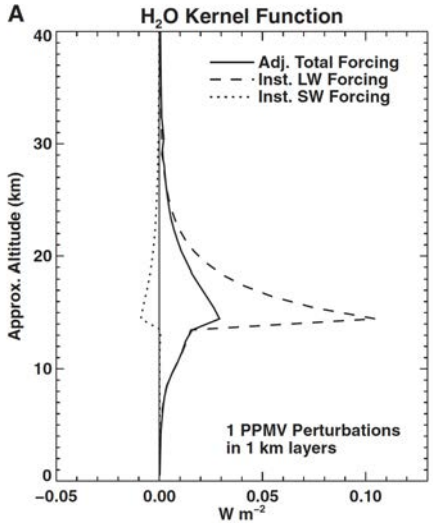
Water vapor in the upper troposphere and lower stratosphere

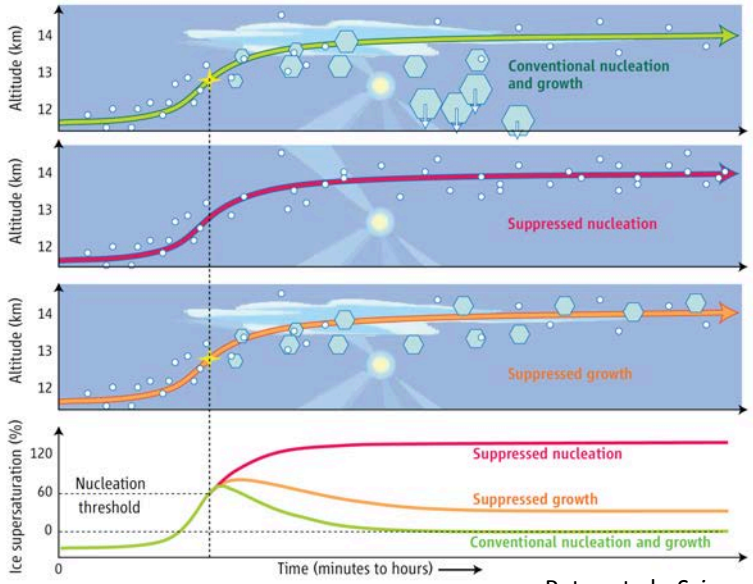
Troy Thornberry

- UTLS water vapor is a significant feedback in the climate system
- Cirrus clouds play a significant role in the radiative balance of the Earth system

  ➢ It is necessary to understand how UTLS water vapor and cirrus respond to climate changes in order to determine the magnitude of the feedback



Solomon et al., *Science*, 2010



Peter et al., *Science*, 2006

- Inter-satellite water vapor measurement offsets and drifts have made it difficult to detect long-term trends in UTLS water vapor
- Longstanding in situ water vapor measurement discrepancies have created uncertainties in understanding of the microphysics related to cirrus formation

CSD UTLS Water Efforts

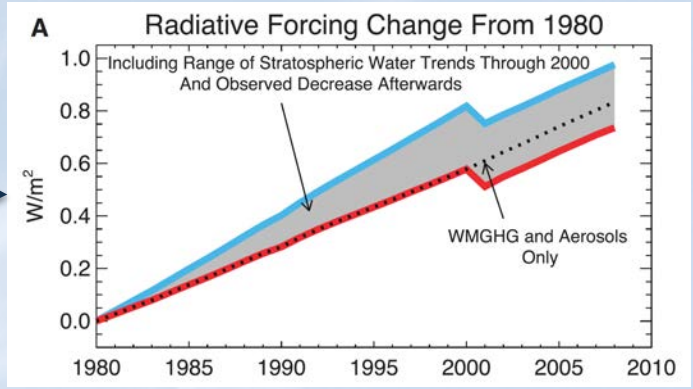
Since 2008, scientists in CSD have worked to address the outstanding science needs related to water in the UTLS on two fronts:

1) **Evaluation** of satellite H_2O data and meteorological reanalyses in order to construct large-scale, long-term records for trend analysis and radiative forcing calculations and related **modeling** activities

