Stratospheric aerosols from major volcanic eruptions: a model study of the aerosol cloud dispersal and *e*-folding time

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Aprile, 25th

INTRODUCTION

Effects of explosive volcanic eruption on climate

SO2 plume located in Lower Stratosphere

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OH oxidation →

Gas phase H2SO4

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↓ **Nucleation**

Ultrafine H2O-H2SO4 particles

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Gas condensation

Thick cloud of optically active particles

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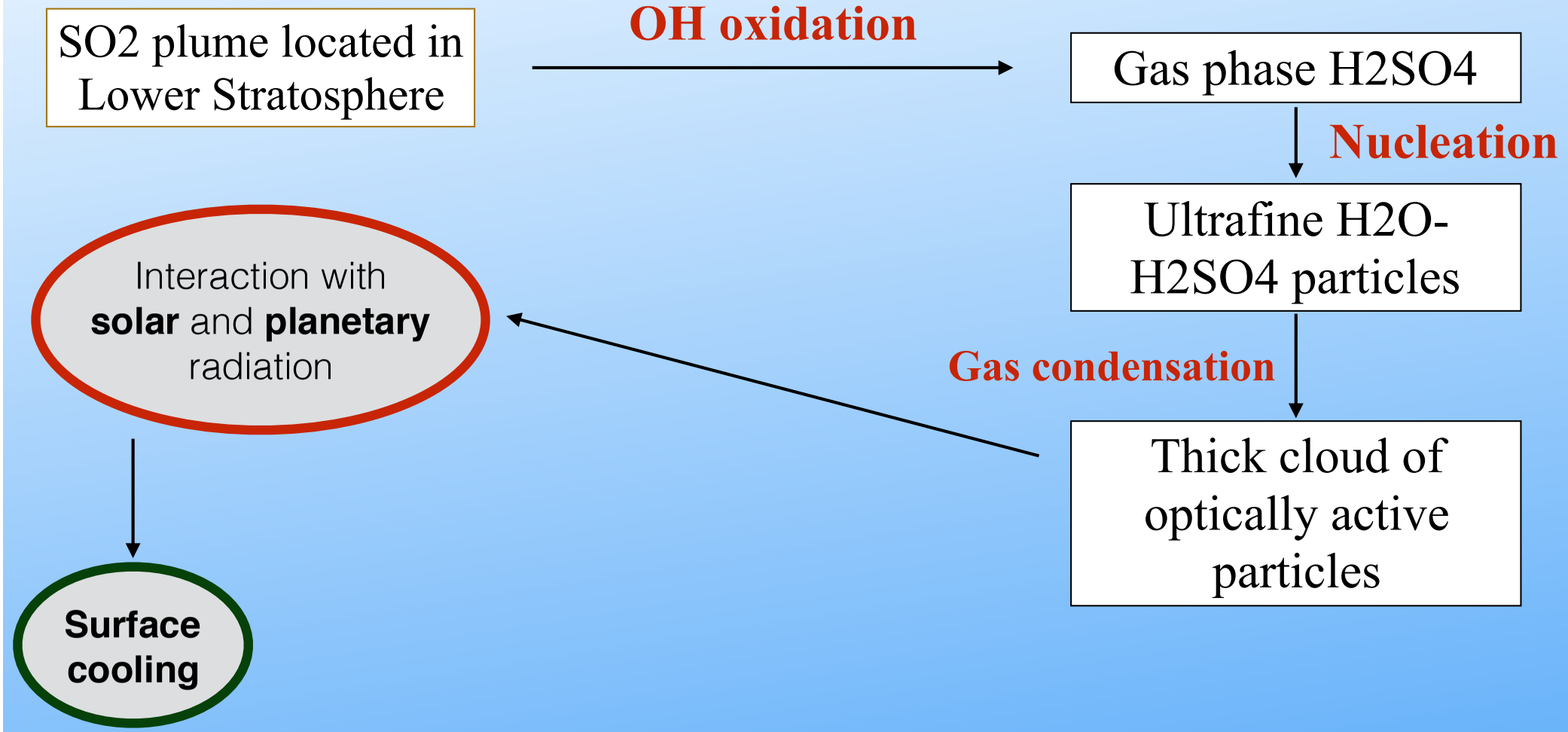

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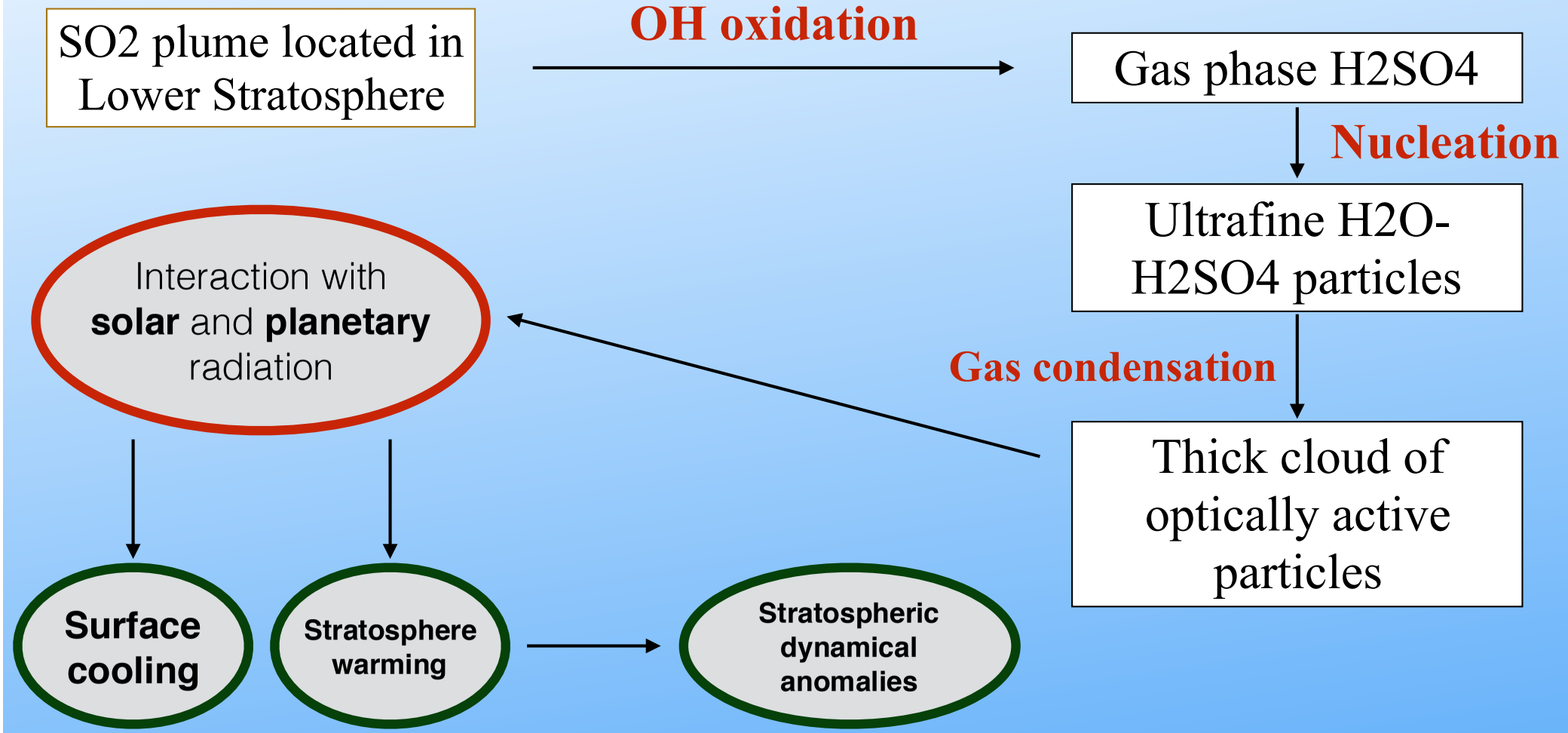


INTRODUCTION

How is the aerosol cloud dispersal connected with the QBO phase?

MODEL DESCRIPTION

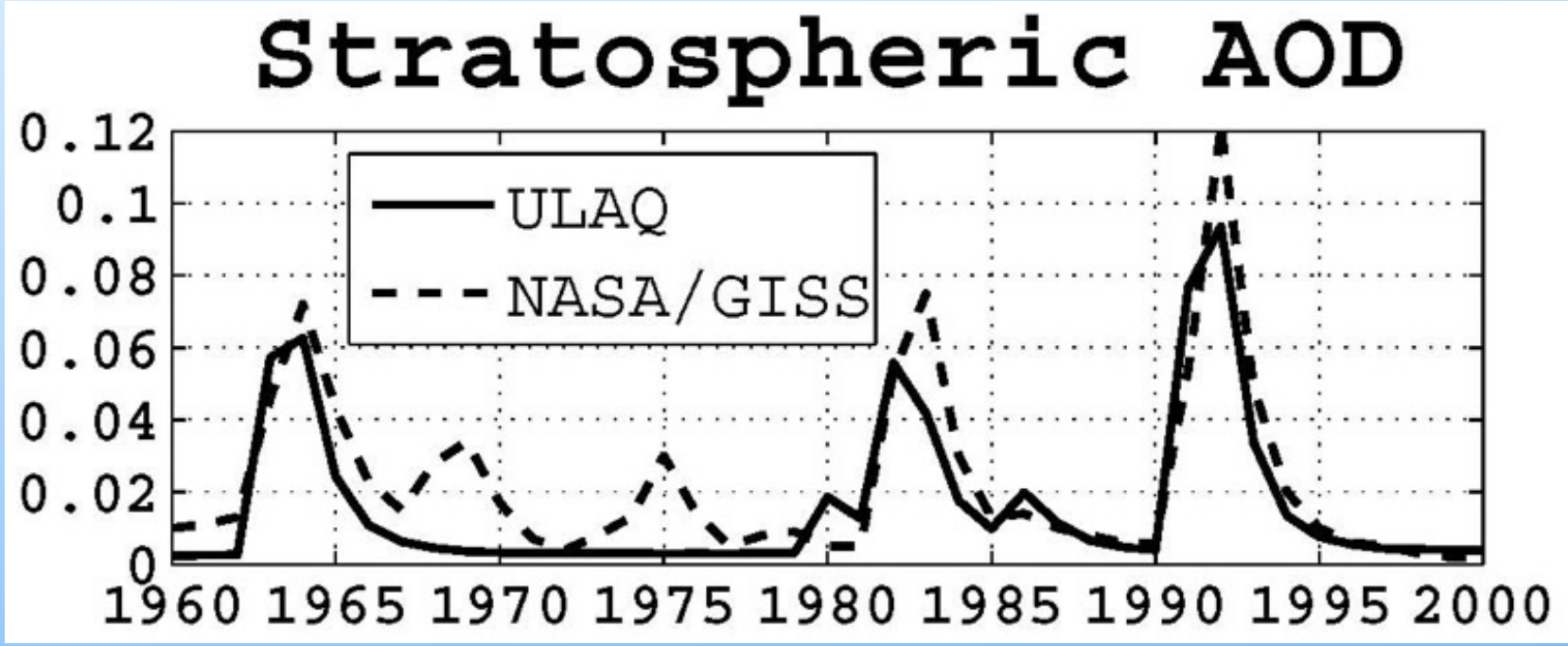
	Resolution	Ocean	Stratospheric Aerosol			Aerosol effect on ozone	
			Source	Eff. radius at 75 hPa tropics [µm]		Het. chemistry	Photo-chemistry
ULAQ-CCM Univ. L'Aquila	5°x 6° L126	Prescribed SSTs	From SO_2	0.2 background	0.3 - 0.6 volcanic	✓	✓

EXPERIMENT SET UP

Eruption	Time	Tg-SO_2	QBO E/W shear
Agung (8S,11E)	16 May 1963	12	**W**
St. Helens (46N,122W)	18 May 1980	2.1	**W**
El Chichón (17N,93W)	4 April 1982	7	**W**
Nevado del Ruiz (5N,75W)	13 November 1985	1.2	**E**
Pinatubo (15N,120E)	16 June 1991	20	**E**

