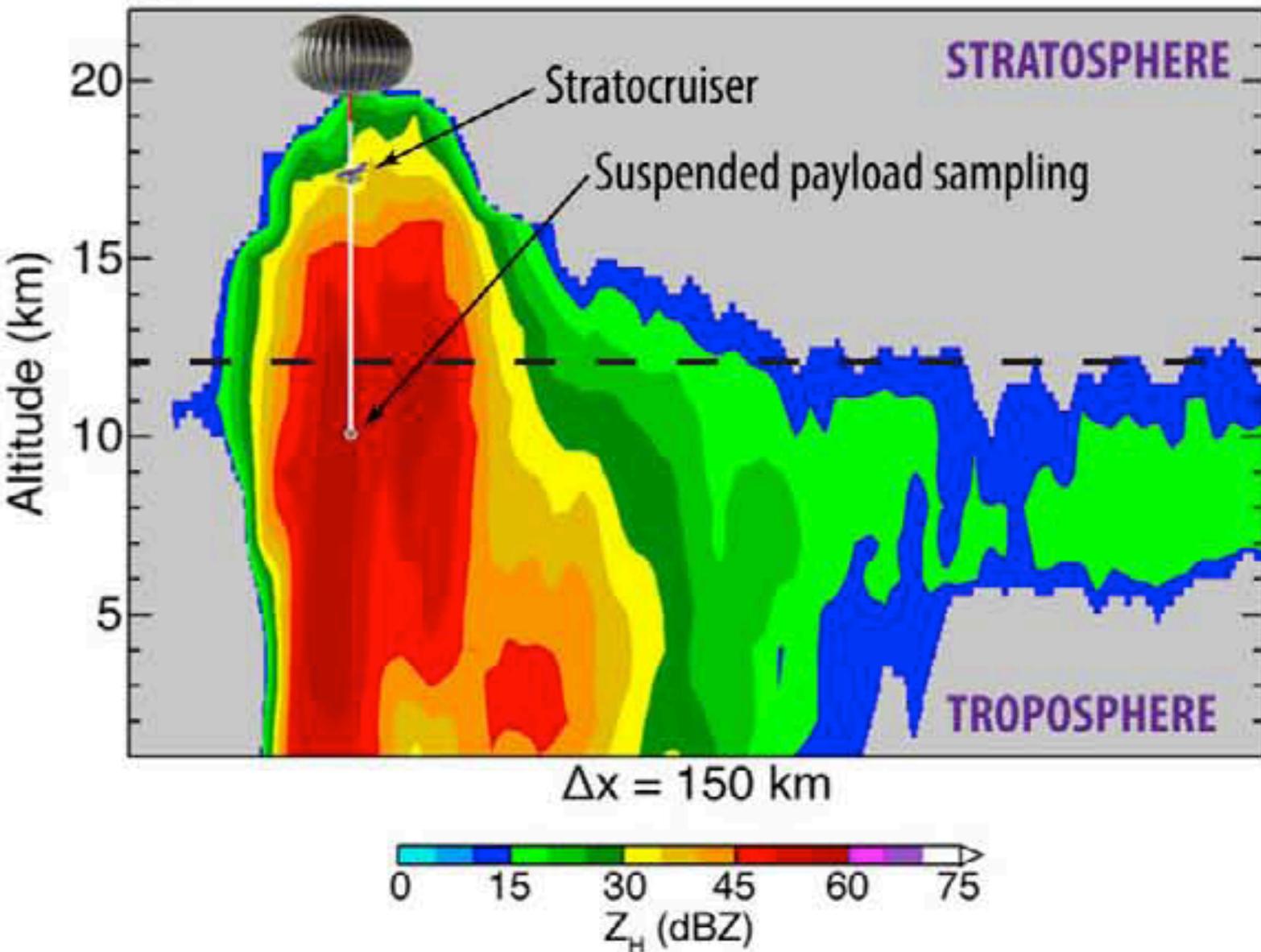


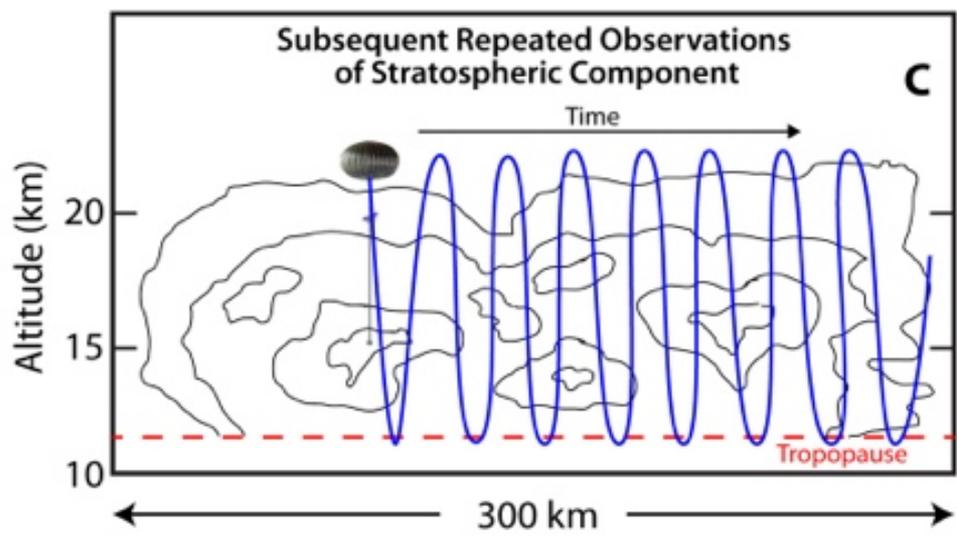
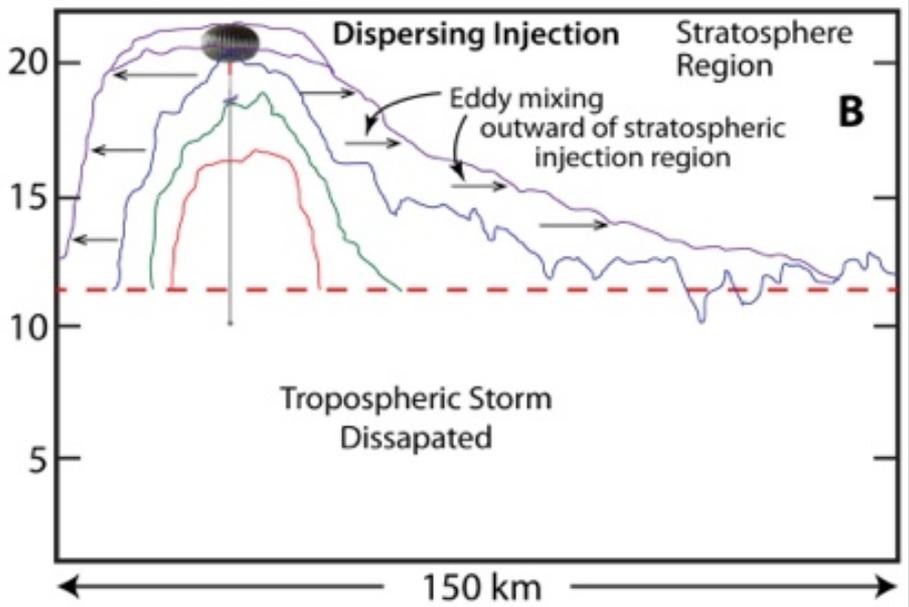
