A Multi-Decadal Study of Cirrus in the Upper Troposphere

S. Massie, R. Khosravi (NCAR, Boulder)
J. Gille (University of Colorado, Boulder)

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Outline

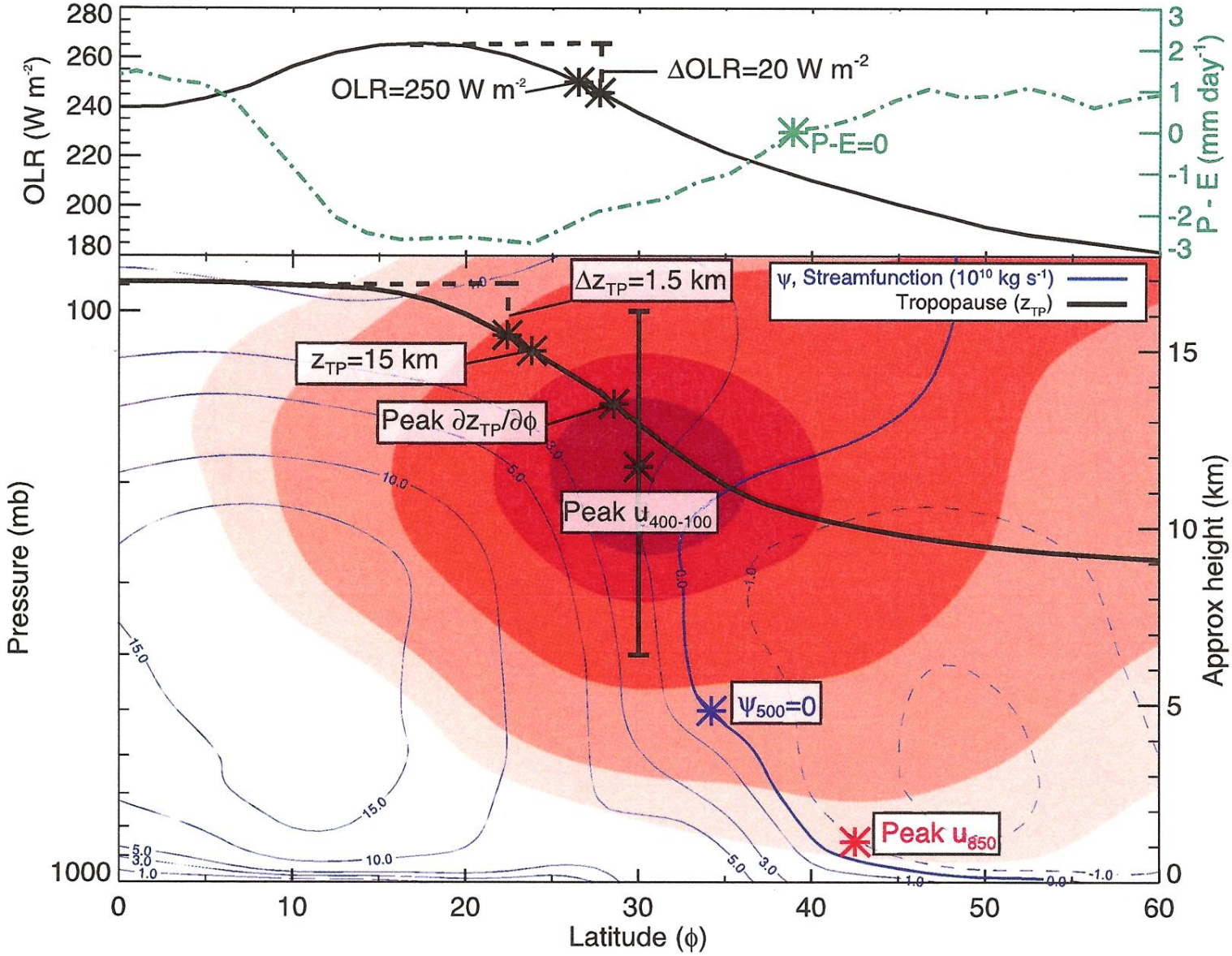
Are cloud geographical distributions changing in the upper troposphere?

Review study of Davis and Rosenlof (J. Clim, 2012)