EXPERIMENT SET UP

Stratospheric global mean Aerosol Thickness Measured .vs. Simulated



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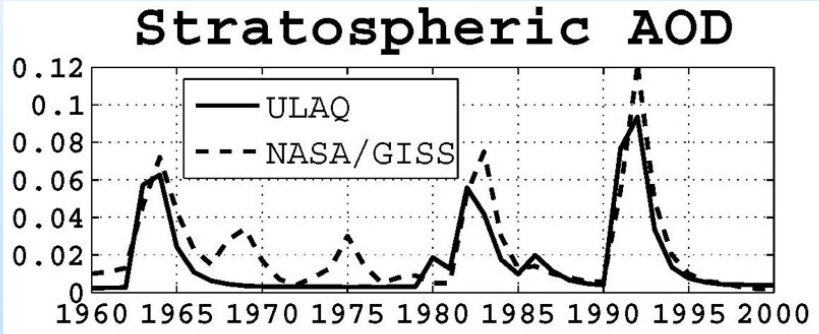

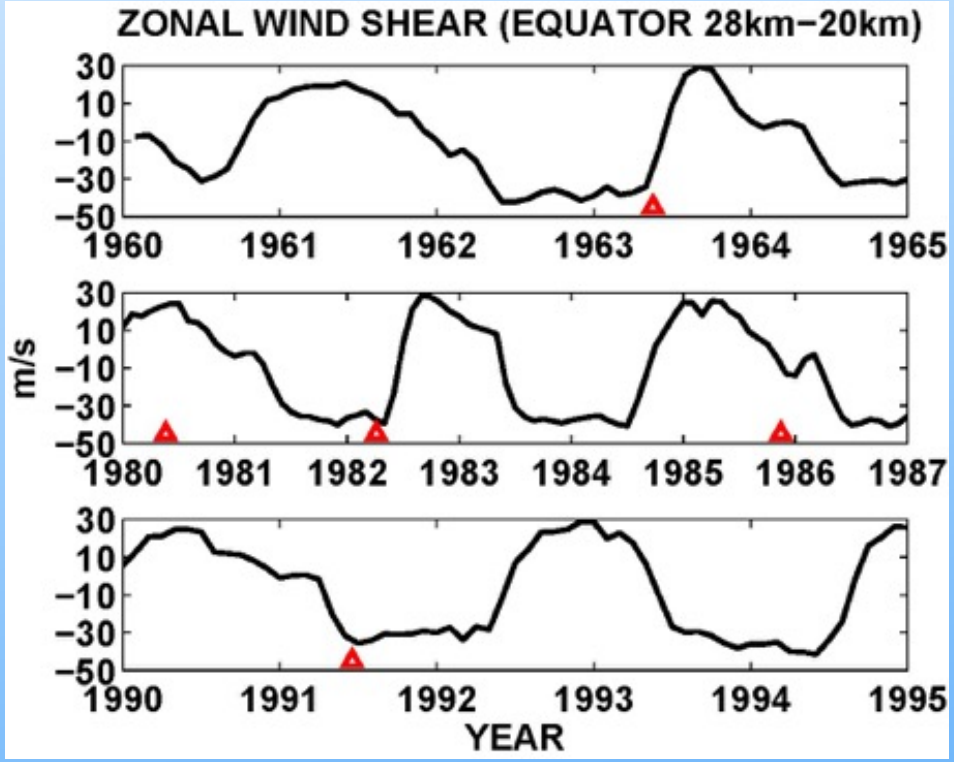

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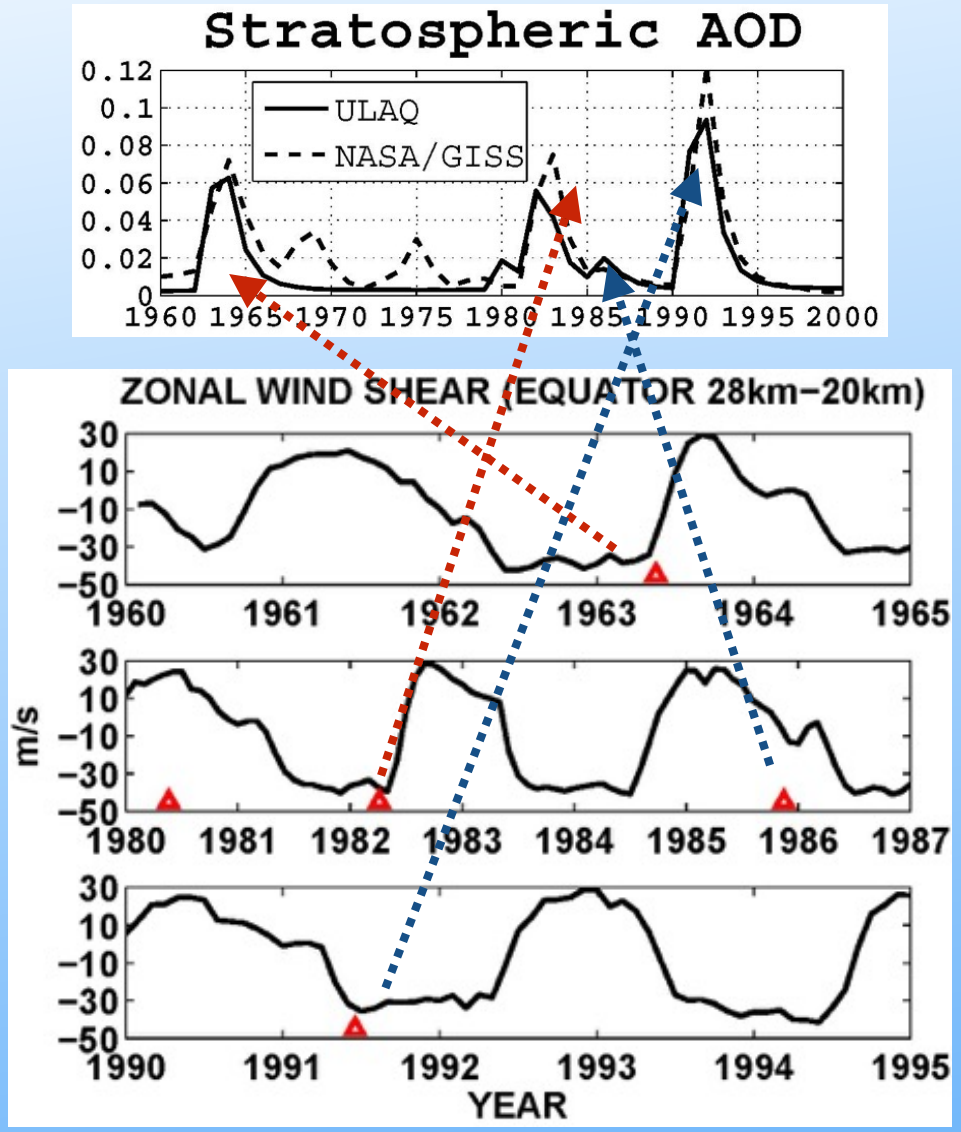


