Current Status of the Aerosols-Clouds-Convection-Precipitation (ACCP) Decadal Survey Study

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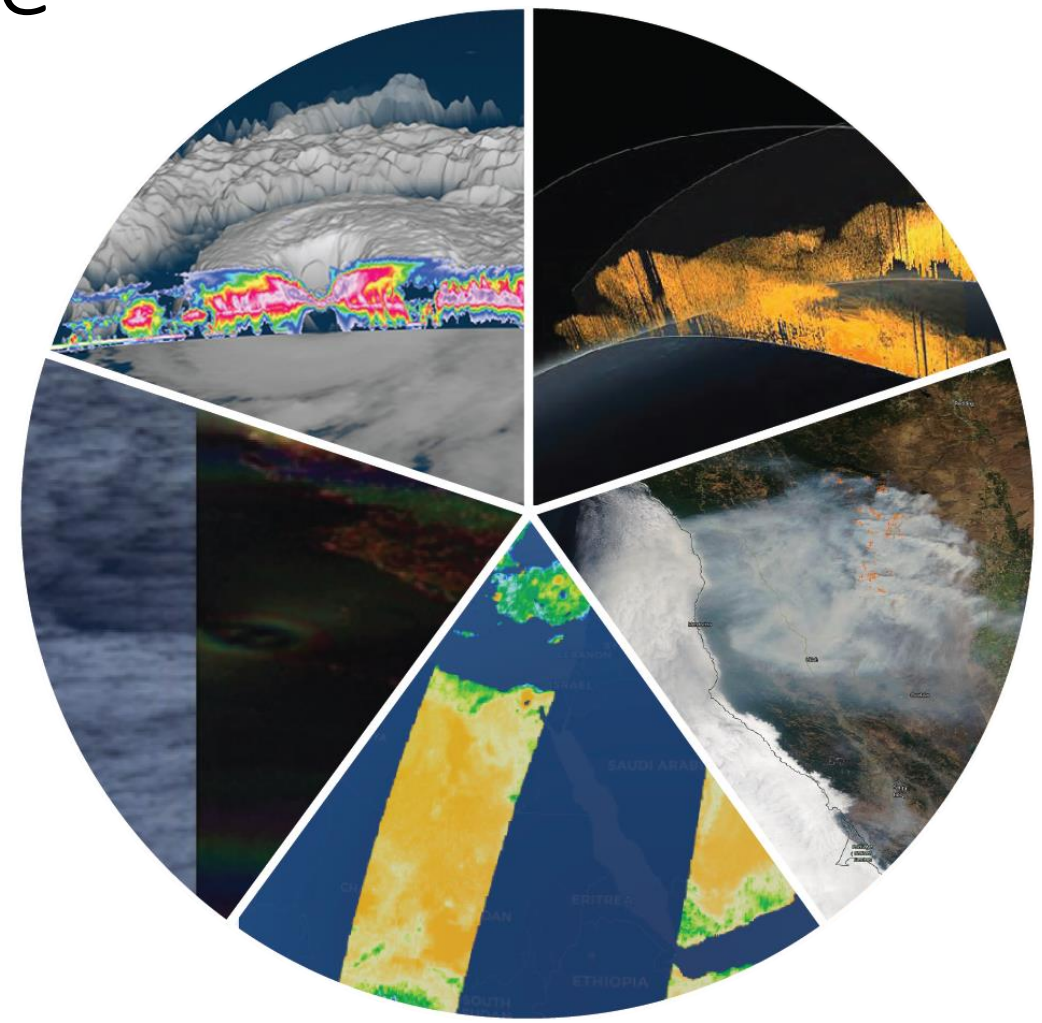
Science Impact Team (SIT) Co-Leads: Jay Mace (U. Utah), Jens Redemann (U. OK)
Science Community Committee Co-Leads: Sue van den Heever (CSU), Greg Carmichael (U. IA)

Joint PI Meeting of JAXA Earth Observation Missions FY2020 January 19, 2021

Outline

- Decadal Survey and ACCP Science Objectives
- ACCP Measurement Capabilities
- Final 3 Architectures
- Summary



2017 DS Recommendations : A & CCP

- The *2017 Decadal Survey* (DS) recommended cost-capped missions with specified caps, creating challenges for teams to envision new science but ensure an implementable observing system.
- Aerosols (A) and Clouds, Convection & Precipitation (CCP) represent 2 of the 5 Designated Observables (DOs) recommended by the DS.