Discuss the cirrus data

Discuss methodology

Present results

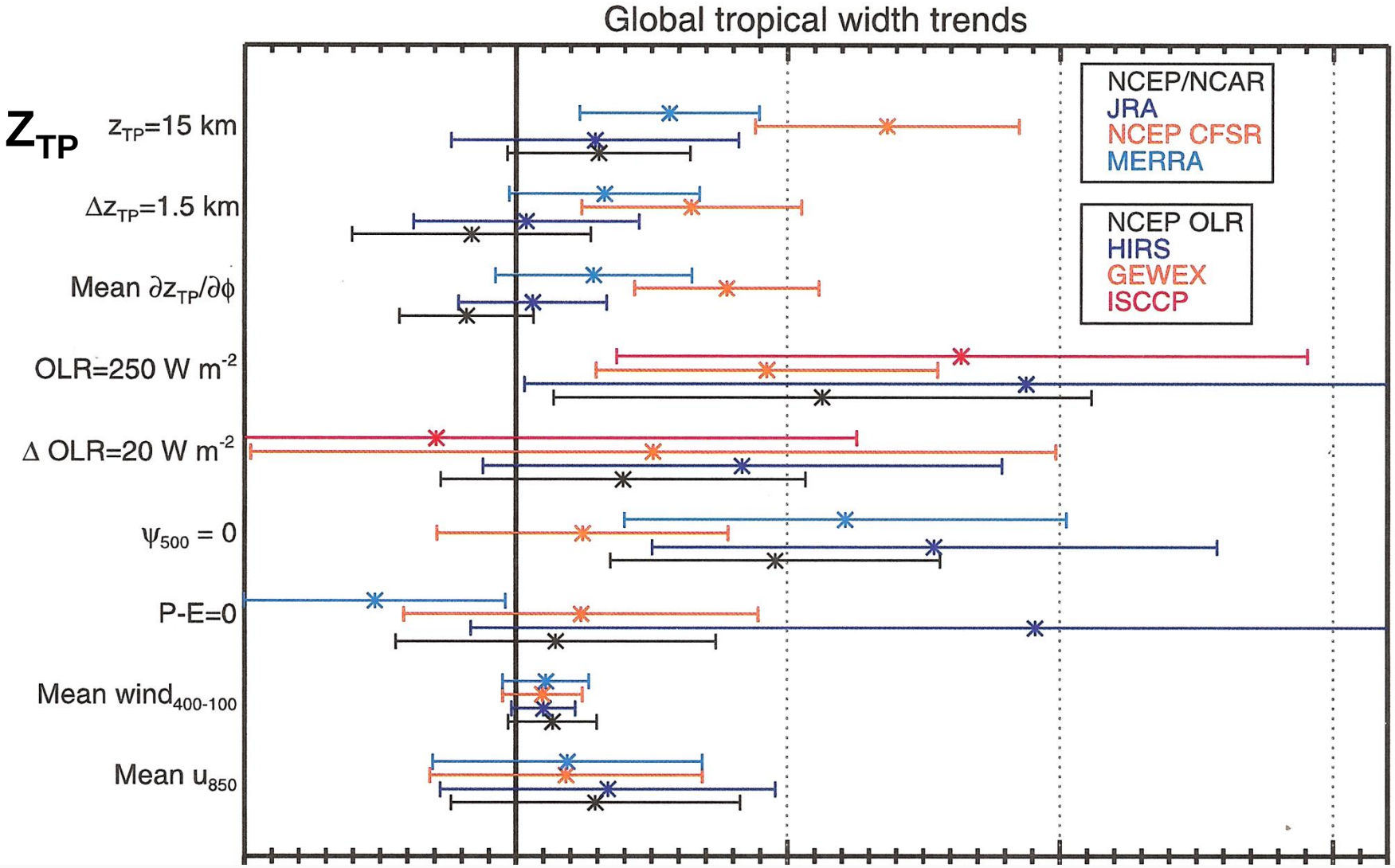


Davis and Rosenlof, JClim, 2012

TABLE 1. Overview of tropical width and jet diagnostics.

Diagnostic	Data source	Definition	Vertical location	Reference
$z_{TP} = 15$ km	Tropopause height	Latitude at which tropopause height equals 15 km	Tropopause	SR07 Lu et al. (2009)
$\Delta z_{TP} = 1.5$ km	Tropopause height	Latitude at which tropopause height is 1.5 km below 15°S–15°N average	Tropopause	Current work
Mean–max $\partial z_{TP}/\partial\varphi$	Tropopause height	Latitude of peak in meridional gradient of tropopause height	Tropopause	Current work
OLR = 250 W m^{-2}	Outgoing longwave radiation	Latitude of OLR = 250 W m^{-2} on poleward side of subtropical maximum	Surface–tropopause	Hu and Fu (2007) Johanson and Fu (2009)
ΔOLR = 20 W m^{-2}	Outgoing longwave radiation	Latitude at which OLR is 20 W m^{-2} below subtropical maximum	Surface–tropopause	Current work
$\psi_{500} = 0$	v	Equatorwardmost latitude of zero crossing of mean meridional streamfunction	500 hPa	Hu and Fu (2007) Lu et al. (2007)
$P - E = 0$	Precipitation rate, Evaporation rate	Latitude of $P - E = 0$ poleward of subtropical minimum	Surface	Previdi and Liepert (2007)
Mean–max $\text{wind}_{400-100}$	u, v	Latitude of peak wind between 400–100 hPa	400–100 hPa	AC08
Mean–max u_{850}	u	Latitude of peak wind at 850 hPa	850 hPa	Lorenz and Deweaver (2007) Son et al. (2009)

