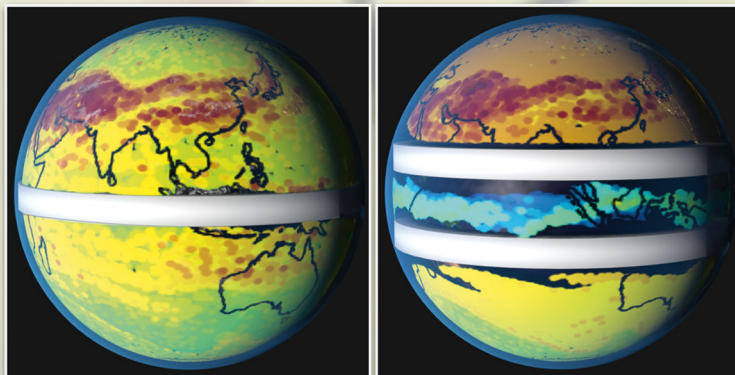
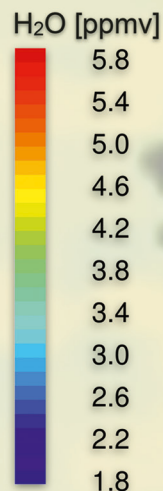
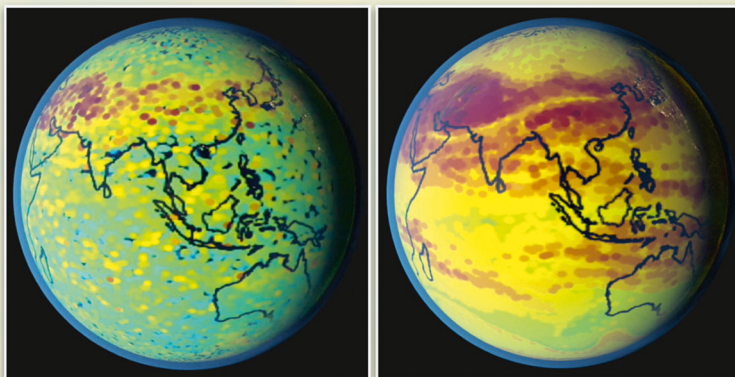


Artificial barriers



Small-scale mixing



Lagrangian Simulation of Stratospheric Water Vapour: Impact of Large-Scale Circulation and Small-Scale Transport Processes

Liubov Poshyvailo

Energie & Umwelt / Energy & Environment

Band / Volume 503

ISBN 978-3-95806-488-1

Forschungszentrum Jülich GmbH
Institut für Energie- und Klimaforschung
Stratosphäre (IEK-7)

Lagrangian Simulation of Stratospheric Water Vapour: Impact of Large-Scale Circulation and Small-Scale Transport Processes

Liubov Poshyvailo

Schriften des Forschungszentrums Jülich
Reihe Energie & Umwelt / Energy & Environment

Band / Volume 503

ISSN 1866-1793

ISBN 978-3-95806-488-1

Contents

1	Introduction and motivation	1
2	Scientific background	5
2.1	Structure of the atmosphere	5
2.2	Upper troposphere and stratosphere (UTLS)	8
2.3	UTLS processes	12
2.3.1	Transport in the tropical tropopause layer (TTL)	14
2.3.2	Brewer-Dobson circulation (BDC)	15
2.4	Stratospheric water vapour (H ₂ O)	18
2.4.1	Sources of stratospheric H ₂ O: transport and dehydration	19
2.4.2	Methane (CH ₄) oxidation as a source of stratospheric H ₂ O	21
2.4.3	Observations and modelling of stratospheric H ₂ O	22
2.4.4	Stratospheric H ₂ O trends	23
3	Data and method	25
3.1	CLaMS model set-up	25
3.1.1	Trajectory module (TRAJ)	25
3.1.2	Mixing module (MIX)	26
3.1.3	Cirrus module (CIRRUS)	27
3.1.4	CLaMS remarks	27
3.2	Meteorological reanalysis data	27
3.3	Satellite observations	28
4	Sensitivities of modelled stratospheric H₂O in the LS	31
4.1	Simulation set-up	32
4.2	Stratospheric entry H ₂ O sensitivity	37
4.3	Reanalysis uncertainty	39
4.4	Horizontal transport	41
4.5	Mixing effects	46
4.6	Discussion	51
4.6.1	Comparison of CLaMS simulated and reanalysis H ₂ O	51
4.6.2	Vertical diffusivity induced by small-scale mixing	54
4.7	Chapter conclusions	55

5	Estimating BDC trends from stratospheric H₂O changes	57
5.1	Theory of the mean age of air (AoA)	58
5.2	Methodology of estimating AoA trends from stratospheric H ₂ O changes	59
5.2.1	Drivers of H ₂ O changes	60
5.2.2	Assessing AoA trends from H ₂ O changes	64
5.2.3	Research strategy	64
5.3	Application of the approximation method to the CLaMS data	65
5.4	Impact of entry mixing ratio propagation	70
5.4.1	The propagation of entry mixing ratios	70
5.4.2	Application of propagation procedure to the conserved mean age tracer	72
5.4.3	Application of propagation procedure to total hydrogen	75
5.4.4	The effects of propagated stratospheric entry H ₂ O and CH ₄ on the AoA trends	76
5.5	Impact of using a monthly AoA-FRF correlation	77
5.6	Discussion	82
5.7	Chapter conclusions	86
6	Summary and conclusions	89
A	Validation of the CLaMS simulations	93
B	Impact of the dehydration at the poles on simulated stratospheric H₂O	95
C	AoA-FRF correlation	97
	Symbols and abbreviations	99
	List of Figures	101
	List of Tables	103
	Bibliography	105
	Afterword	125

Energie & Umwelt / Energy & Environment
Band / Volume 503
ISBN 978-3-95806-488-1