RESULTS

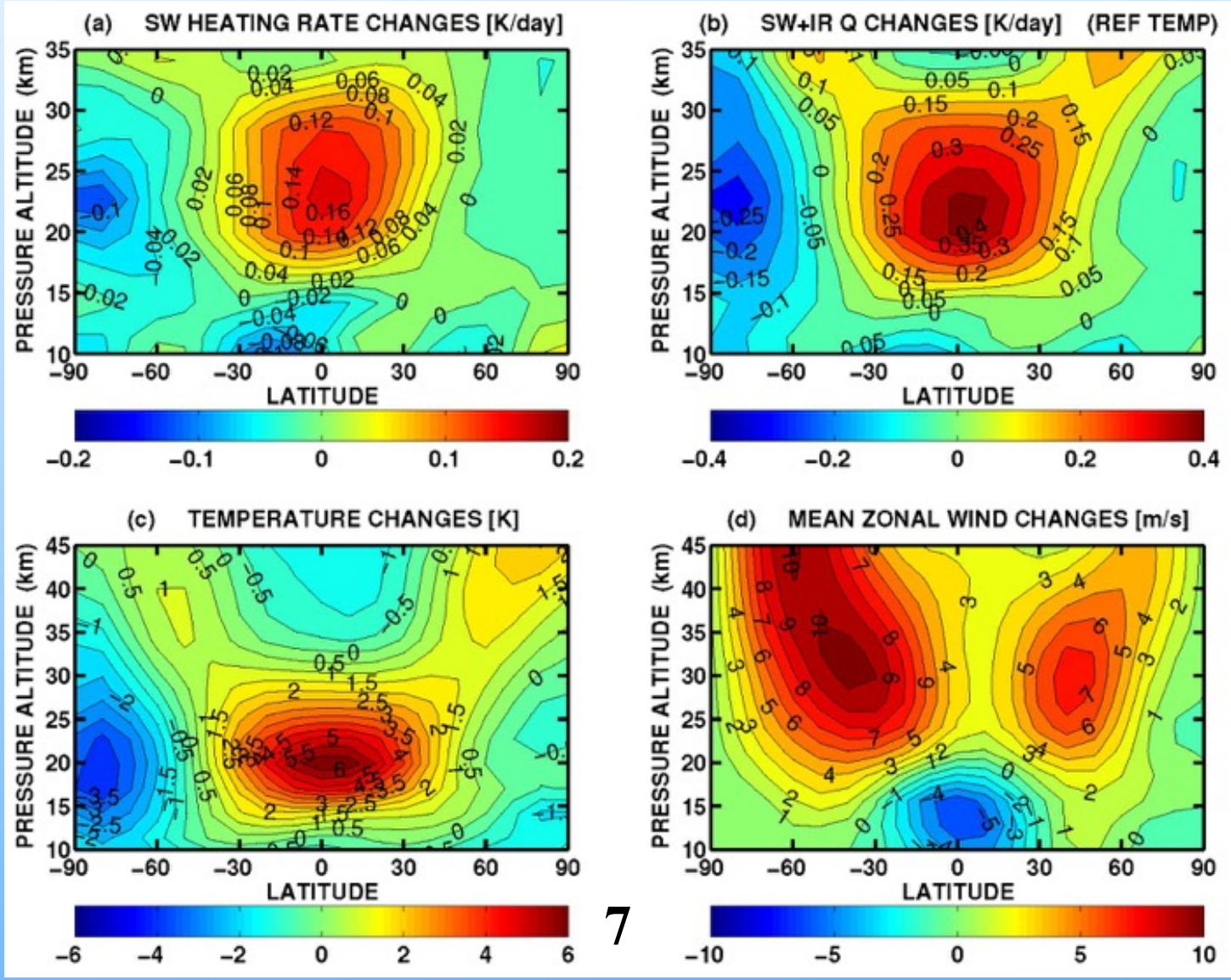
LOWER STRATOSPHERIC DYNAMICAL ANOMALIES

EQUATORIAL WINDS QBO AND AEROSOL TRANSPORT

AEROSOL CLOUD DISPERSAL AND e - FOLDING TIME

LOWER STRATOSPHERIC DYNAMICAL ANOMALIES

Pinatubo case: UTLS zonal anomalies



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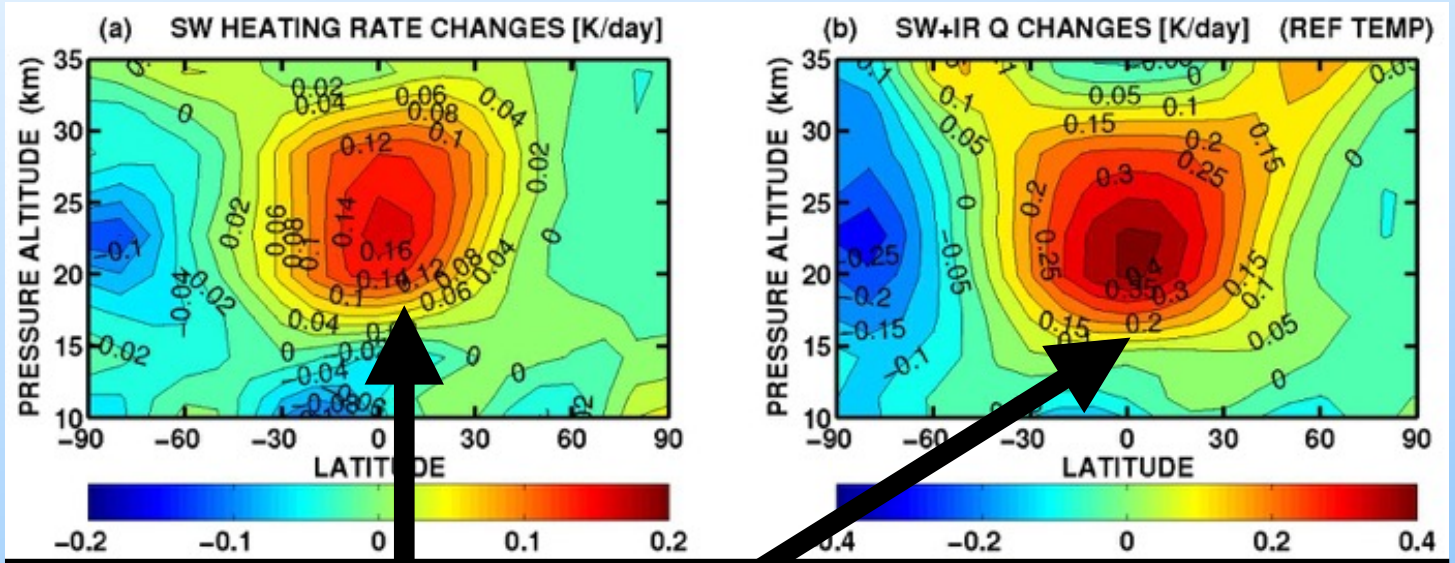
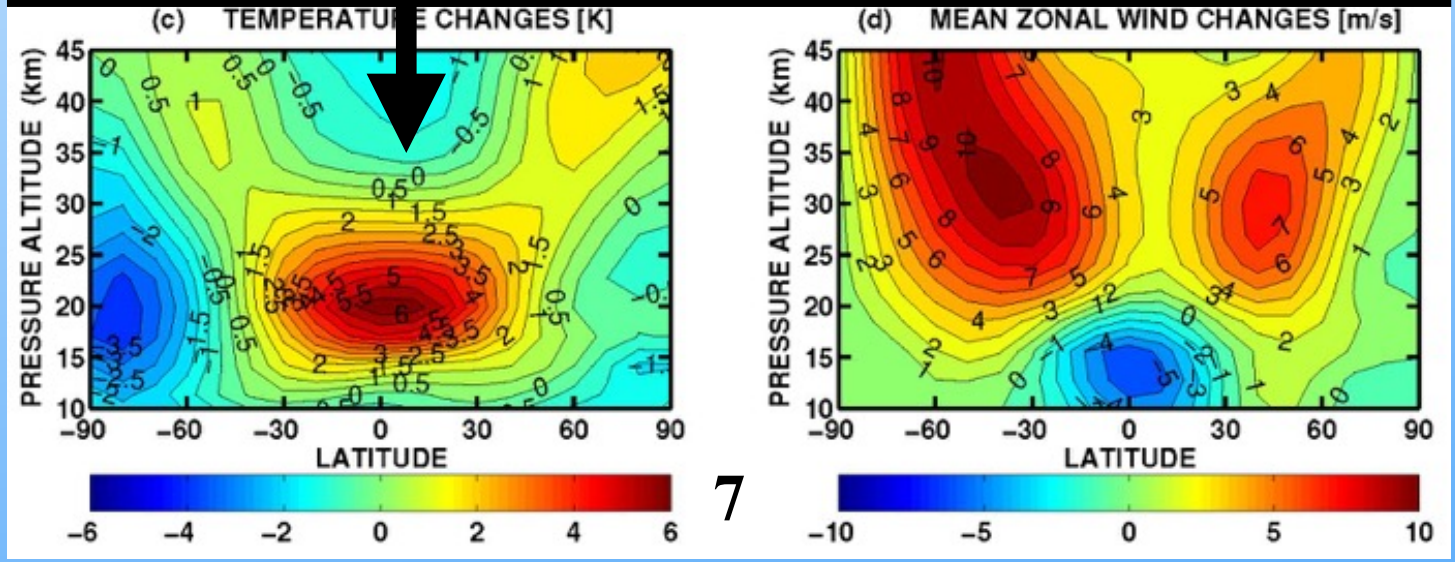


Higher heating rates in the lower stratosphere

Pinatubo case: UTLS zonal anomalies

Lower stratosphere warming



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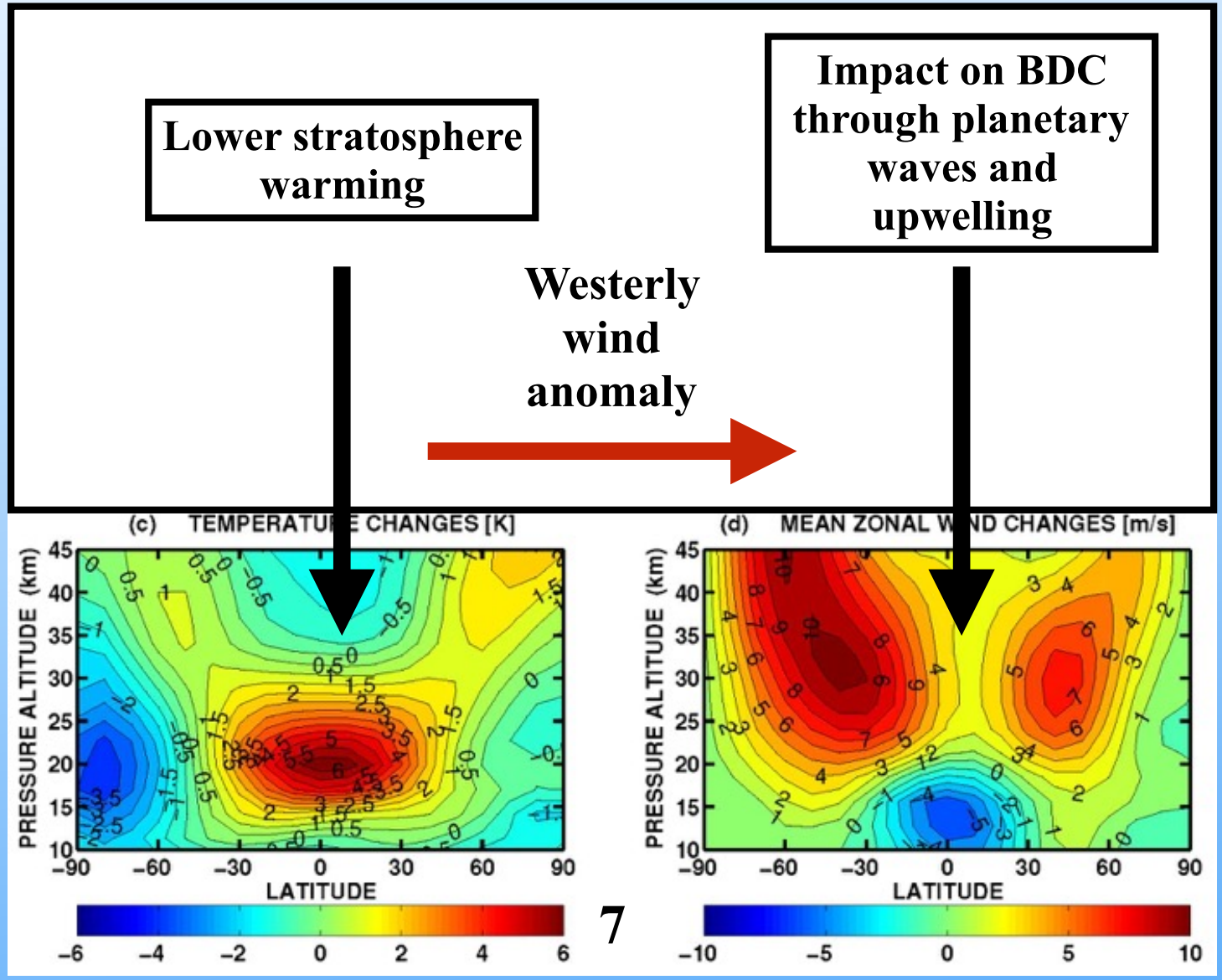
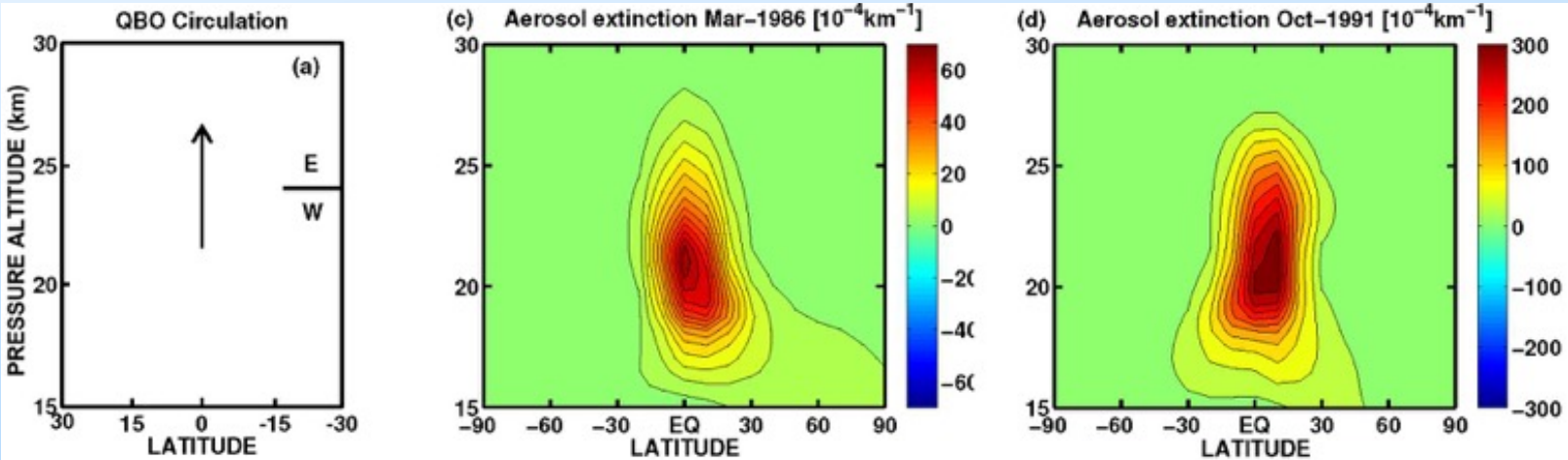


EQUATORIAL WINDS QBO AND AEROSOL TRANSPORT



Dominant E shear:

definite upwelling motion in the tropical stratosphere

Aerosol extinction 4 months after the eruption: (Ruiz and Pinatubo)