Davis and Rosenlof, JClim, 2012



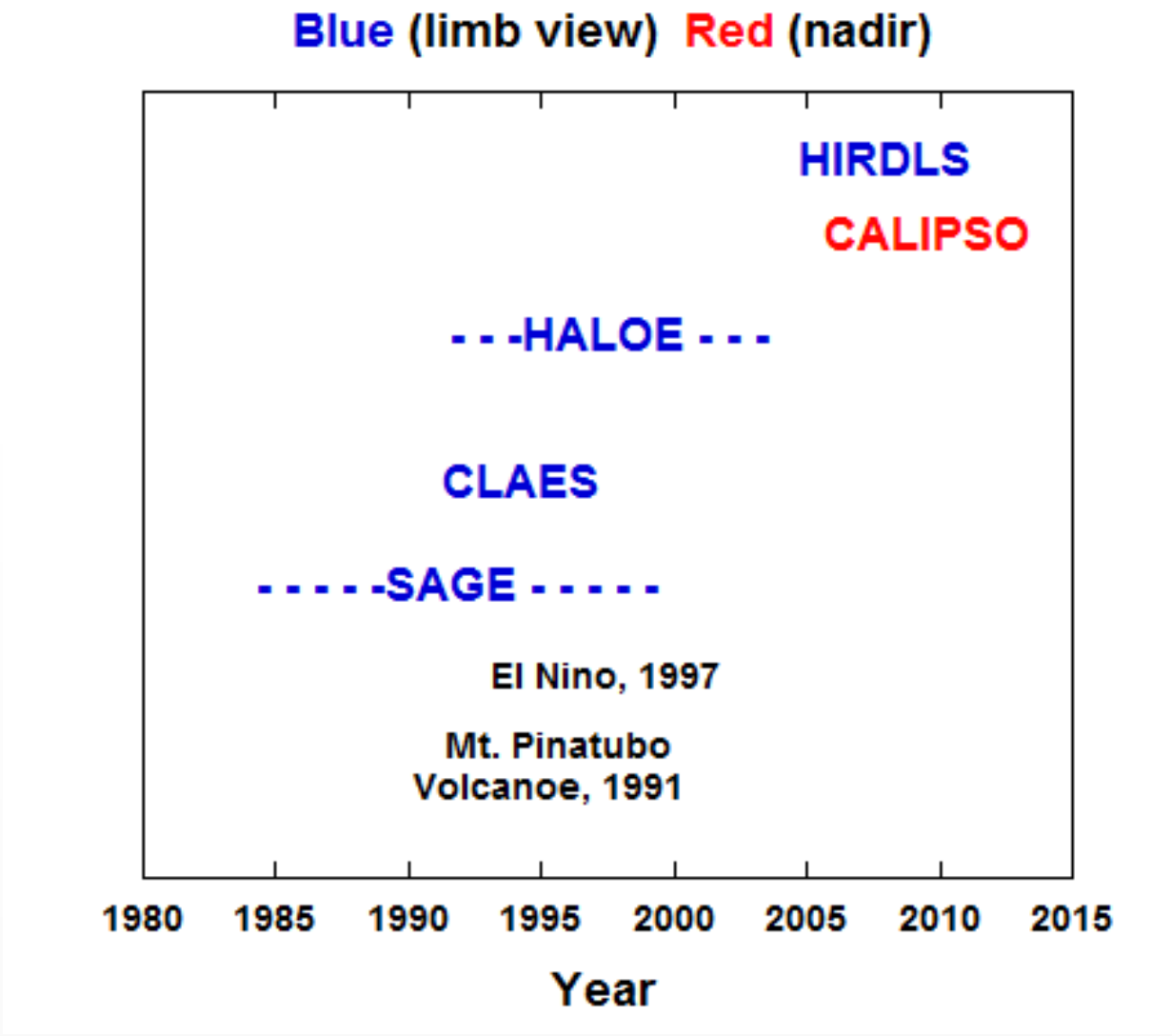
Davis and Rosenlof, JClim, 2012

Changes in the Tropics (° / decade)

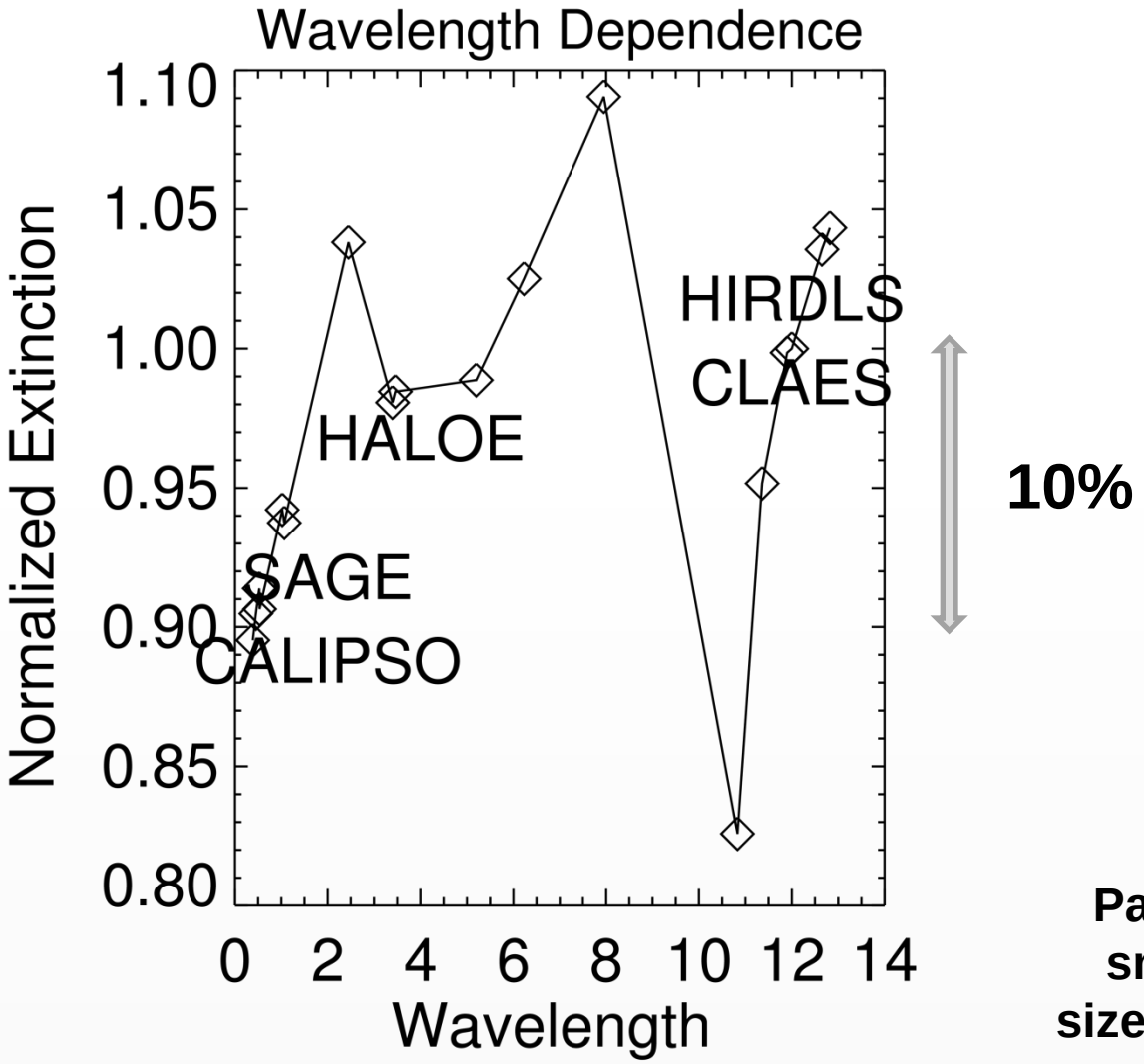
	Z_{TP}	
	$z_{TP} = 15$ km	$\Delta z_{TP} = 1.5$ km
NCEP	0.31	−0.16
	(0.34)	(0.44)
CFSR	**1.4**	**0.65**
	(0.48)	**(0.41)**
ERA-40[b]	0.76	0.48
	(0.95)	(0.66)
ERA-I[c]	−0.23	−0.48
	(1.2)	(1.2)
JRA	0.29	0.038
	(0.53)	(0.42)
MERRA	**0.56**	0.33
	(0.33)	(0.35)