	Aerosols (A)	Clouds, Convection & Precipitation (CCP)
Observable Priorities	Aerosol properties, aerosol vertical profiles, and cloud properties to understand their effects on climate and air quality	Coupled cloud-precipitation and dynamical state for monitoring global atmospheric hydrological cycle and understanding contributing processes and cloud-climate feedback
Anticipated Measurement Approaches*	Backscatter lidar and multichannel, multi-angle/ polarization imaging radiometer	Radar(s), potentially with Doppler capability, with multi-frequency passive microwave and sub-mm radiometer

*Space-based, with expectations of complementary suborbital field programs with more capable airborne instruments.

ACCP Key Science Questions

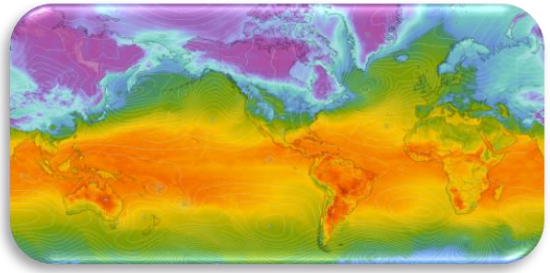
Q1 **Convective Storm Processes:** Why do storms form when and where they do, and how do they grow to produce heavy rainfall?

Q2 **Air Pollution Processes and Distribution:** Why do air-quality events that adversely impact human health, agriculture, and ecosystems occur where and when they do?

Q3 **Climate Sensitivity and Feedback:** How will changes to clouds and aerosol particles influence the future climate of the Earth?

ACCP at a Glance

Overarching Goal: Characterize the Role of Aerosols, Clouds, & Precipitation in Weather, Climate, and Air Quality Prediction



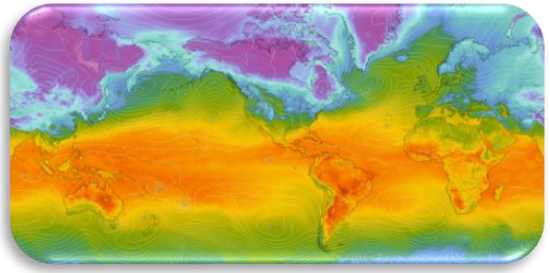
W-4 Convective Storm Processes

W-5 Air Quality Processes and Distribution

C-2 Climate Sensitivity, Cloud Feedback, Aerosol Forcing

DS Science Questions

ACCP at a Glance



Condensation
Collision/Coalescence
Riming/Freezing
Precipitation

Emissions
Humidification
(Chemical Transformations)

Nucleation, Condensation
Collision/Coalescence
Precipitation

Radiative Heating
Nucleation

Wet Removal
Redistribution

Nucleation

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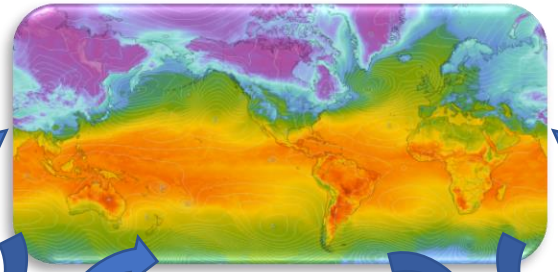
Small Scale Processes

DS Science Questions

ACCP at a Glance



Circulation
Vertical Transport
Detrainment

Large-scale Control

Global
Air-quality

Large-scale
Transport

Cloud & Aerosol
Radiative Effects
on Circulation

Large-scale control

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Large Scale Processes

Small Scale Processes

DS Science Questions

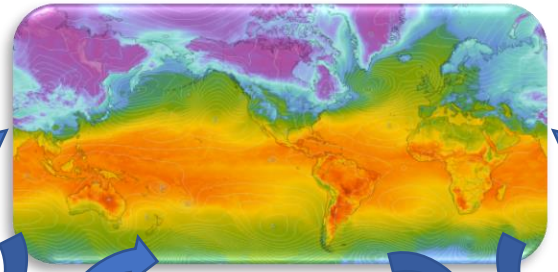
Measurement Needs

Large Scale Processes

Small Scale Processes

DS Science Questions

ACCP at a Glance



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Vertical Motion
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Precipitation Properties
Rainfall Extremes
Latent Heating