- highly confined around the equator

- less isentropic poleward transport above the tropopause

EQUATORIAL WINDS QBO AND AEROSOL TRANSPORT

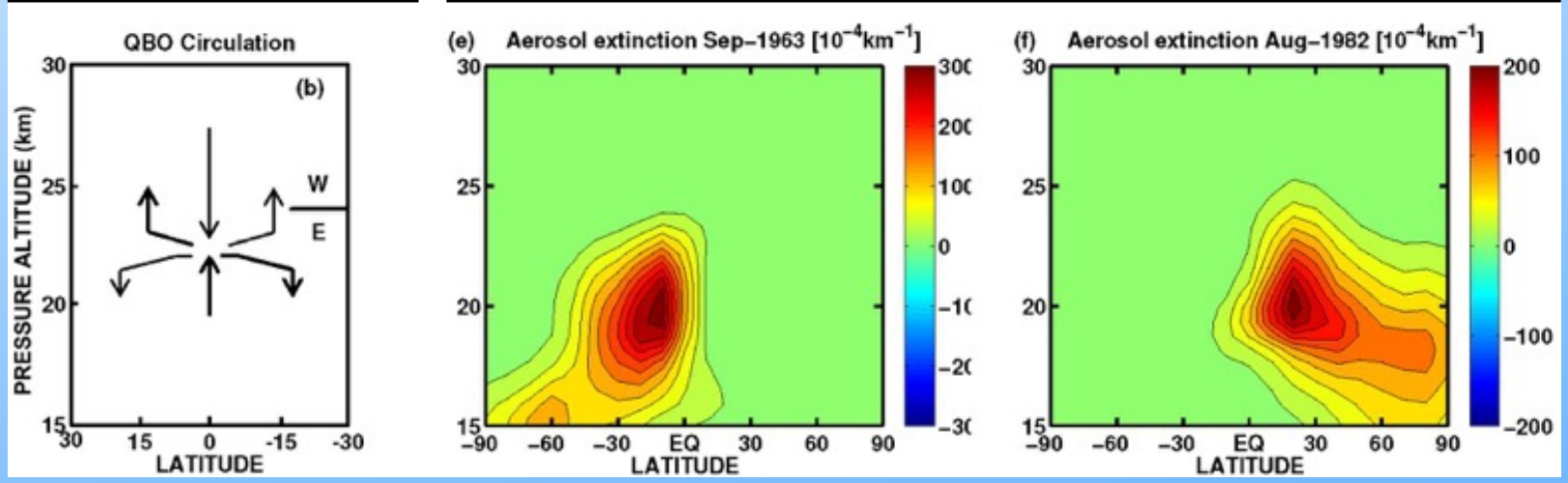
Dominant W shear:

descent relative to the mean stratospheric circulation

Aerosol extinction 4 months after the eruption: (Agung and El Chicón)

- less tropical confinement

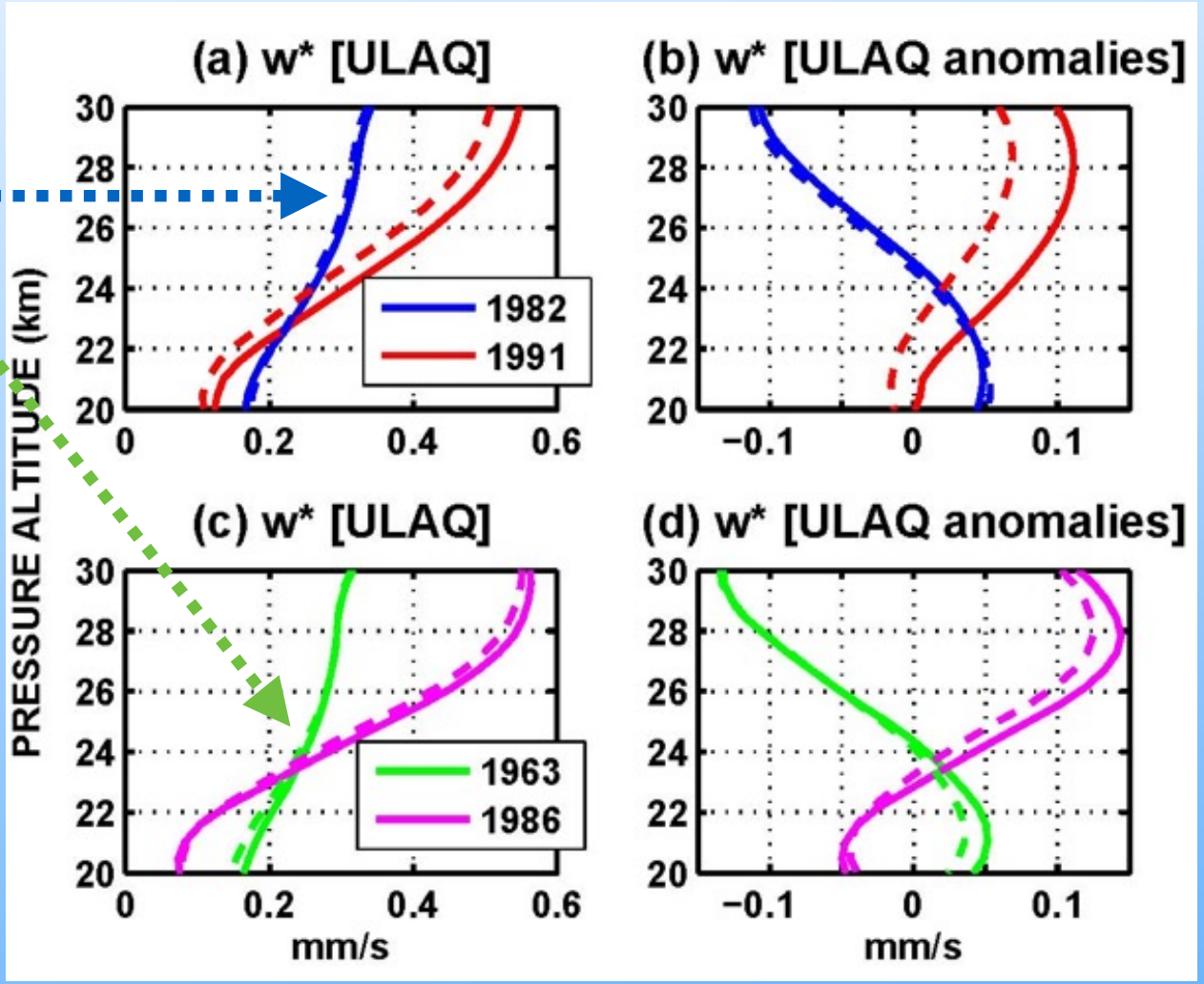
- fast poleward isentropic transport above the tropopause



EQUATORIAL WINDS QBO AND AEROSOL TRANSPORT

Tropical w* profiles

QBO
W SHEAR



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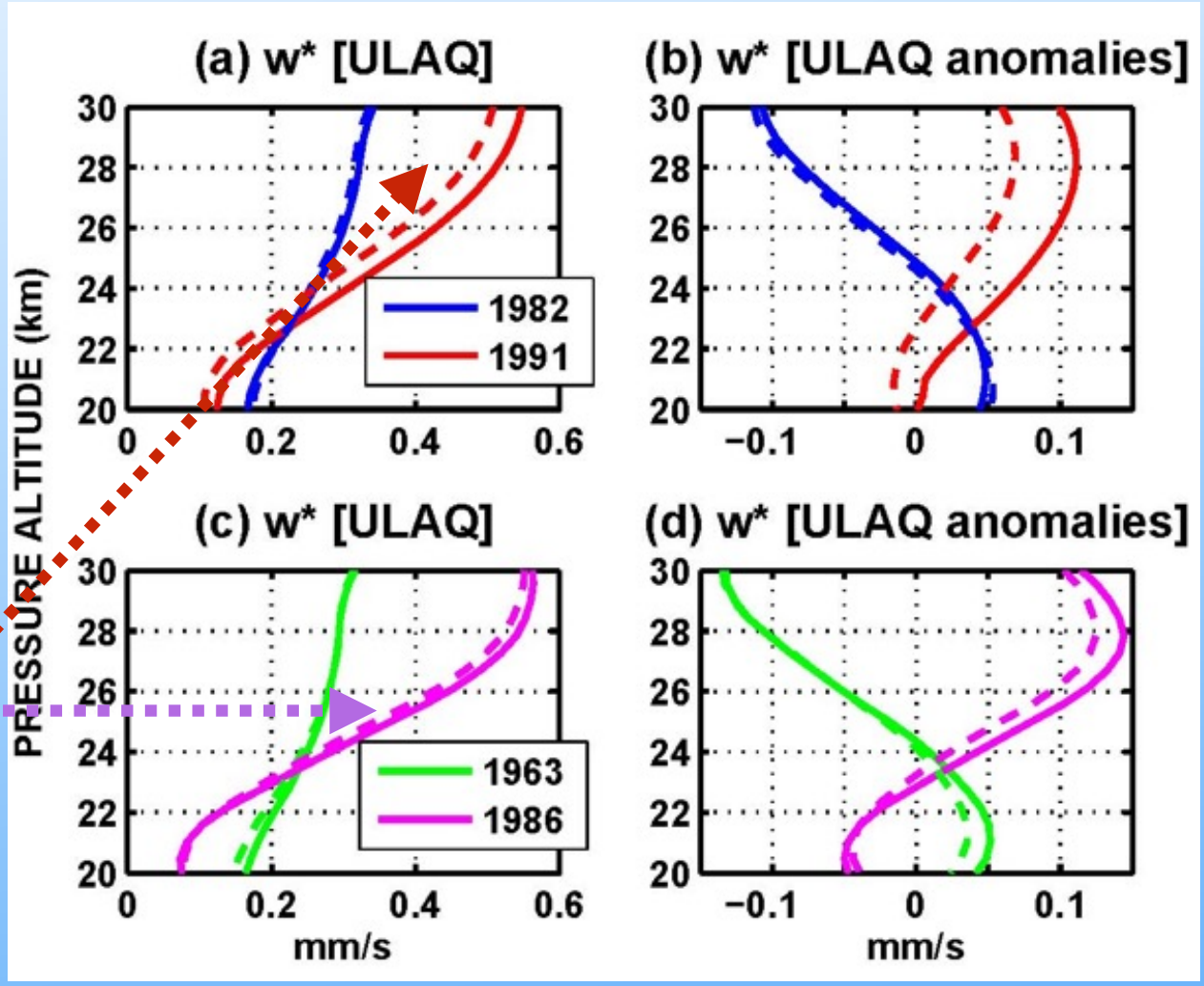

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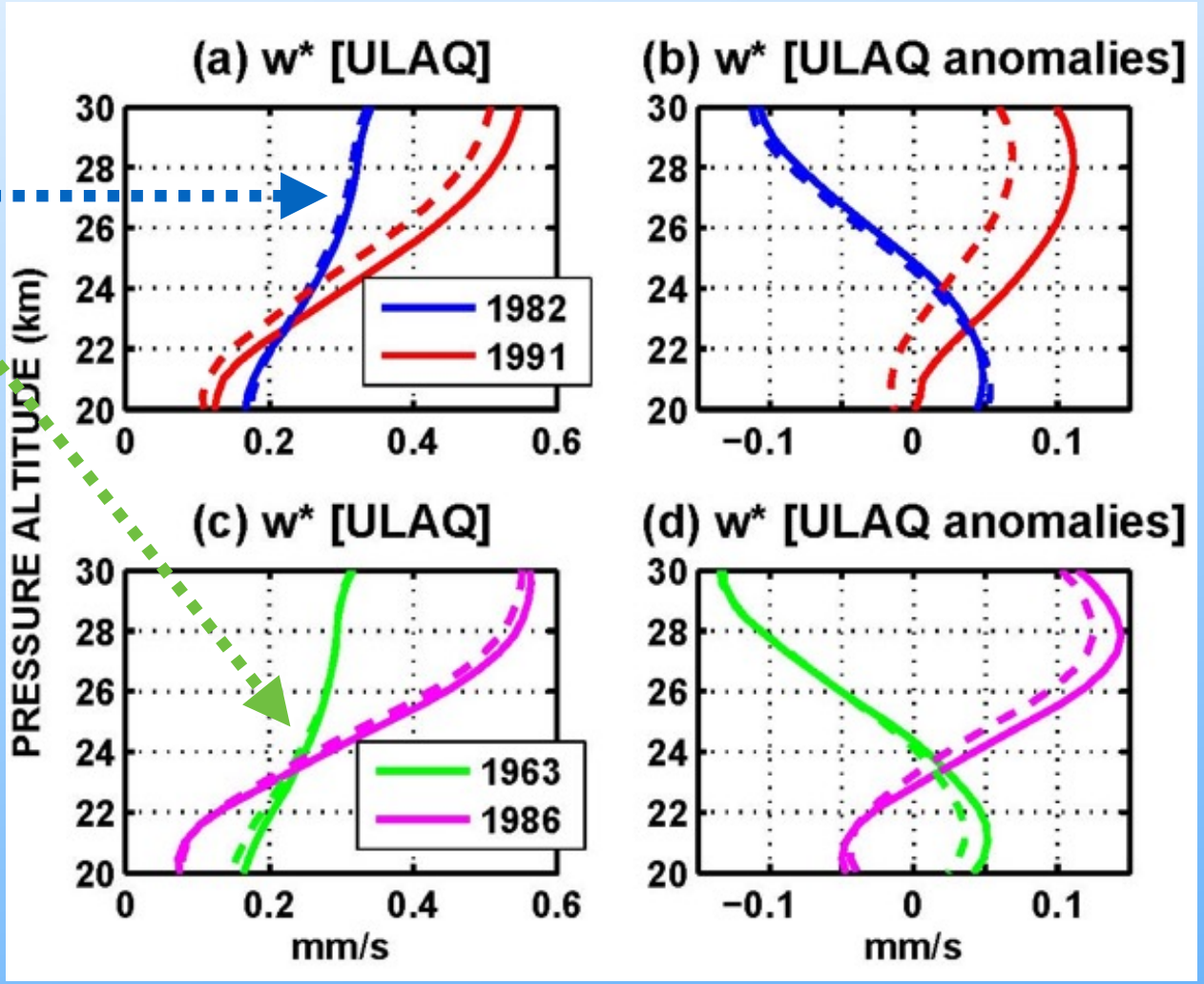