Bold = statistically significant

Davis and Rosenlof, JClim, 2012



1985 - 2010
= 25 years



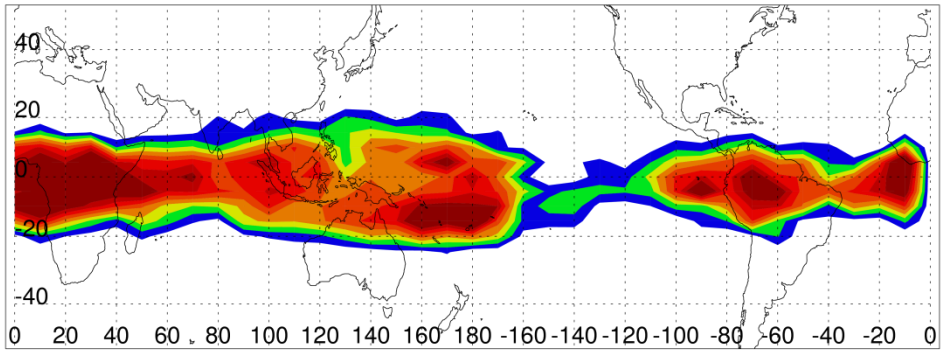
Input:
Paul Lawson
small cirrus
size distribution

Symbols denote observation wavelengths

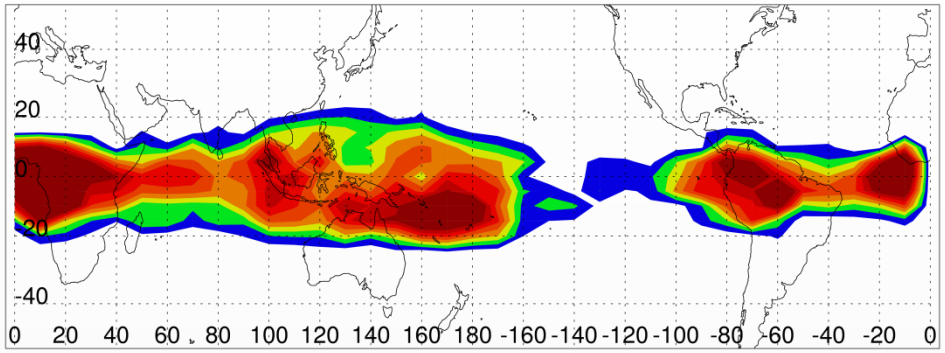
Calculation of Cirrus Frequency of Occurrence

SAGE	**Use extinction ratio technique with 0.525 and 1.02 μm data**
CLAES	**Extinction > 9 10^{-4} km^{-1}**
HALOE	**Extinction > 0.98 x 9 10^{-4} km^{-1}**
HIRDLS	**Extinction > 9 10^{-4} km^{-1}**
CALIPSO	**Use CLay file cloud counts**