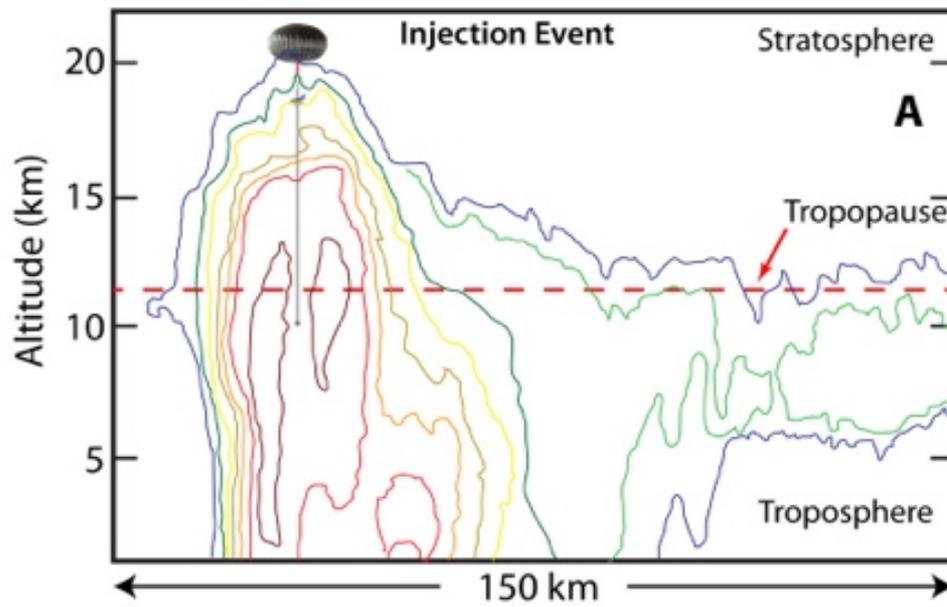
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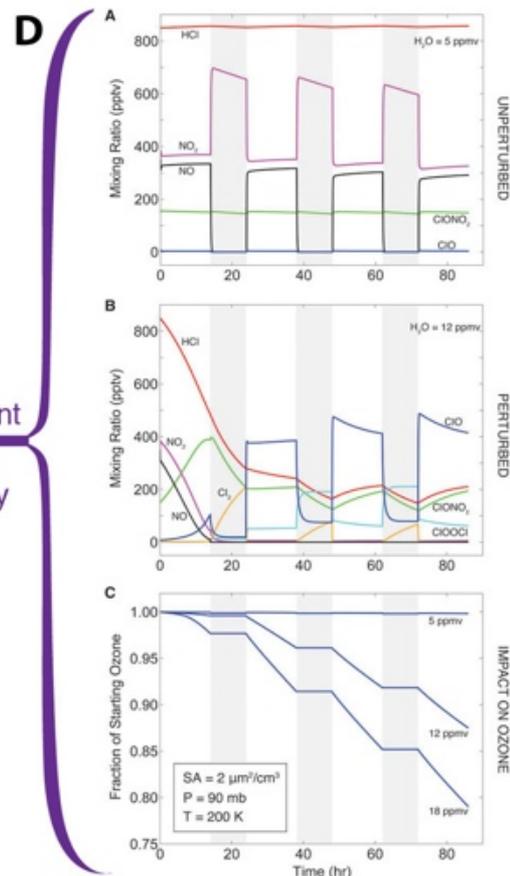