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Aerosol Microphysical
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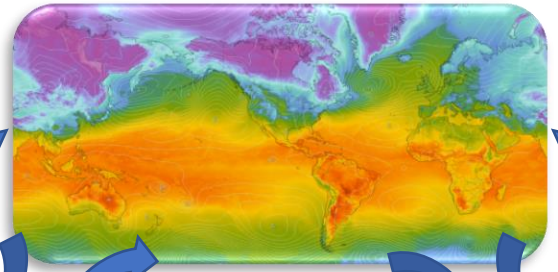

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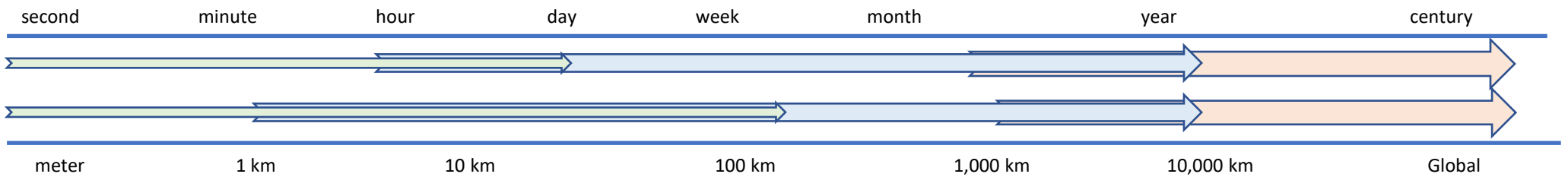
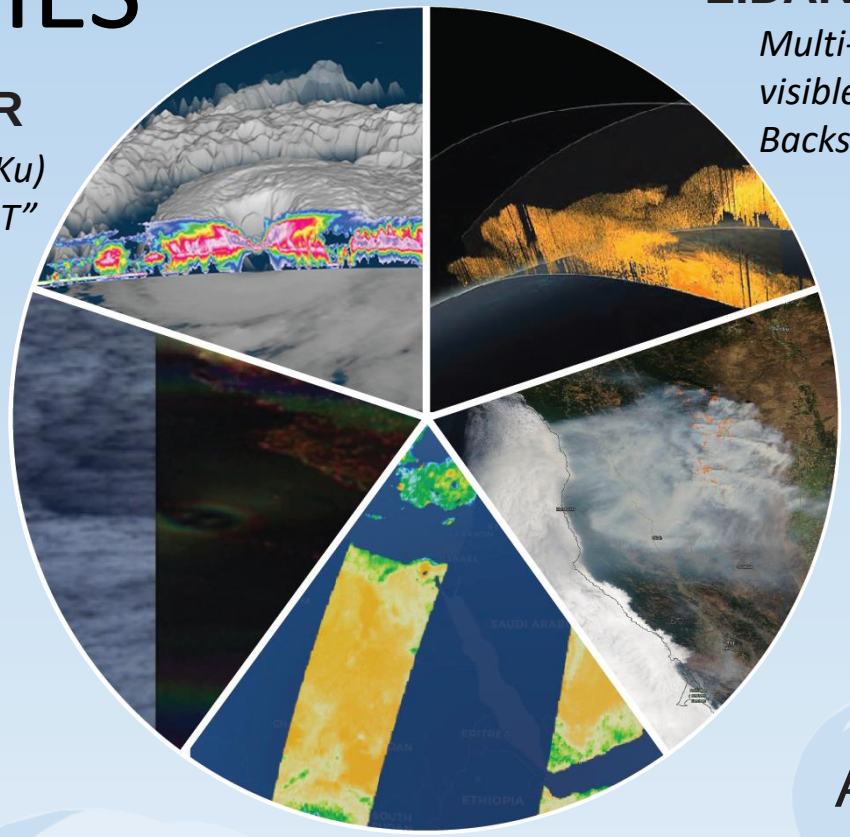


CORE MEASUREMENT CAPABILITIES

RADAR
Multi-wavelength (W, Ka and/or Ku) Doppler or "Delta-T"