Monthly Averages - April 2007 Example



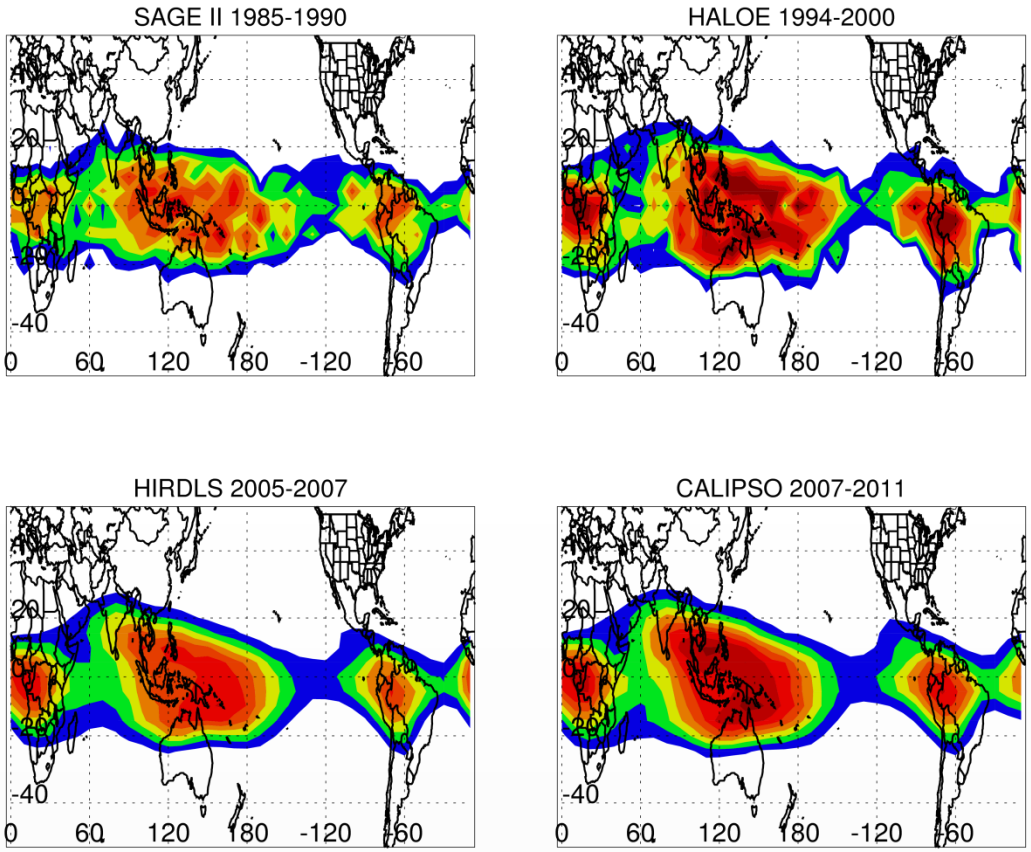
HIRDLS, 100 hPa

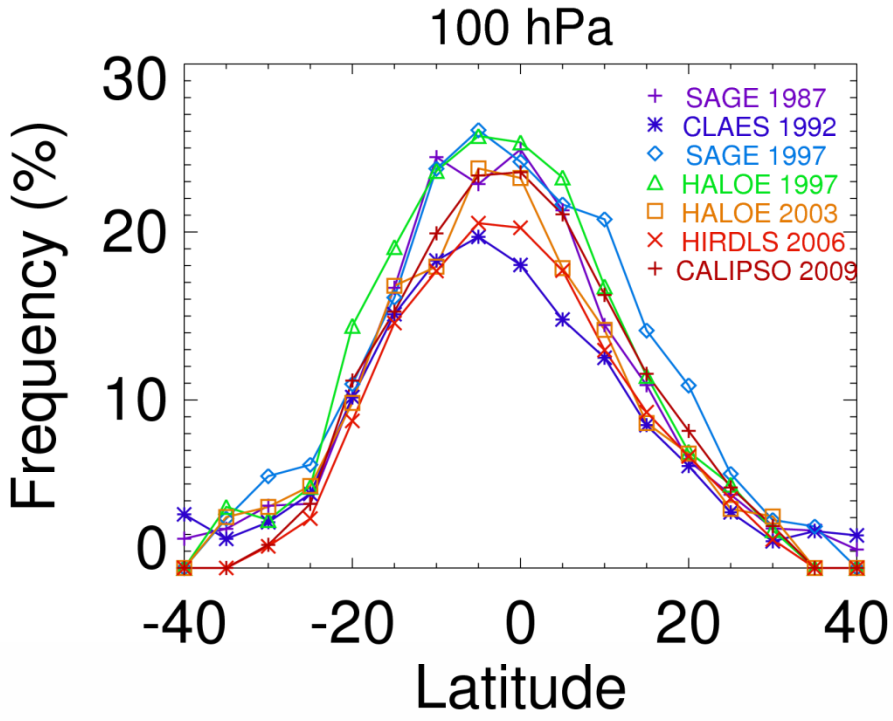


CALIPSO, 16 km

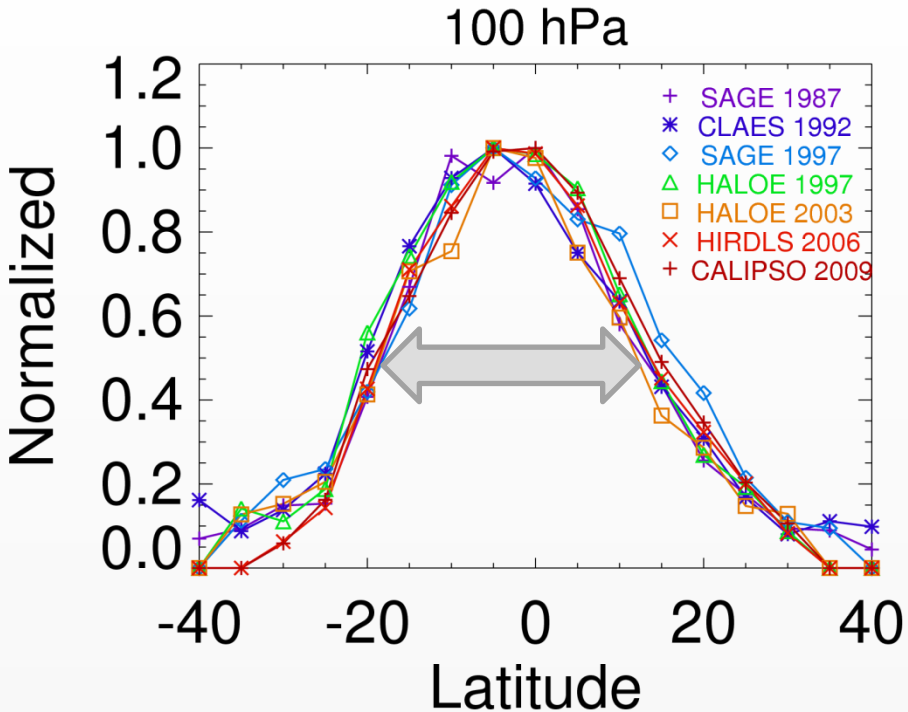
Frequency of Occurrence (%)