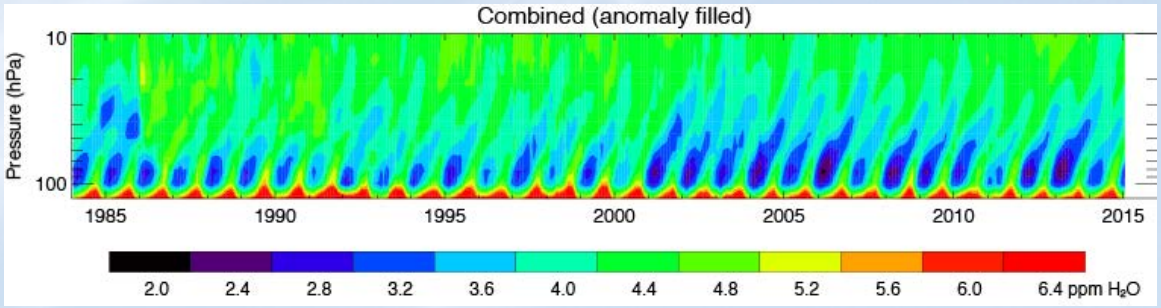
2) In situ measurement **development**, **deployment**, **evaluation**, **calibration** and **intercomparison** in order to constrain the uncertainty in UTLS water vapor to improve understanding of the microphysics of cirrus formation and TTL dehydration

Satellite, Reanalysis Data and Modeling
Activities and Accomplishments

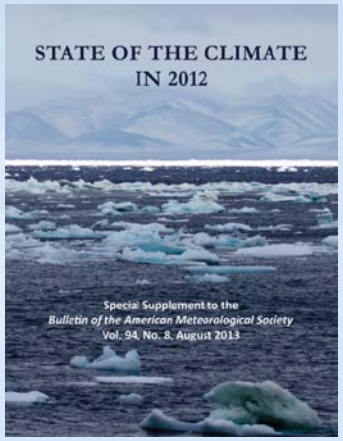
- Modeling of the importance of UTLS water vapor in the climate system
  - Solomon et al., Science, 2010
  - Dessler et al., PNAS, 2013



- Development of the Stratospheric Water and OzOne Satellite Homogenized (SWOOSH) data set
  - Synthesized consistent satellite record for use in interannual variability and trend analyses (S. Davis)



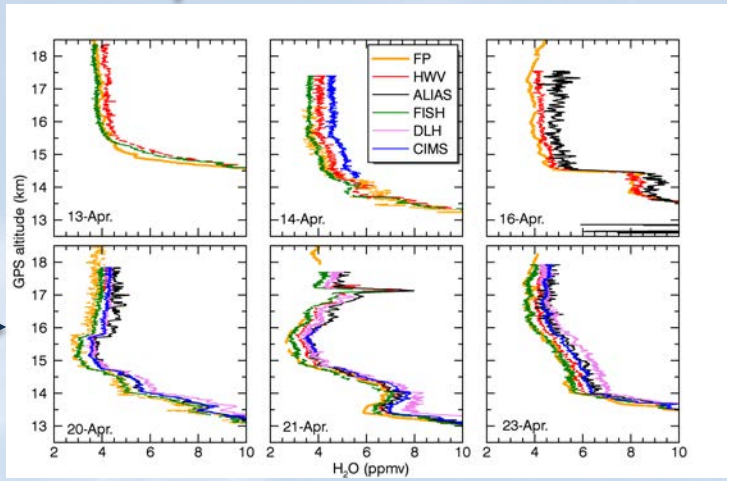
- Stratospheric water section of BAMS annual State of the Climate Report