LIDAR
Multi-wavelength (2 visible, maybe 1 UV) Backscatter and/or HSRL



POLARIMETER
Multi-wavelength, VNIR-SWIR; Multi-angle

SPECTROMETER
Multi-wavelength (UV-VIS-NIR-SWIR-LWIR-FIR) reflectances and brightness temperatures

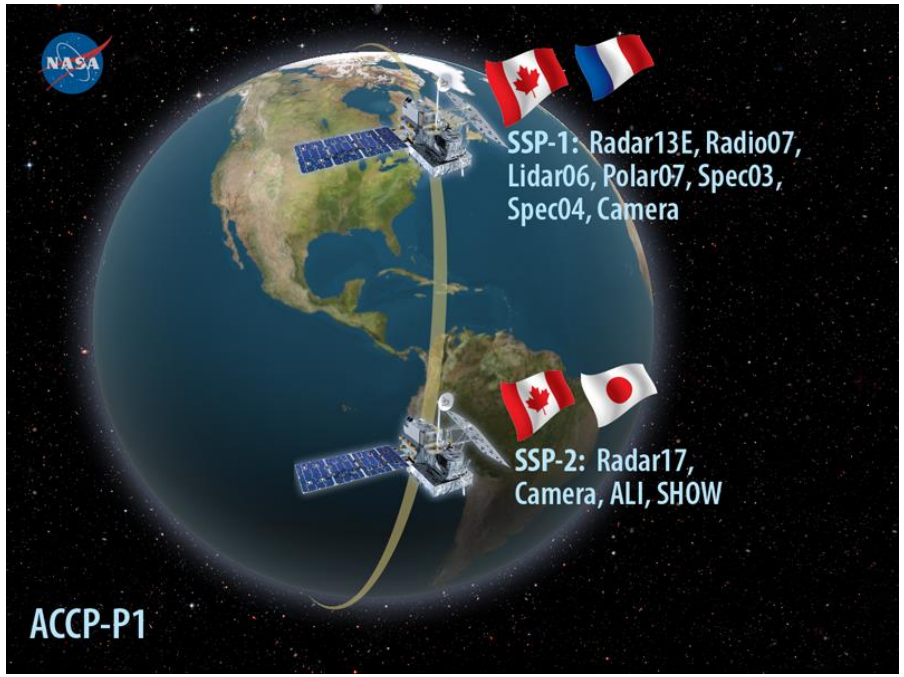
RADIOMETER
Multi-wavelength Microwave (~100-900 GHz), "Delta-T"

Additional instruments considered:
- Tandem stereo cameras
- Aerosol limb sounder
- Moisture limb sounder

ACCP requires a suite of spaceborne instruments* to measure and characterize the complexity of hydrometeors and aerosols.

**To also include as, or more capable, airborne in-situ and remote sensing instruments, deployed in synergistic/complementary suborbital campaigns.*

Top Candidates for Final 3 Architectures—Two Polar Orbit Only Solutions



"All-In" International
Only 1 Launch 2031

De-Scope Options:

1. *Descope ALI/SHOW*
2. *Descope Camera dt*
3. *Descope UV lidar channel*

Note: If prohibited from International LV then this option exceeds cap

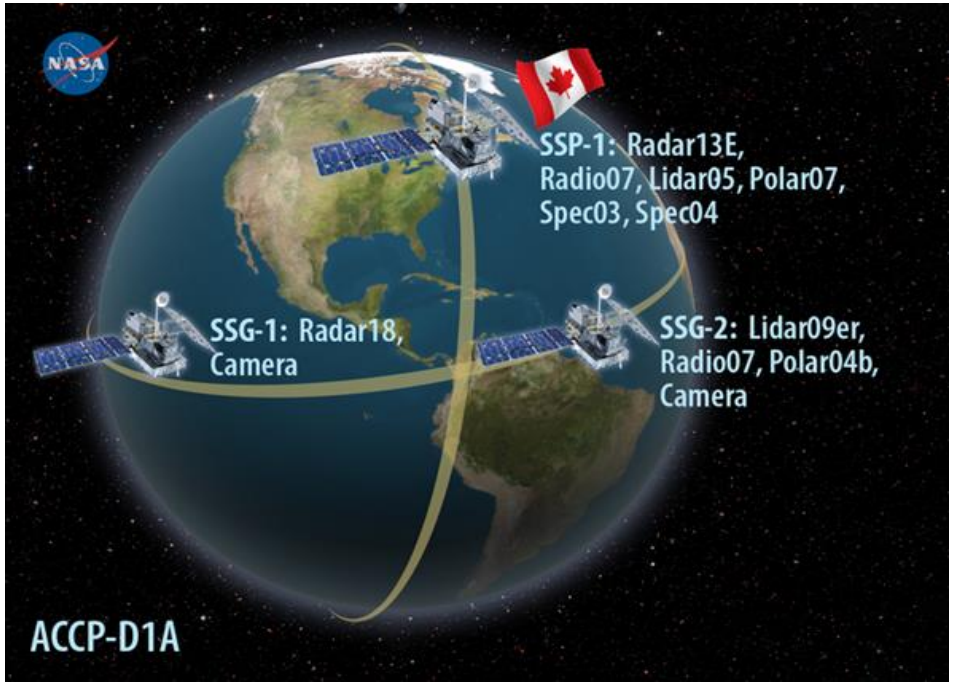
Option 1

- W-, Ka-, Ku-band Doppler and dBZ (JAXA Ku), with wide Ku swath
- Microwave radiometer (118-880 GHz)
- 355 (CNES) and 532 nm HSRL, 1064 nm backscatter lidar
- Polarimeter (550 km swath, 0.5 km resolution)
- Spectrometers (LUUV, VIS, NIR, SWIR, LWIR, FIR)
- Time-differenced stereo camera measurements
- Aerosol and humidity limb sounders (CSA)

Option 2

- Replaces JAXA Ku with U.S. nadir-only Ku for significant cost savings

Top Candidates for Final 3 Architectures—Dual Orbit Solution



Early Science Option
1st Launch As Early as 2027-2028

De-Scope Options:

1. *Descope Camera dt*
2. *Descope Ku to Ka in inclined orbit*

Polar component changes:

- Moves Ku Doppler, dBZ to inclined orbit
- Removes 355 nm channel from lidar
- Moves stereo cameras to inclined orbit

Added inclined component:

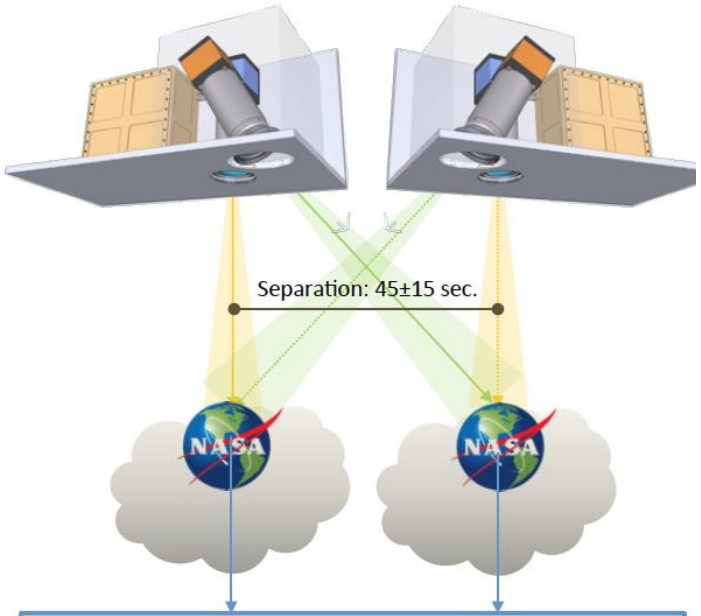
- W-band dBZ, Ku-band Doppler and dBZ
- Microwave radiometer (118-880 GHz)
- 532 and 1064 nm backscatter lidar
- Polarimeter (1130 km swath, 1 km resolution)
- Time-differenced stereo camera measurements