5 10 15 20 25 30 35 40 45

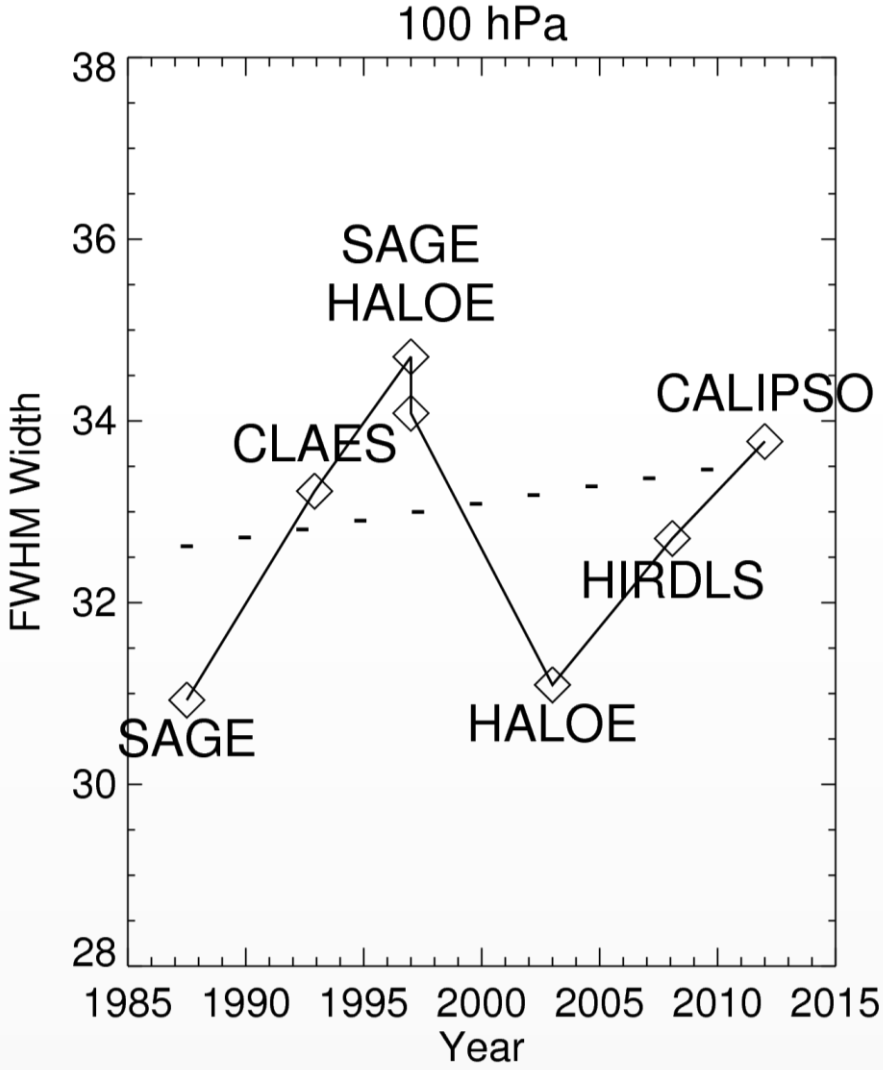

SAGE II 1985-1990
HALOE 1994-2000
HIRDLS 2005-2007
CALIPSO 2007-2011
20
-40
0
60
120
180
-120
60
Cloud Frequency (%)
5
10
15
20
25
30
35
40
45