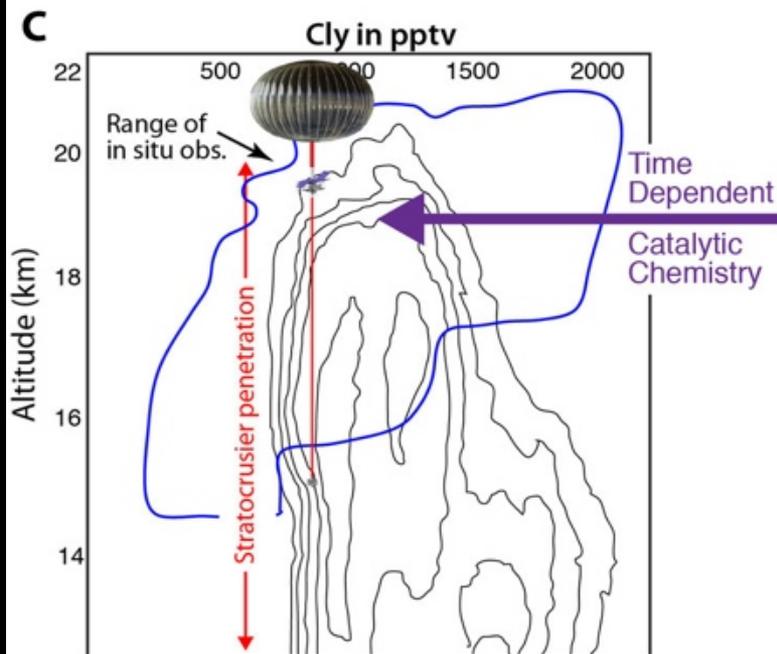
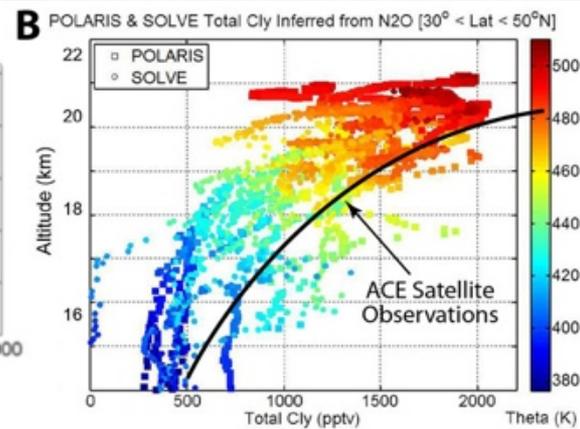
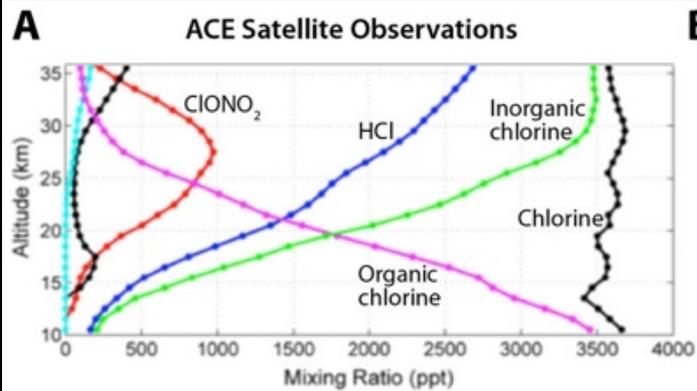