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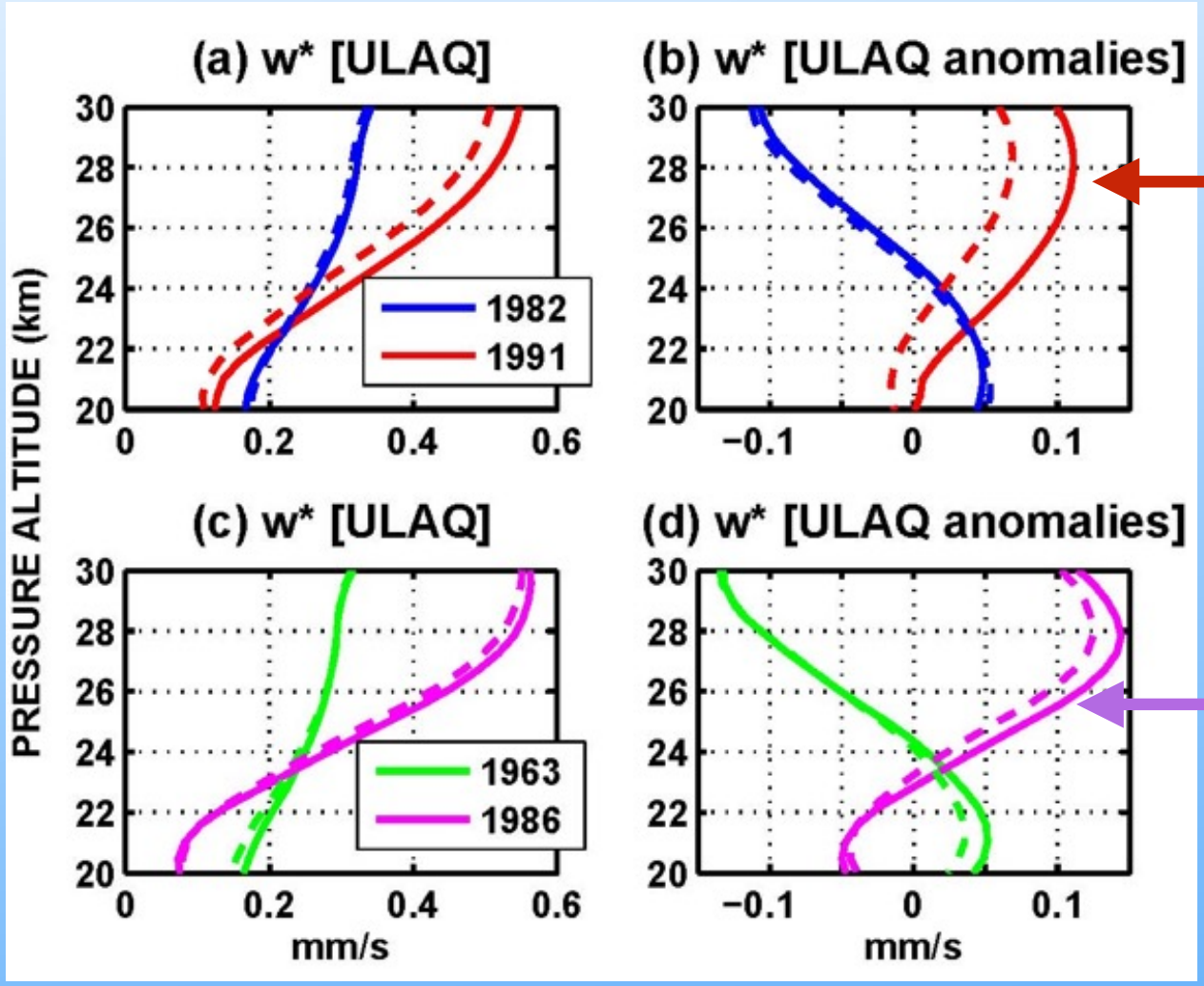

For VE simulations a significant positive w* anomaly is found during QBO E shear

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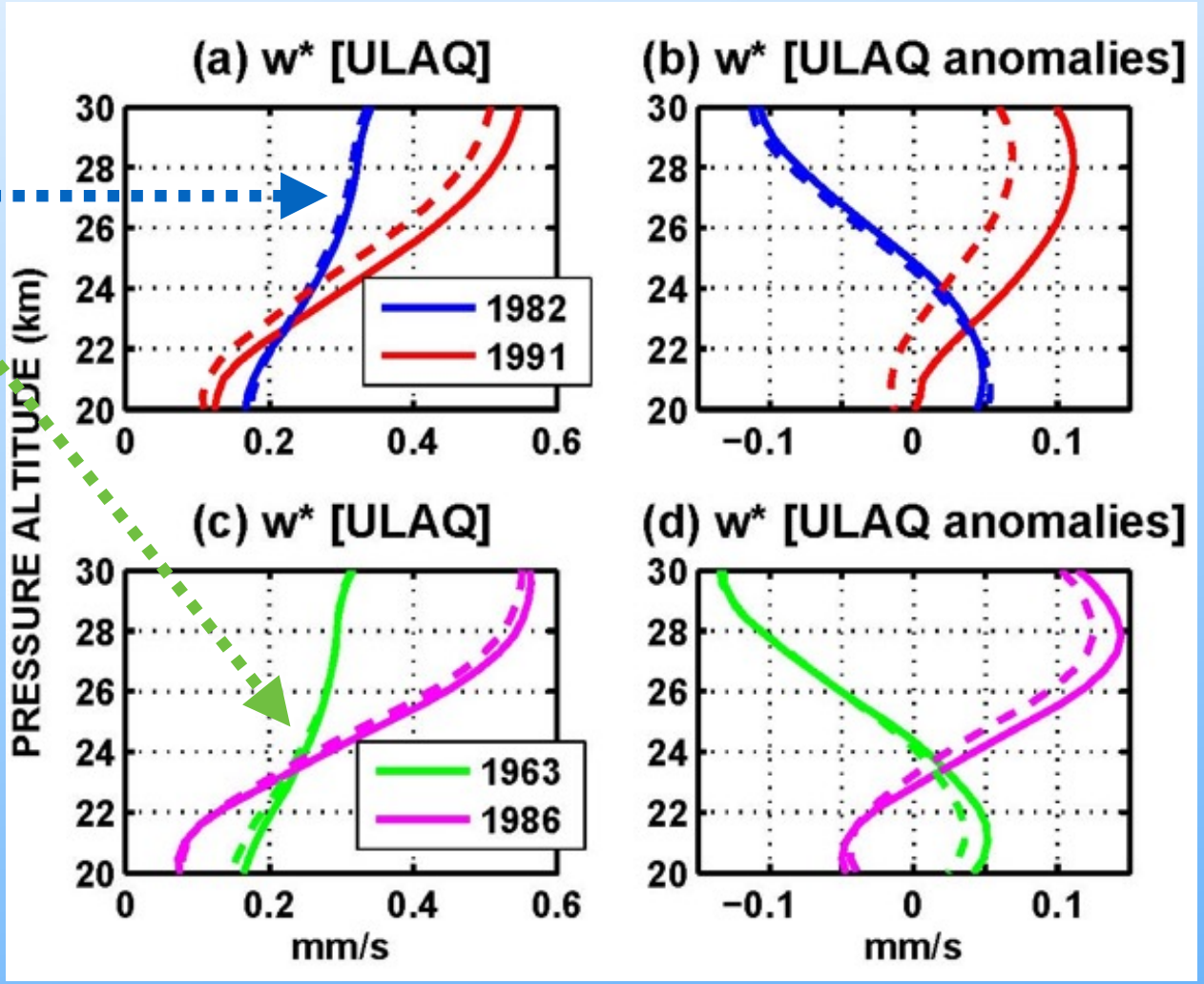
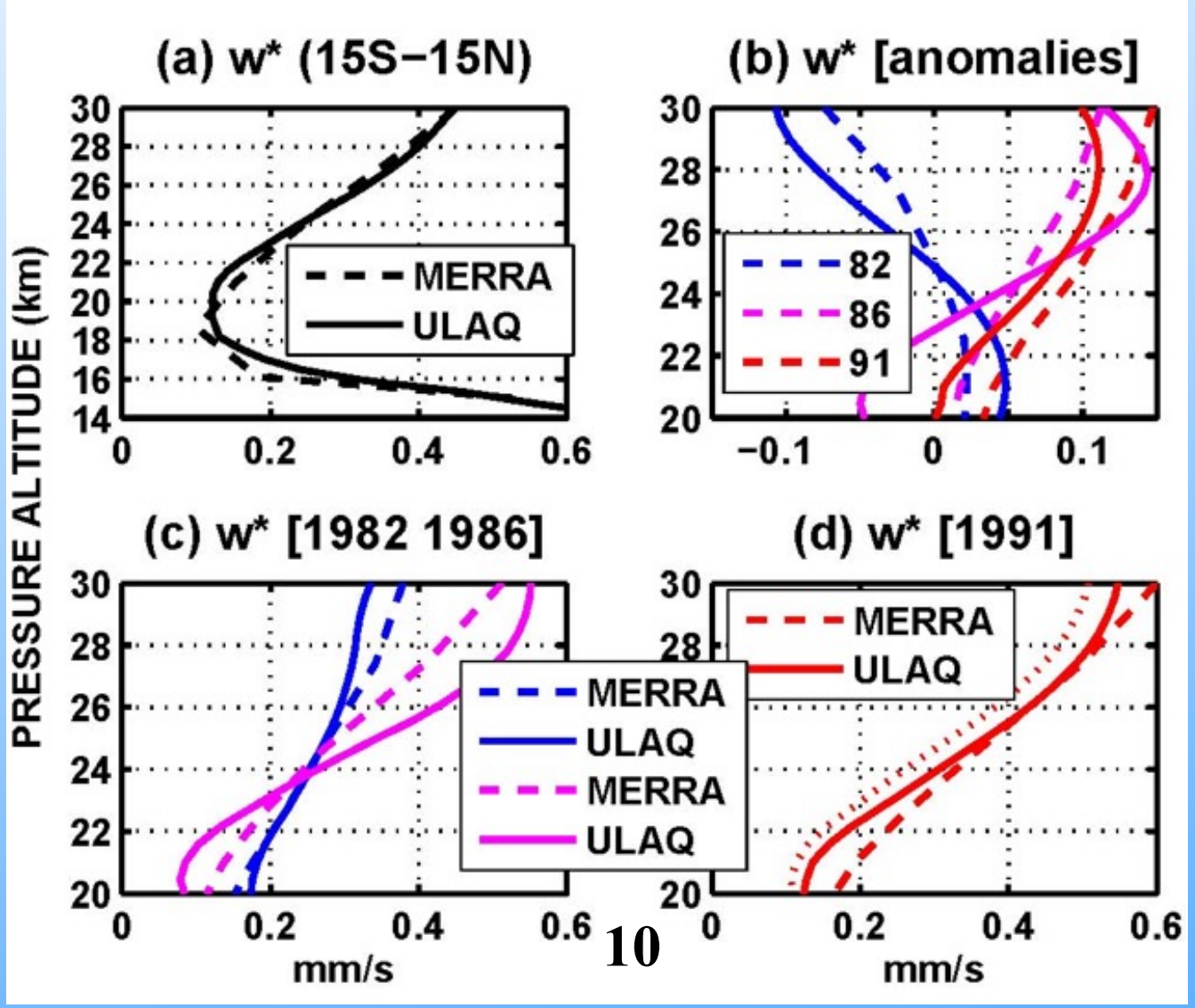