Multi-year Averages



Normalized Curves
Calculate FWHMs

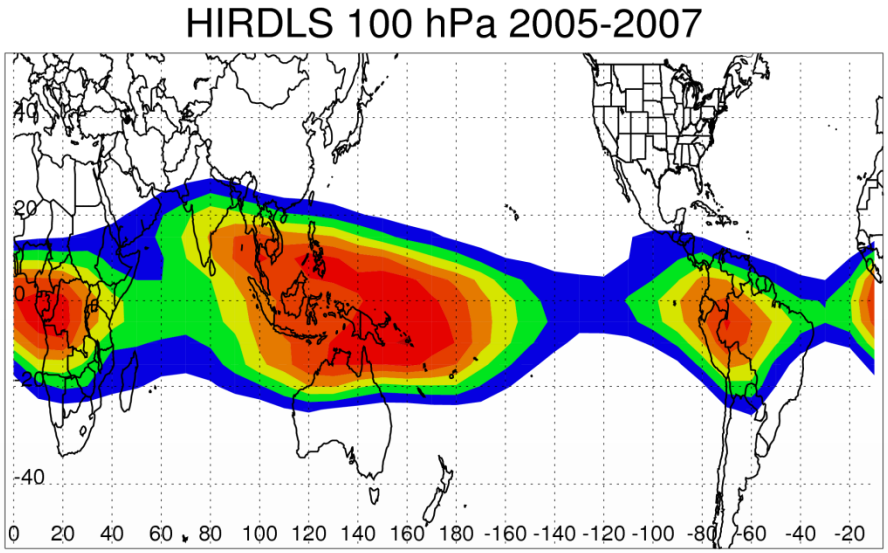


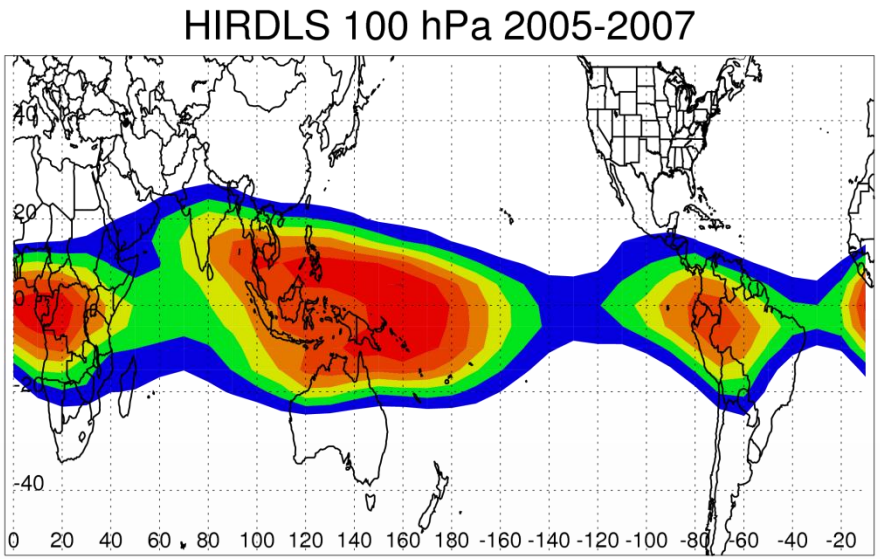
Slope

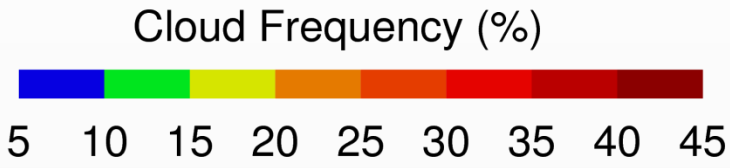
0.38 ± 1.5 (2σ)