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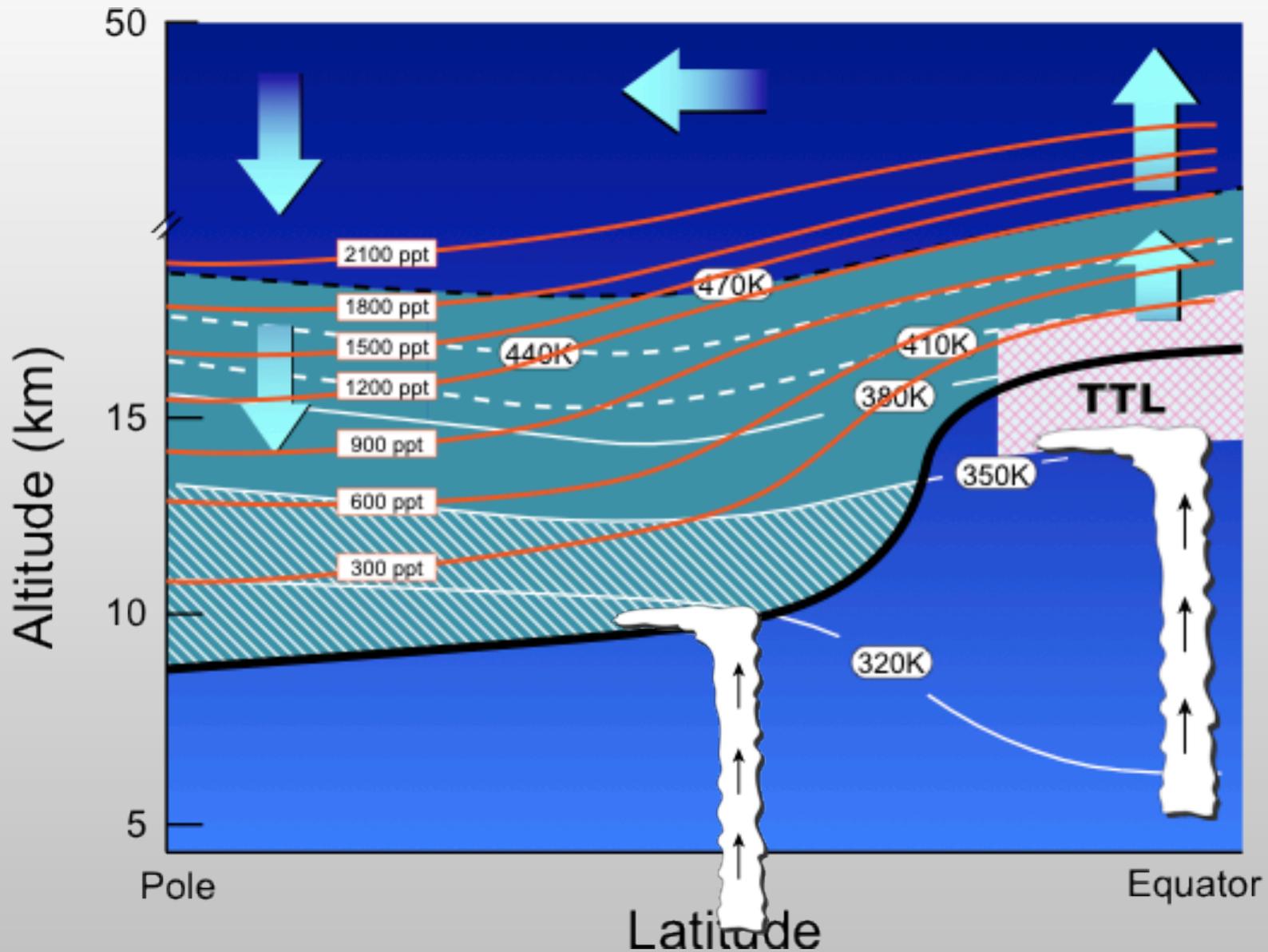