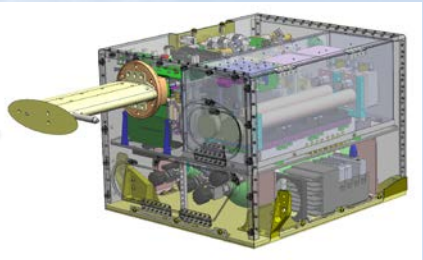


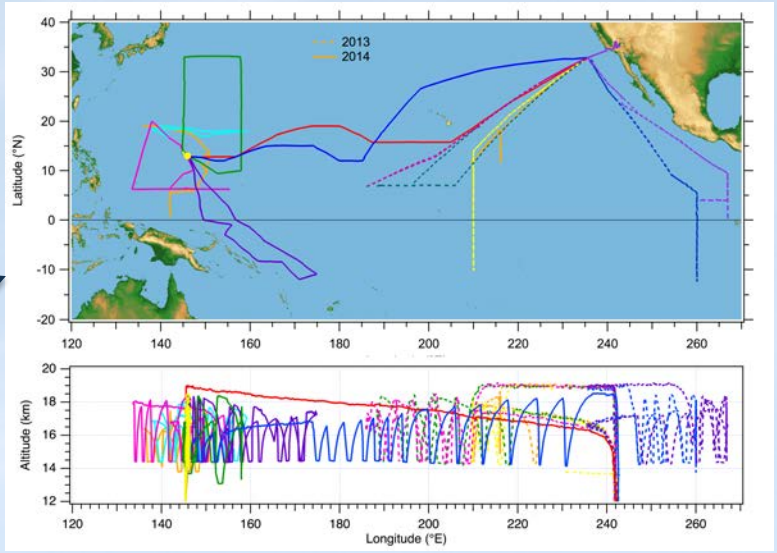
- SPARC Water Vapour Assessment
  - K. Rosenlof co-lead author
- SPARC Reanalysis Intercomparison Project (S-RIP)
  - S. Davis chapter co-lead author

In situ measurement activities/accomplishments

- Developed new methods for UTLS H_2O measurement and calibration
  (Thornberry et al., AMT, 2013; Rollins et al., AMT, 2011)
- Participated in the NASA MACPEX campaign UTLS in situ water vapor intercomparison
  - ➢ Led the intercomparison analysis
    (Rollins et al., JGR, 2014)
- Laboratory study of the potential for HNO_3 interference with frost-point hygrometer measurements (Thornberry et al., AMT, 2011)
- Constructed a two-channel hygrometer for UTLS water vapor and cirrus IWC measurement (Thornberry et al., AMT, 2015)
  - ➢ Only in situ calibrated UTLS hygrometer
- Conducted extensive measurements of UTLS H_2O and cirrus ice water content over the tropical Pacific during the NASA ATTREX campaign

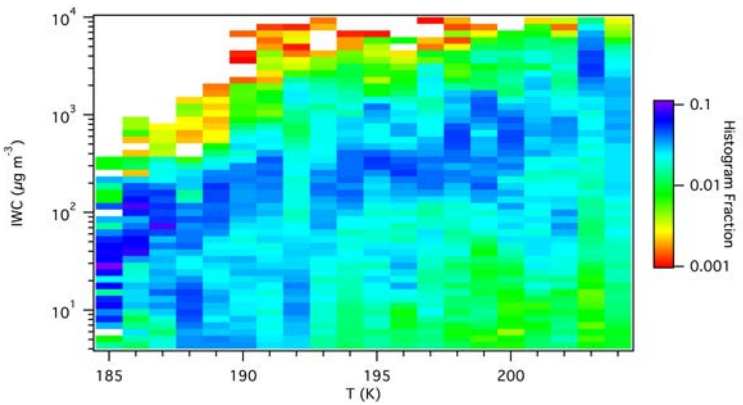






Near future work

- Use ATTREX observations to calculate mass-dimensional relationship of TTL cirrus and parameterize T dependence of IWC
  - Important parameter for global models and satellite retrievals



- Compare observed vs reanalysis-derived dehydration
  - Constrain model treatment of TTL dehydration processes

- Investigate the microphysical and dynamical sources of inefficiency in the TTL dehydration process
  - Improve model parameterization of dehydration