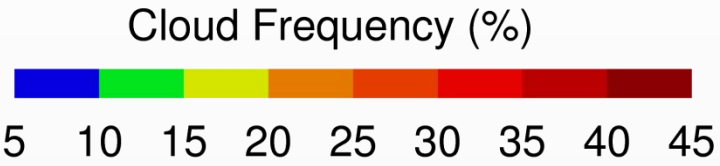
° per decade

HIRDLS Version 6 and Version 7





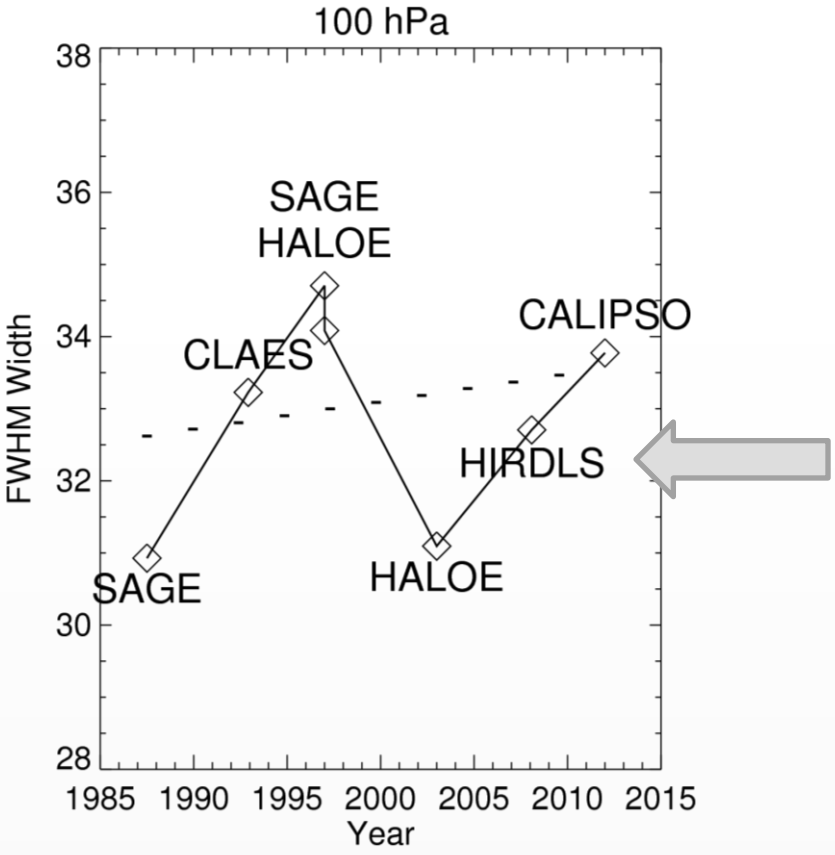


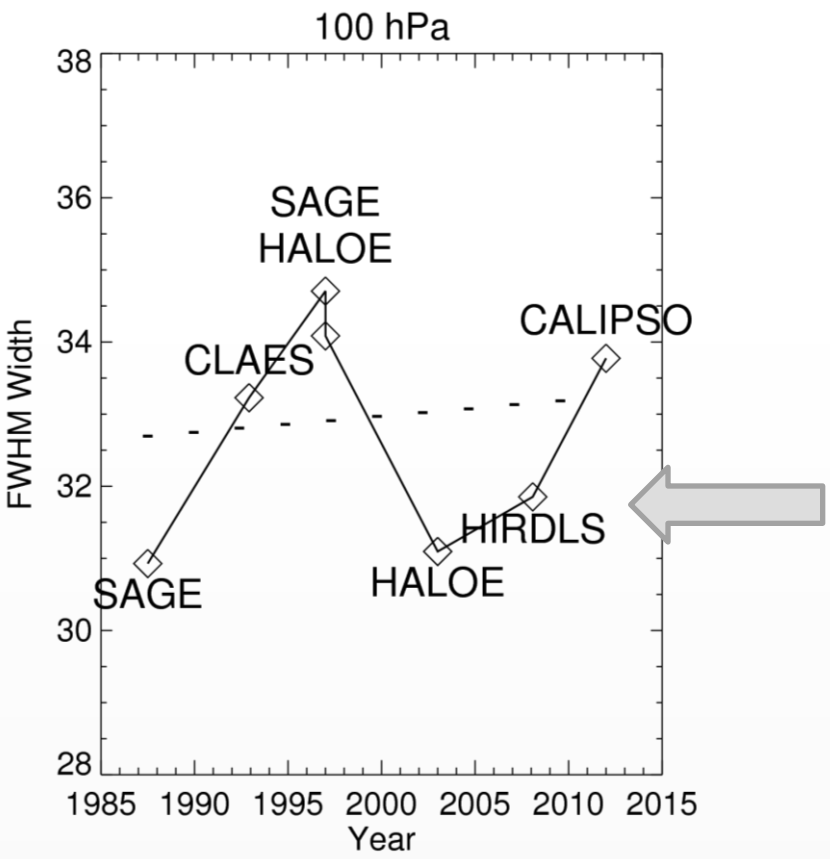


Version 6

Version 7

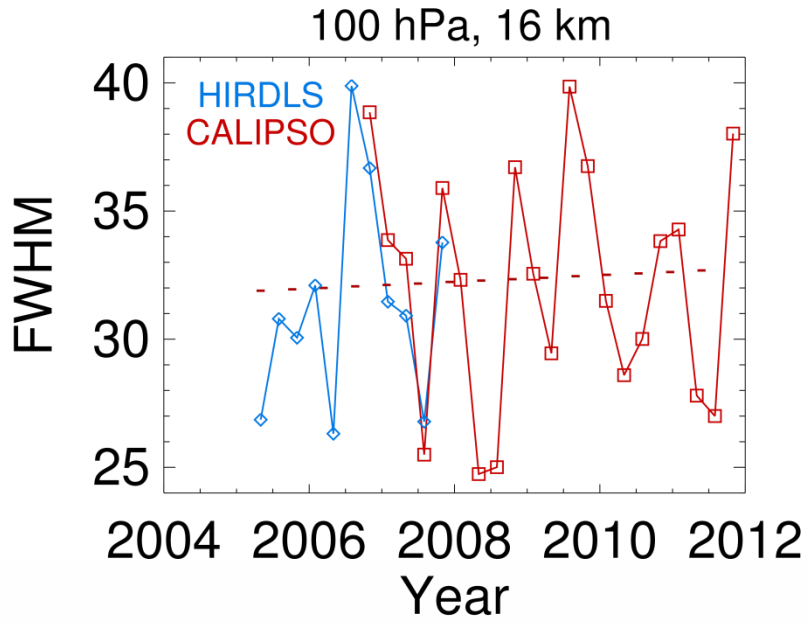
HIRDLS Version 6 and Version 7



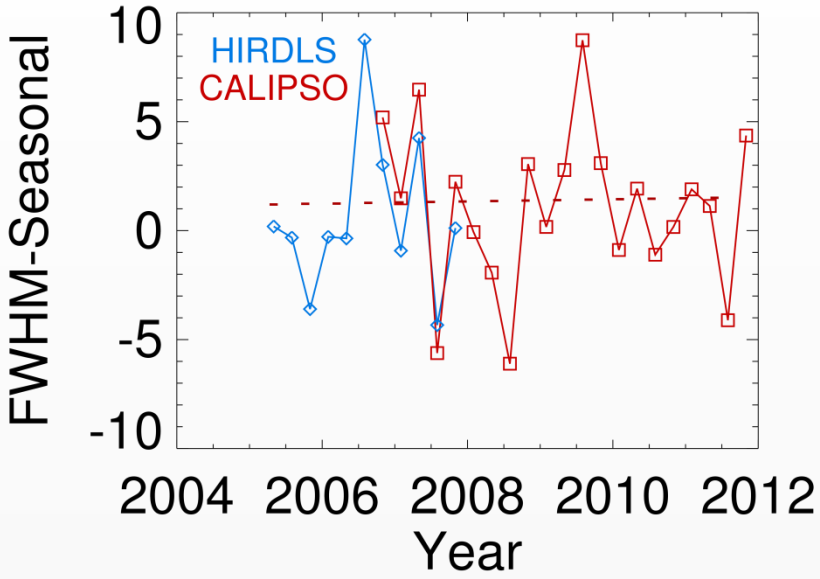


Version 6
0.38 ± 1.5° /decade

Version 7
0.22 ± 1.6° /decade



HIRDLS and CALIPSO Seasonal FWHMs



Subtract the seasonal variations

Deviations from the seasonal means are important

Conclusions

Cirrus geographical distributions in the upper troposphere are not changing by a detectable statistical amount

Based upon cirrus observed by 5 satellite experiments during 1985 – present, the full width half max (FWHM) widths near 100 hpa have a trend (slope) of

$$0.38 \pm 1.5^\circ\ (2\sigma)\ \text{per decade}$$

Future work: work with lower altitude data, considering opaque clouds. Use HIRDLS cloud flag data (for opaque clouds) and also analyze Cloudsat data.

Thank You

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To provide facility support to the wider community; and,
To apply the results to benefit society.

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