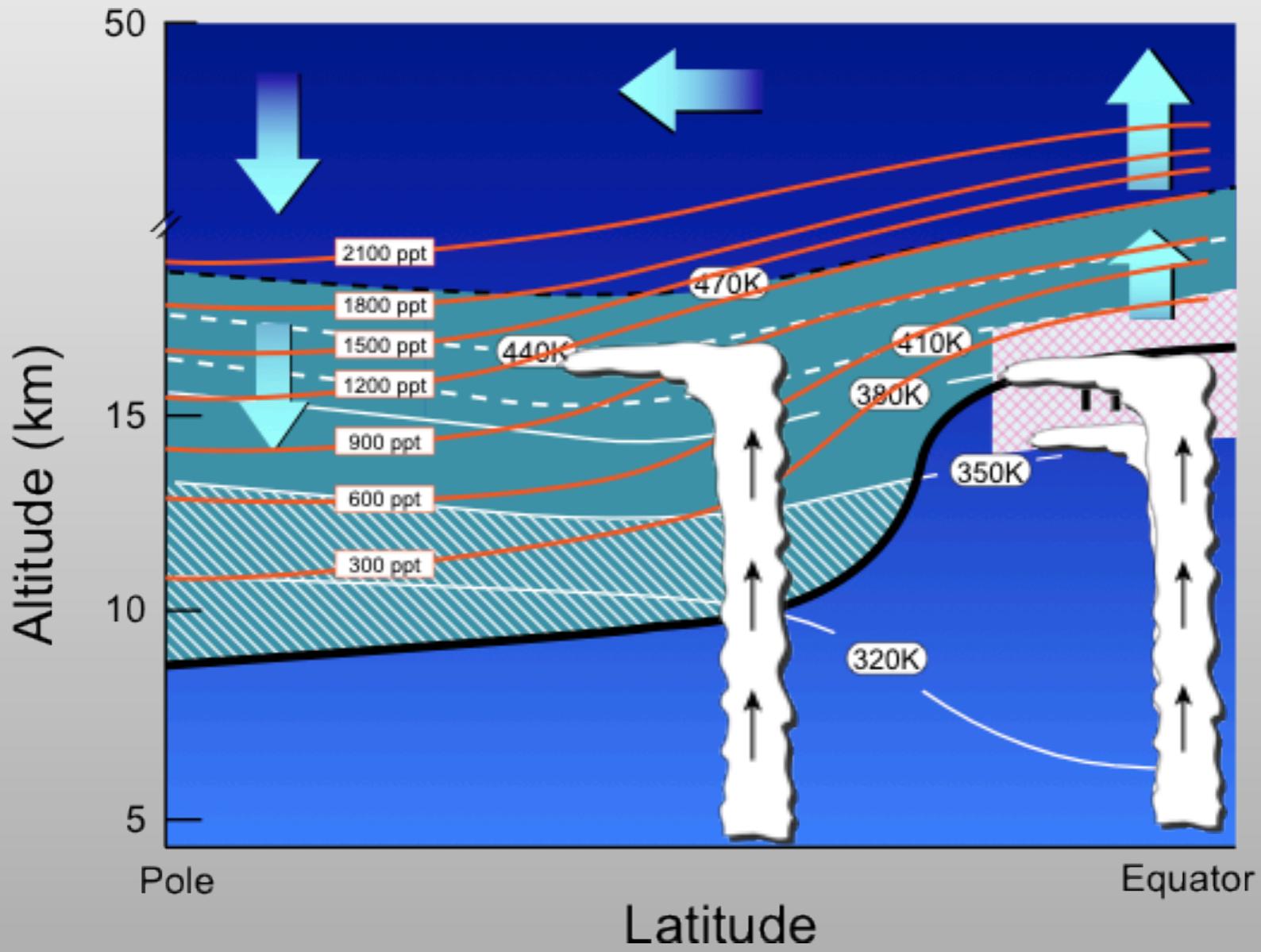
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Focus on Convection