EQUATORIAL WINDS QBO AND AEROSOL TRANSPORT

Tropical w* profiles evaluation

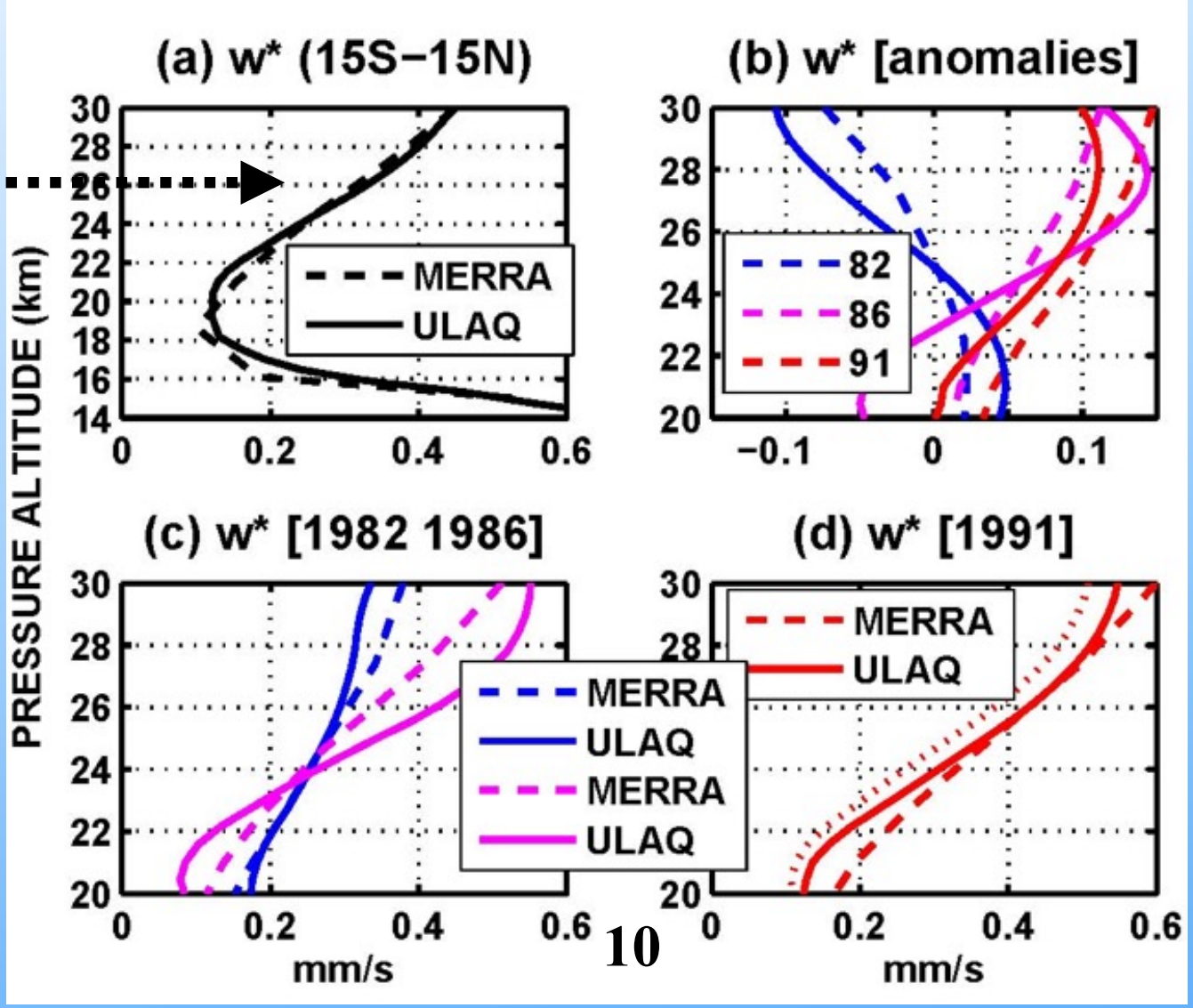
Very good agreement between model w* and MERRA



EQUATORIAL WINDS QBO AND AEROSOL TRANSPORT

Tropical w* profile evaluation

1979-2010 mean w* profile



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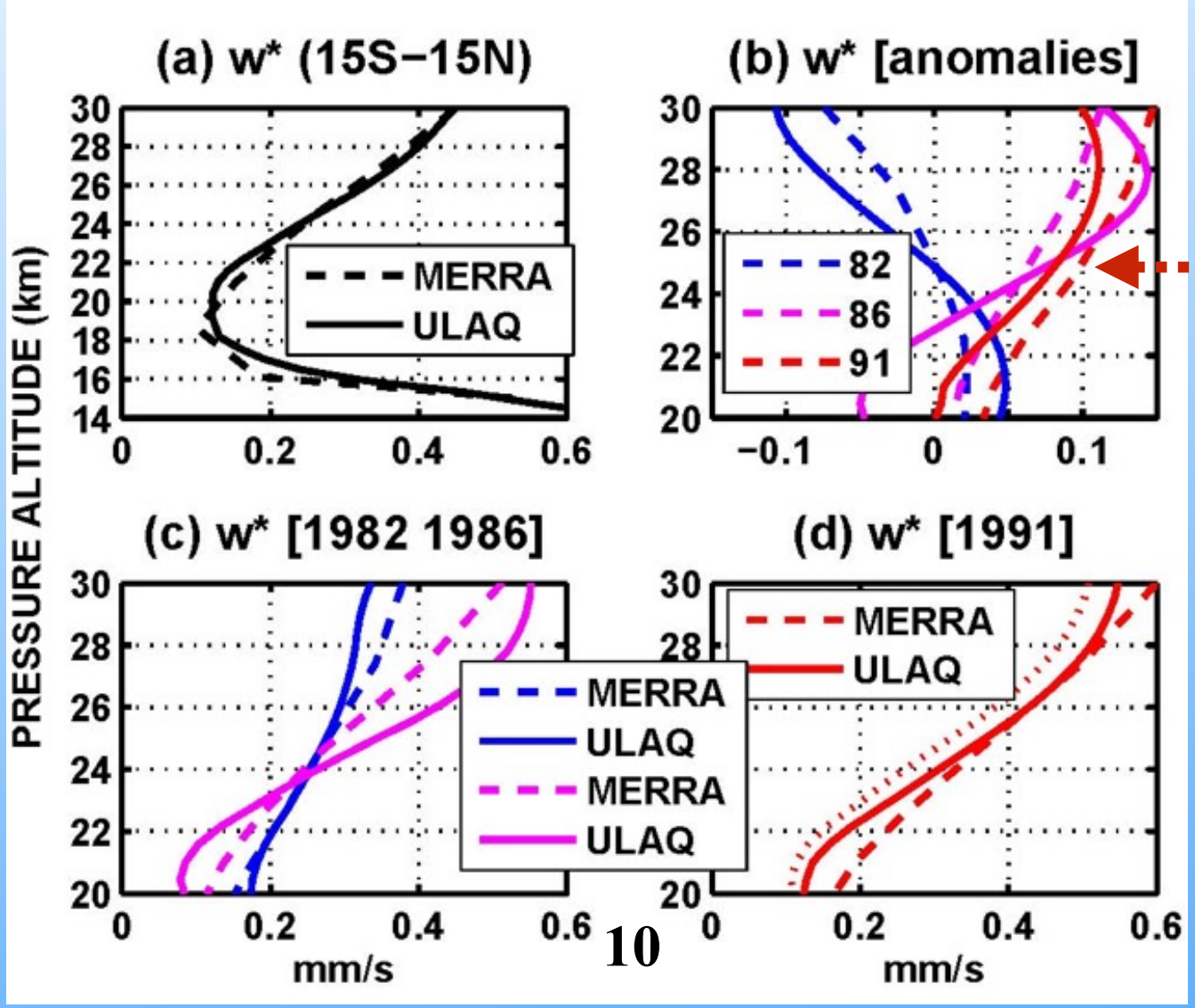

Good agreement for w* anomalies on eruption years with both QBO shears

AEROSOL CLOUD DISPERSAL AND e-FOLDING TIME

Particle loss in the stratosphere 4-6 months after the eruption due to stratosphere-troposphere exchange

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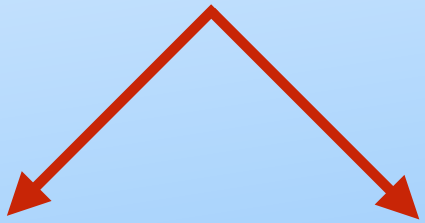

Gravitation particles settling

Large scale transport due to Brewer-Dobson circulation

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Average particle size

Dependent on the magnitude of volcanic SO2 injection

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Isolation of the stratospherical tropical pipe → More time into the stratosphere

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Dependent on the QBO phase

Isolation of the stratospherical tropical pipe → **More time into the stratosphere**