Summary

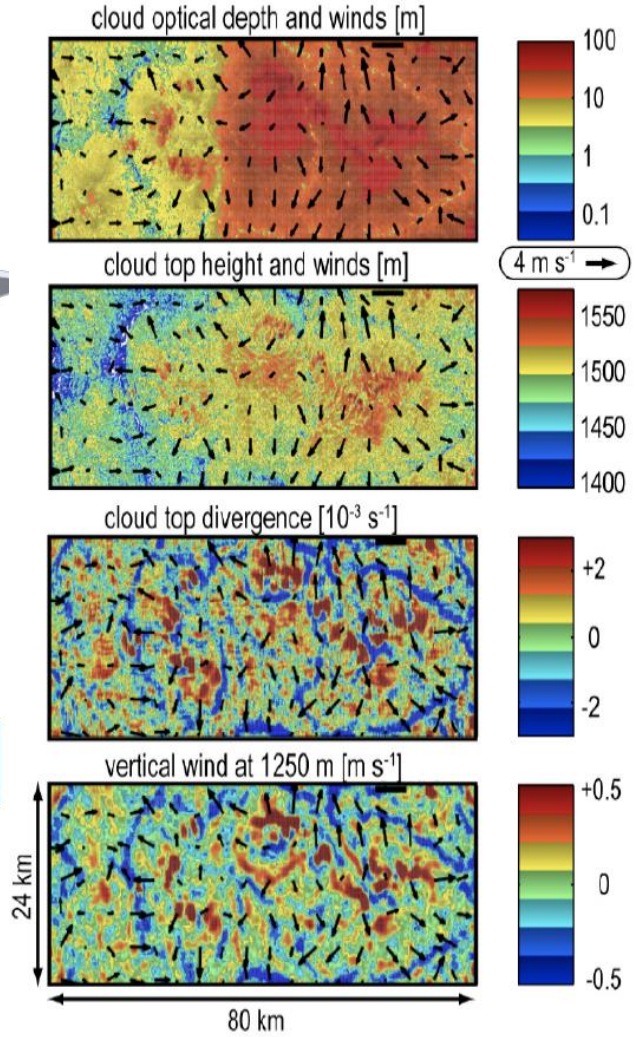
- ACCP science focused on convection, aerosol distribution and processes, and climate sensitivity and related forcing
- Key active measurements include multi-frequency Doppler radar and HSRL lidar, combined with synergistic passive measurements
- Architectures narrowed to 3 choices
- Notional launch time frame:
  - Polar only in 2031
  - Dual orbit in ~2027-2028 for inclined, 2031 for polar

Extra slide

Time-Differenced Stereo Cameras



Same cloud feature is observed from 2 view angles (stereo/3D image) twice (cloud motion after 45 sec.).

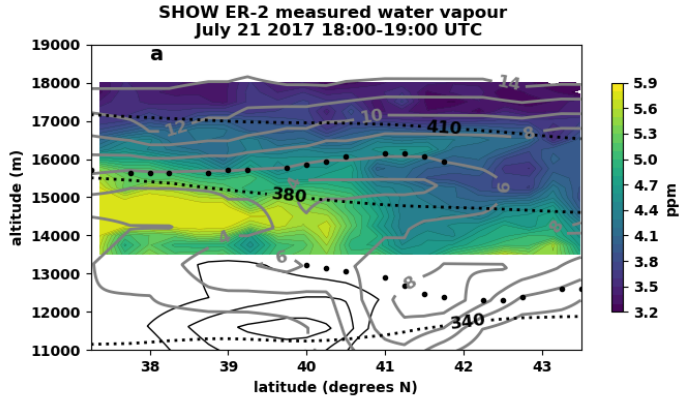


From R. Marchand, A. Davis, L. Forster, and M. Kurowski

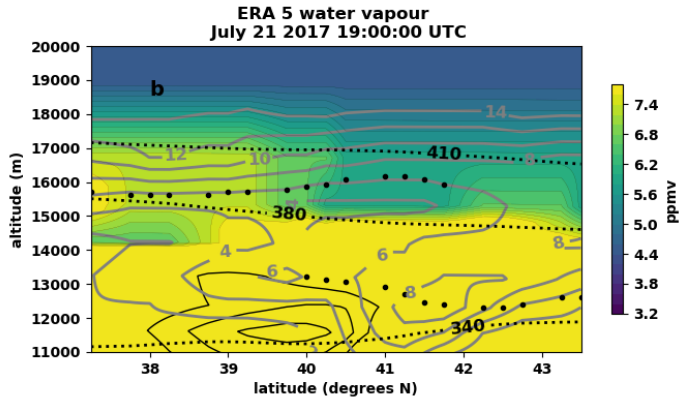
Aerosol and Moisture Limb Sounding

- SHOW addresses environmental humidity profiles important to high clouds and their radiative impacts

- ALI obtains profiles of UTLS aerosols, cloud properties



SHOW water vapor



ERA-5 water vapor