Summary of the Required Measurement

Molecule

- ClO
- BrO
- ClONO₂
- ClOOCl
- N₂O
- CH₄
- CO
- CO₂

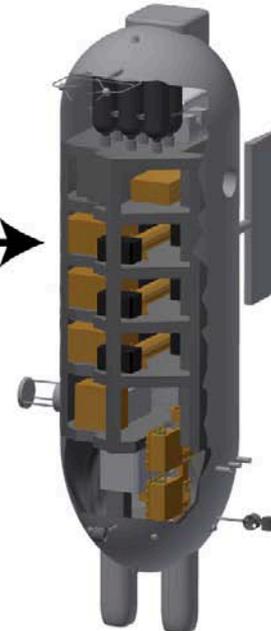
Strato-
cruiser

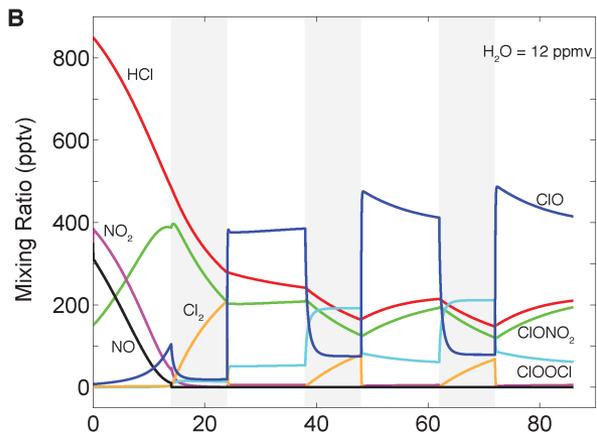


Molecule

- ClO
- HCl
- NO₂
- H₂O
- HDO
- H₂O total
- O₃
- N₂O
- CH₄
- CO
- CO₂

Suspended
Payload





Safety Parachute

Upward-looking Camera

Gas Deck

Data Uplink Antenna

Electronics

Ultrasonic Anemometers

HCl, NO_2

CO_2 , CO, N_2O , CH_4

HDO Vapor and Condensed
 H_2O Vapor and Condensed

Water Vapor Instrument

Inlets

ClO

Vane Anemometers

O_3