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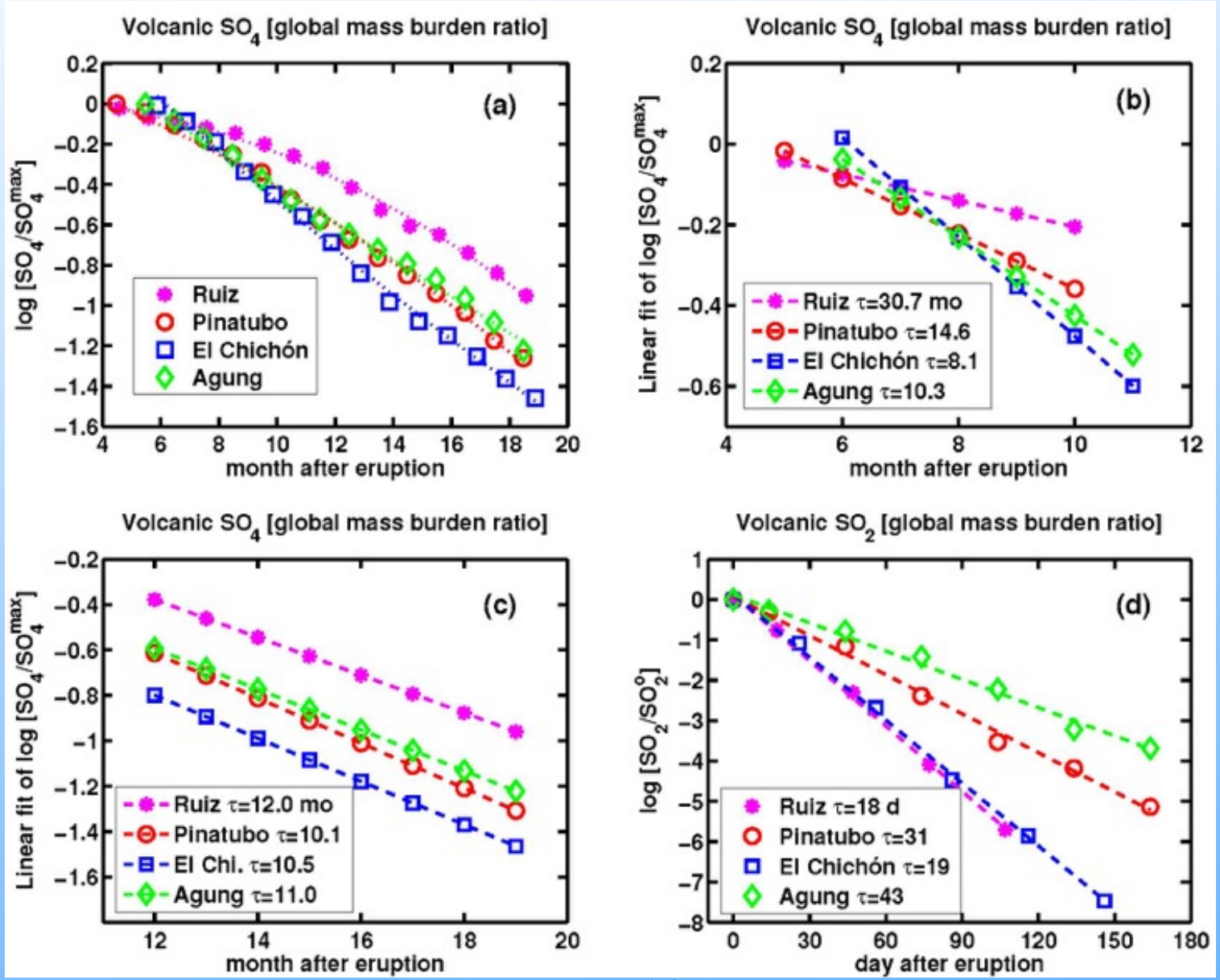
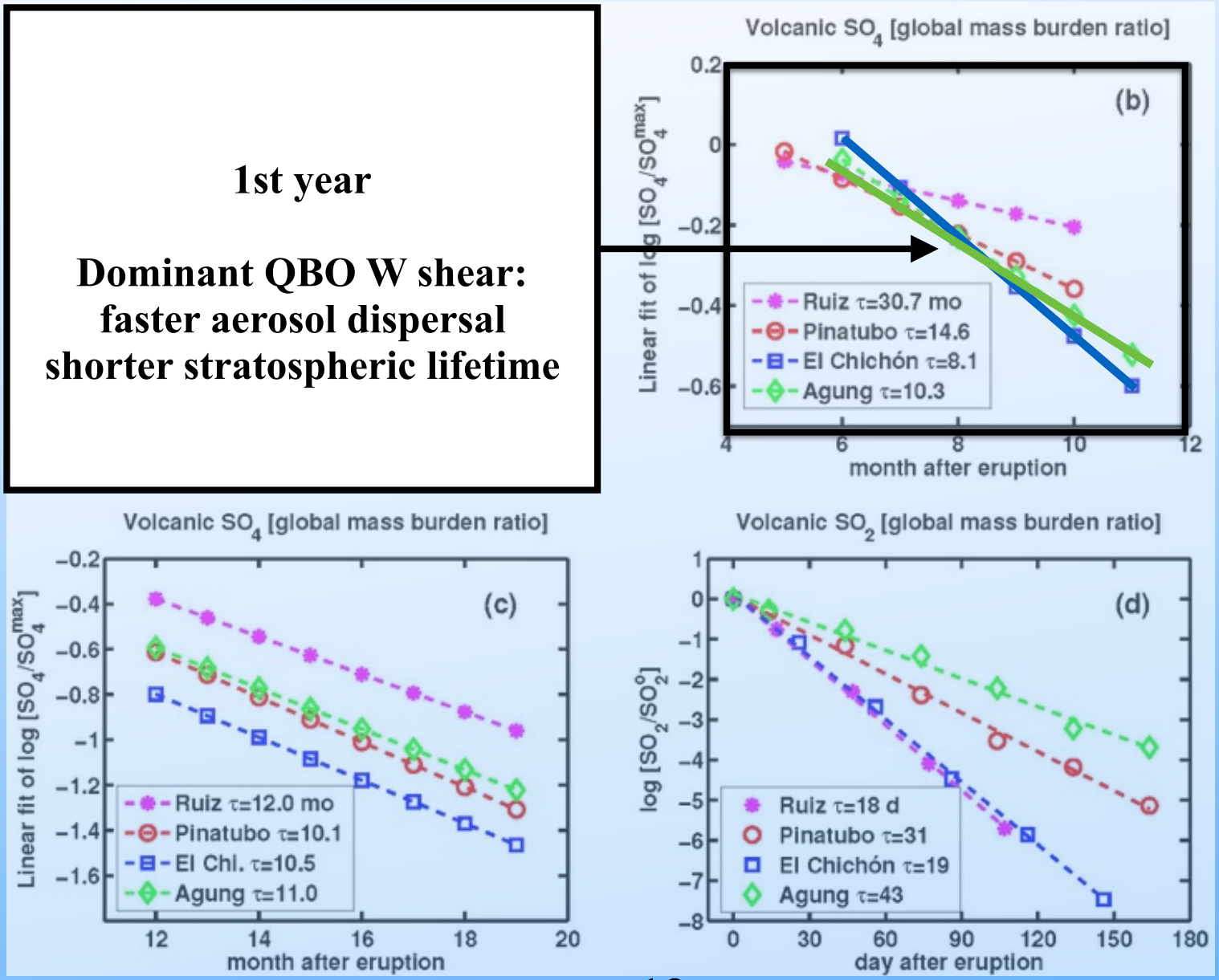


AEROSOL CLOUD DISPERSAL AND e-FOLDING TIME

1st year

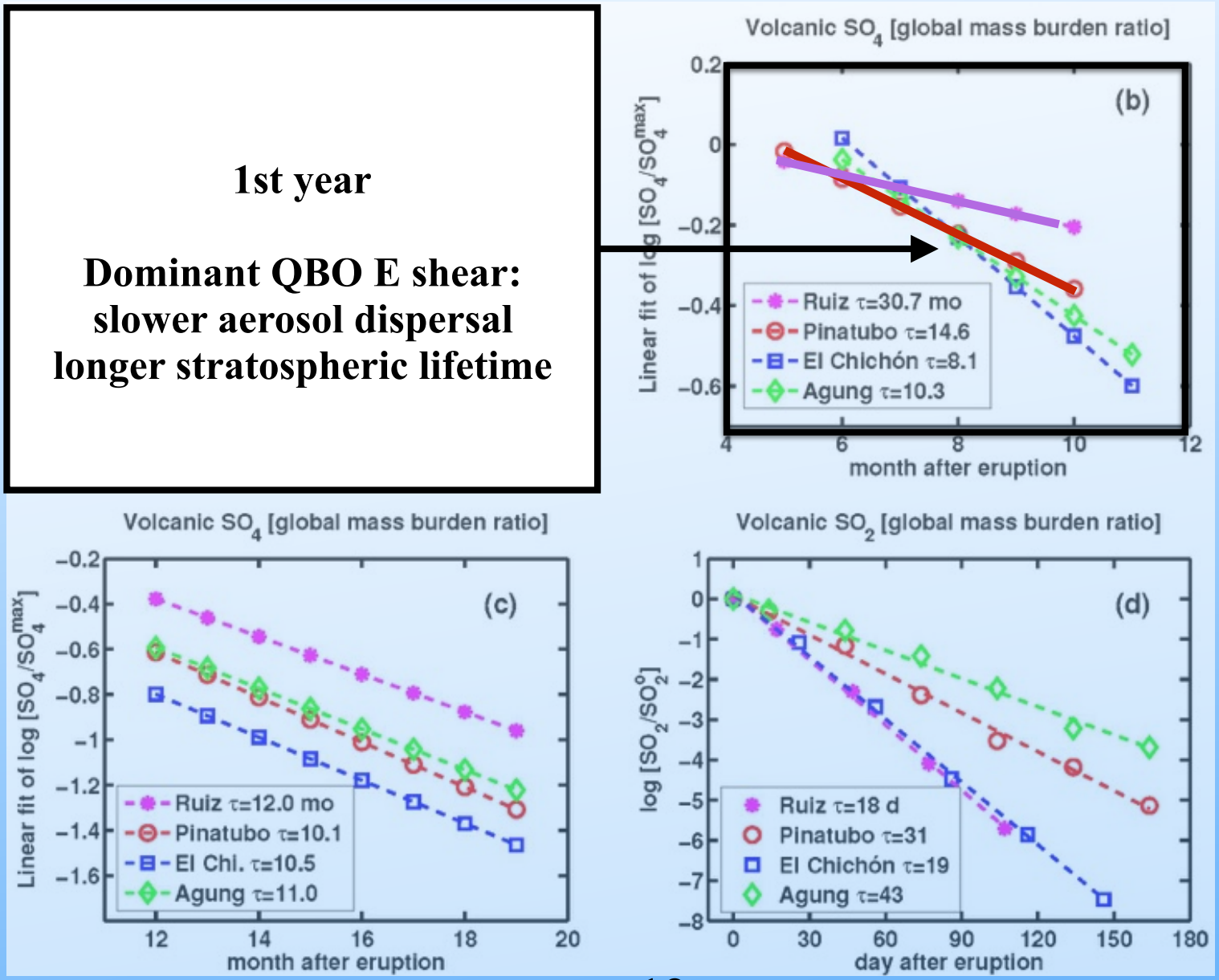
Dominant QBO W shear:
faster aerosol dispersal
shorter stratospheric lifetime



AEROSOL CLOUD DISPERSAL AND e-FOLDING TIME

1st year

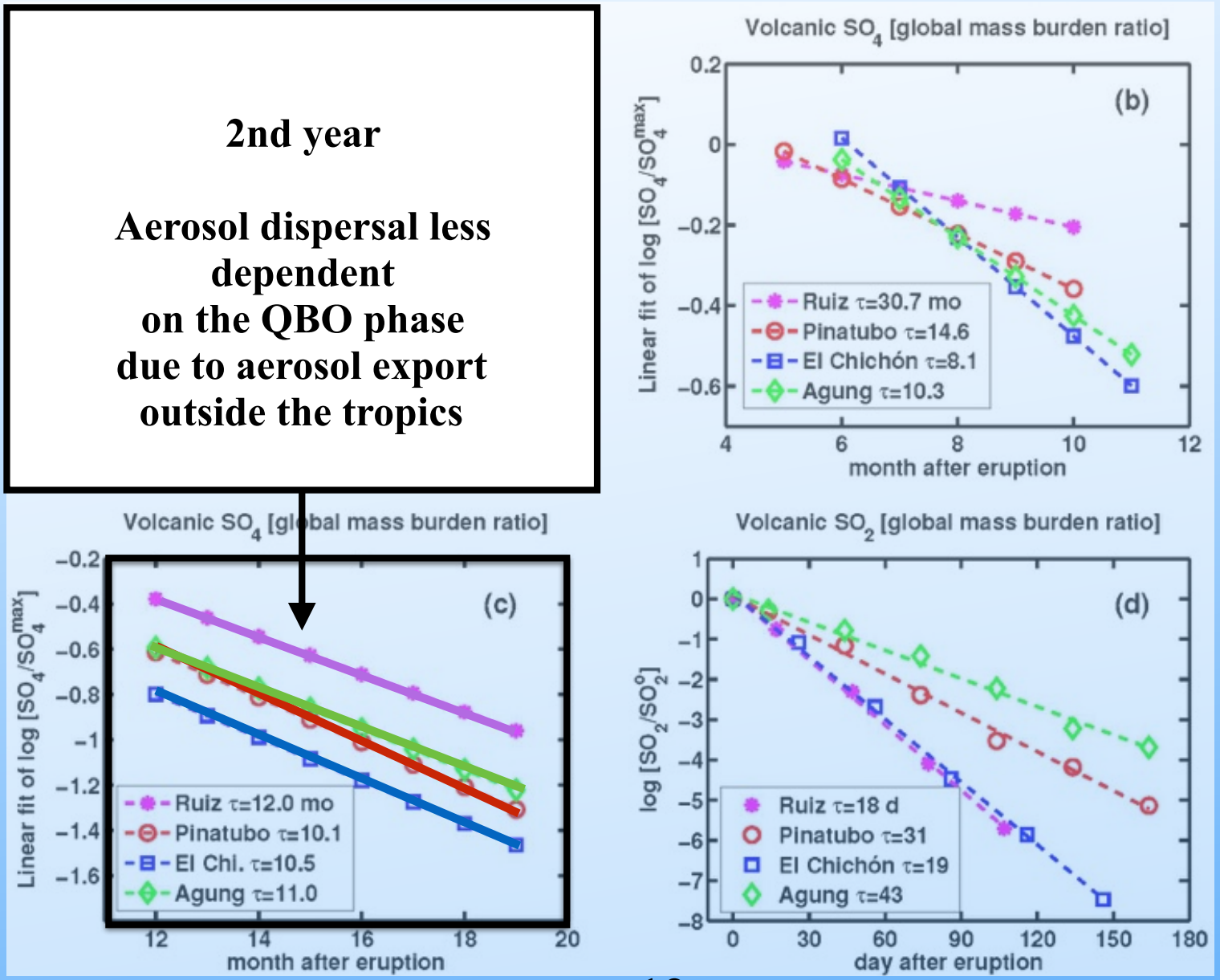
Dominant QBO E shear:
slower aerosol dispersal
longer stratospheric lifetime