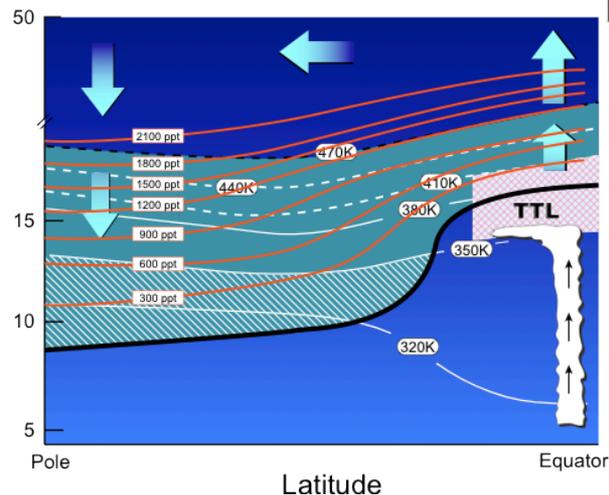
Panoramic Camera Array

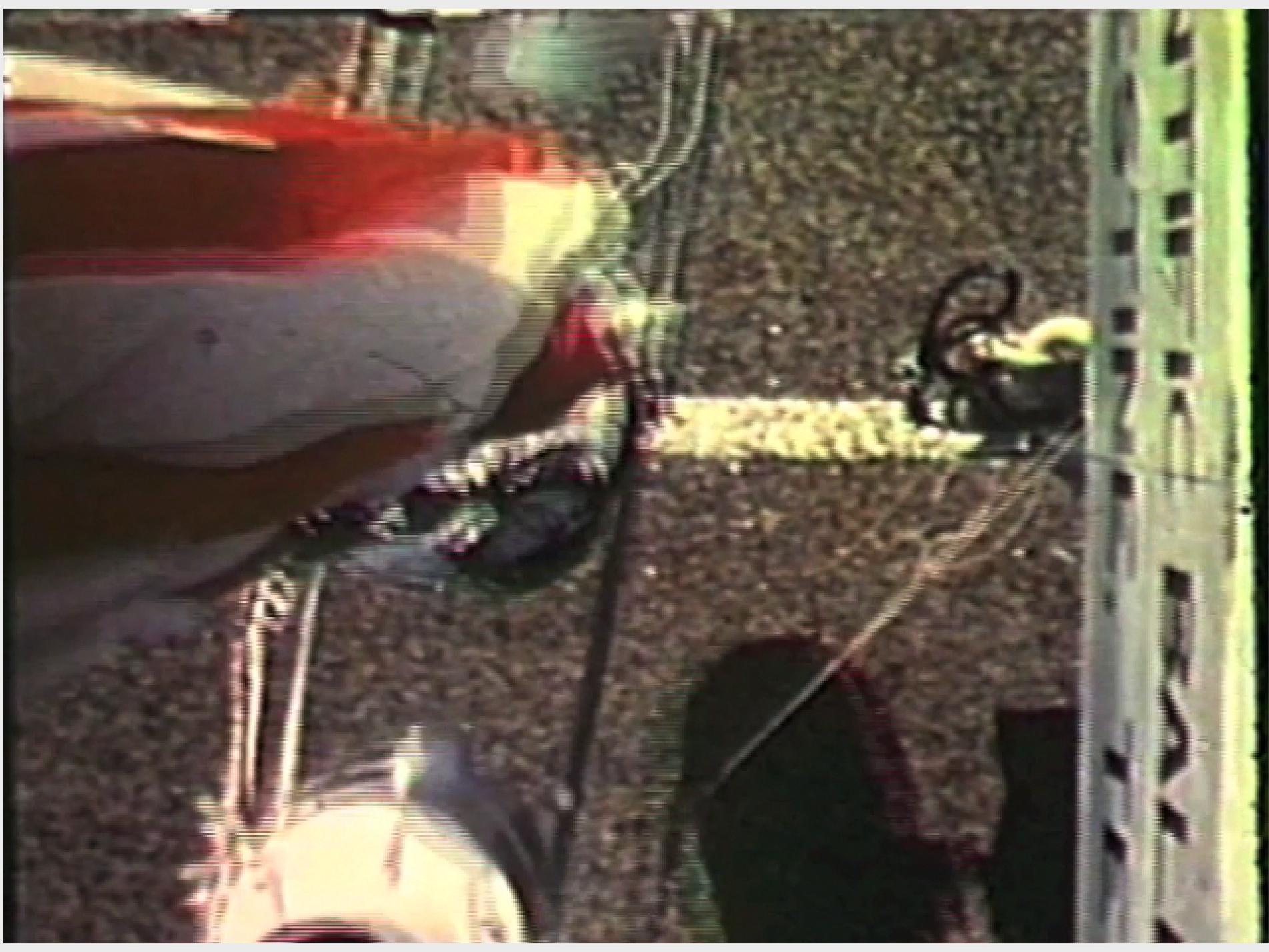
Down-looking Camera

Total Water Inlet

ClO Inlet

PERTURBED





Science Team

- Jim Anderson Harvard
- Bill Gibson Harvard/SwRI
- Kerry Emanuel MIT
- Paul Newman NASA GSFC
- Steven Wofsy Harvard
- John Langford Aurora Flight Sciences
- Ken Bowman Texas A&M
- Eric Jensen NASA Ames
- Cameron Homeyer Univ. of Oklahoma
- Jesse Kroll MIT
- Mario Molina UCSD
- Ross Salawitch Univ. Maryland
- Jessica Smith Harvard
- David Wilmouth Harvard
- Stephen Leroy Harvard
- Ron Cohen UC Berkeley

END