AEROSOL CLOUD DISPERSAL AND e-FOLDING TIME

2nd year

Aerosol dispersal less dependent on the QBO phase due to aerosol export outside the tropics



CONCLUSIONS

1 - Our simulations show the effects of major explosive volcanic eruptions in the 20th century: enhanced diabatic heating rates and increase in stratospheric tropical temperatures

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1 - Our simulations show the effects of major explosive volcanic eruptions in the 20th century: enhanced diabatic heating rates and increase in stratospheric tropical temperatures

2 - The impact on tropical upwelling is larger when aerosols are more confined in the tropical region (QBO E shear)

3 - The QBO shear greatly affects the aerosol lifetime during the first year after the eruptions: to an E shear corresponds a longer lifetime

CONCLUSIONS

Thank you for your attention

How do we know our results are not artefacts from the model?

SAGE evaluation

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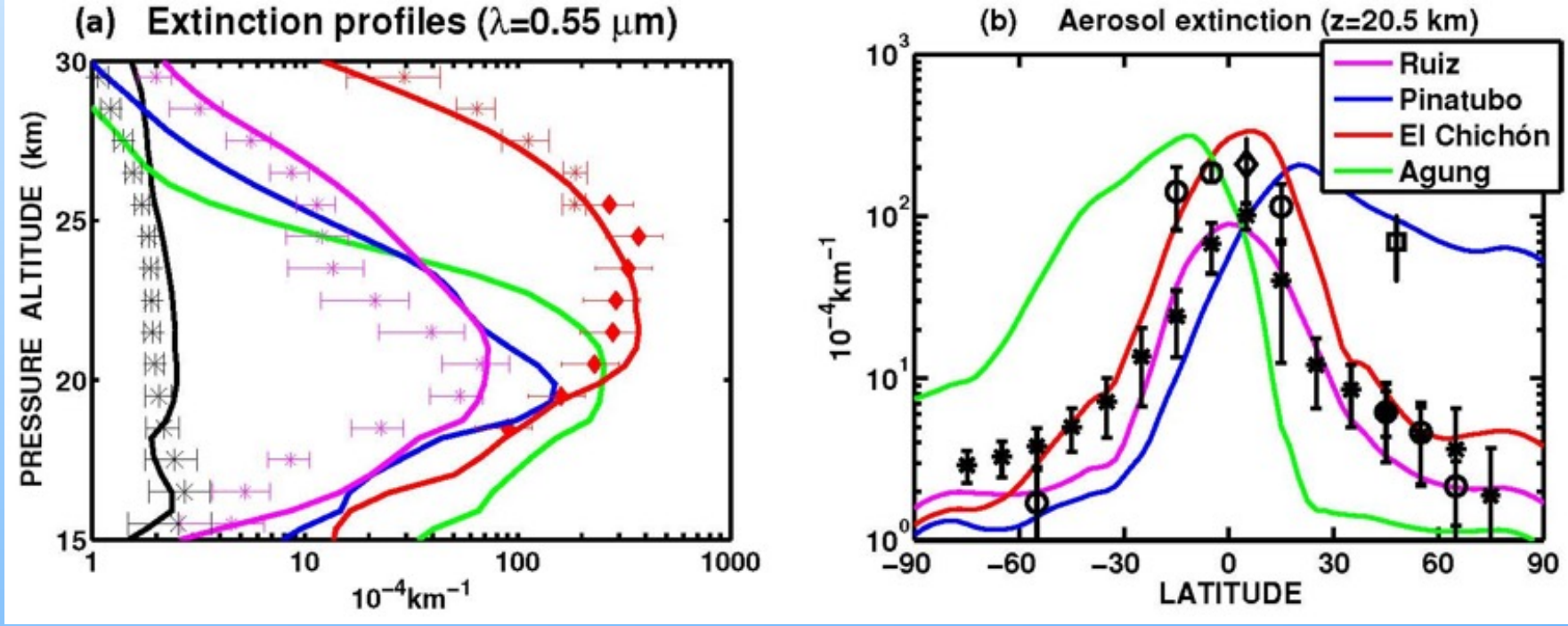

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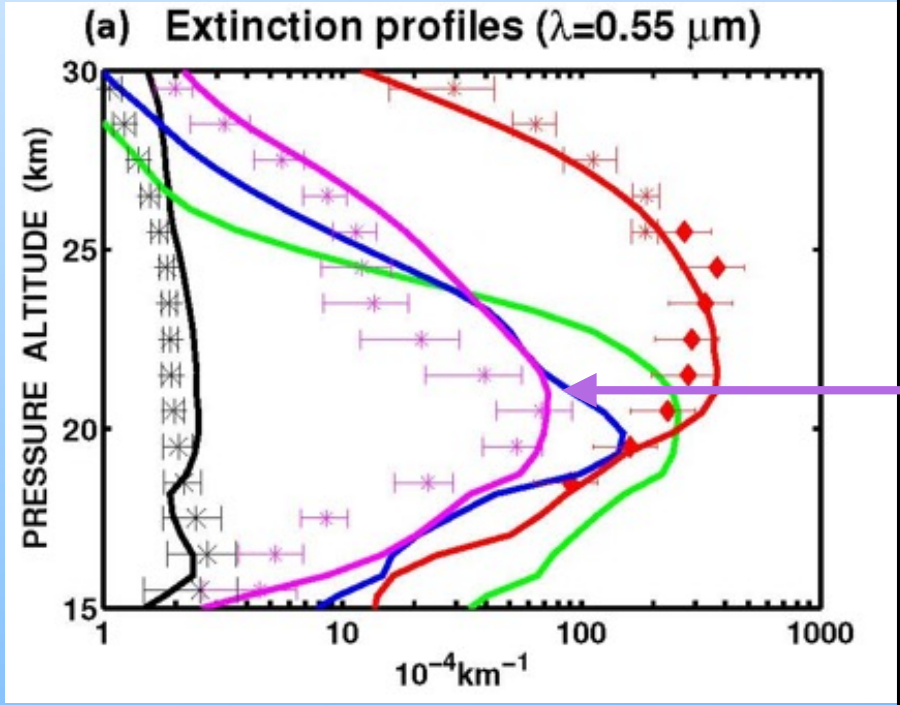

(*) SAGE II observations

(-) Model results

Ruiz

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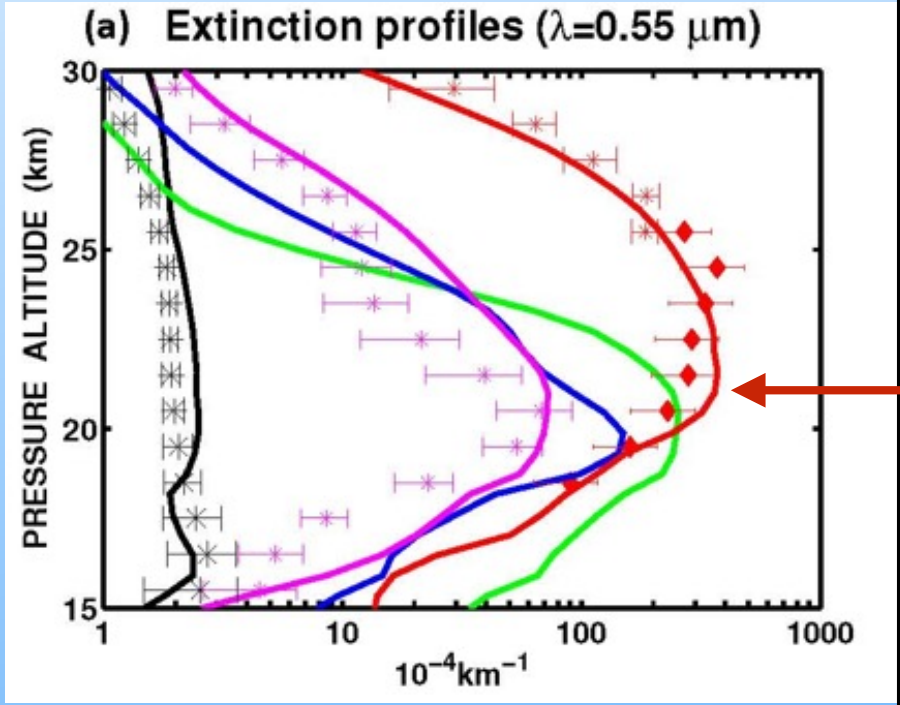
SAGE evaluation



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El Chichòn

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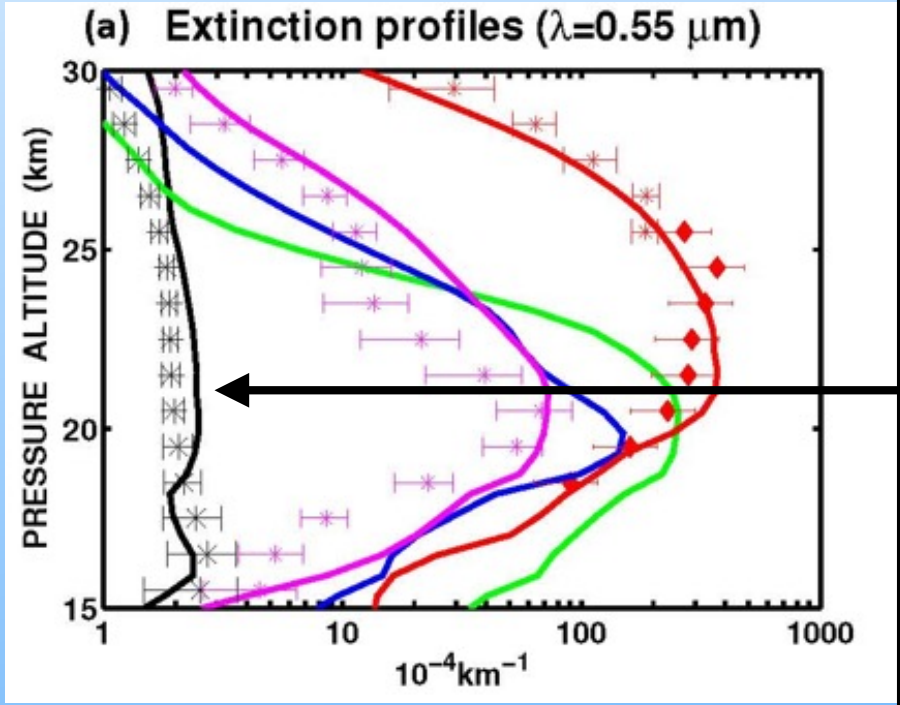

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Volcanic free