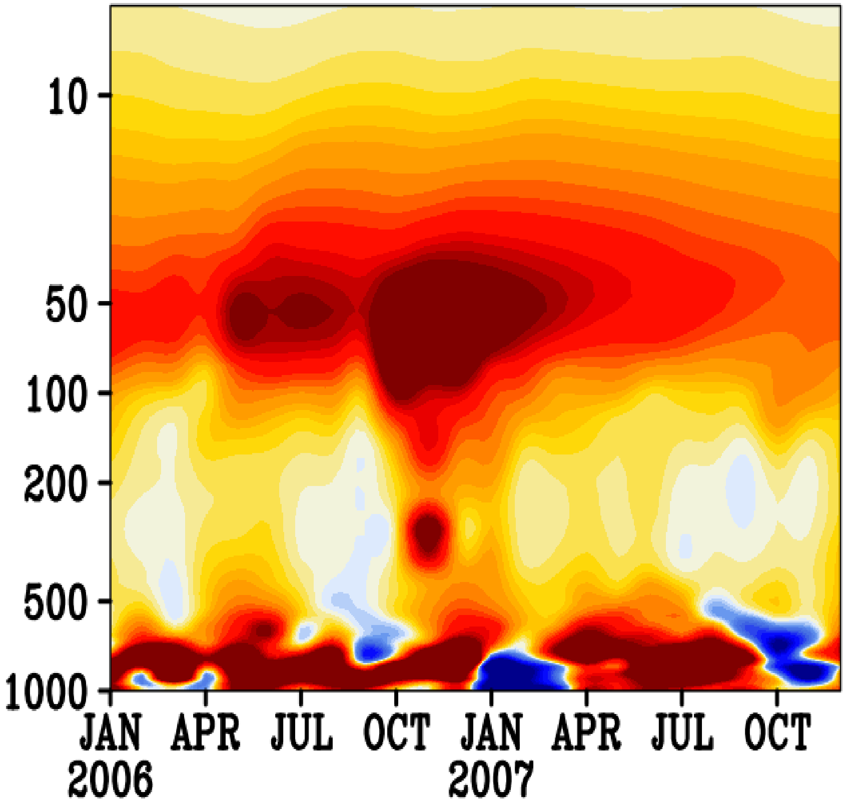
Impact of volcanic aerosols on the tropical stratosphere and disruption of the QBO



Presented by:
Prashant Chavan

Experimental Set-up

- We employ the state-of-the-art **ECHAM6-HAMMOZ chemistry-climate model**.
- **Emission sensitivity experiments:** All aerosols including volcanic emissions were kept **ON (BASE) and** all volcanic aerosol emissions are switched **OFF (VAL0)** during 2001-2013.
- We analyse the **difference between BASE and VAL0** simulations during 2001-2013.
- Table shows the list of volcanoes erupted all over globe during period 2001 – 2013.

Sr. no.	Volcano	Month Year	Location	VEI
1	Shiveluch	June 2001	56.65 ^{o}N,161.36^{o} E	4
2	Ruang	September 2002	2.30 ^{o}N, 125.37^{o}E	4
2	Reventador	November 2002	0.08 ^{o}S,77.66 ^{o}W	4
4	Anatahan	May 2003	16^{o}N 146^{o}E	3
5	Manam	November 2004	4.08 ^{o}S, 145.04 ^{o}E	4
6	Sierra Negra	Oct 2005	1^{o}S 91^{o}W	3
8	Soufrière Hills	May 2006	17^{o}N 62^{o}W	3
8	Rabaul	October 2006	4.27 ^{o}S, 152.20 ^{o}E	4
9	Jebel at Tair	Sep 2007	16^{o}N 42^{o}E	3
10	Chaiten	May 2008	42.83 ^{o}S, 72.65 ^{o}W	4
11	Mt okmok	July 2008	53.48 ^{o}N, 168.17 ^{o}W	4
12	Kasatochi	August 2008	55.00 ^{o}N, 175.00 ^{o}W	4
13	Redoubt	Mar 2009	60^{o}N 153^{o}W	3
14	Sarychev	June 2009	48.00 ^{o}N, 153.20 ^{o}E	4
15	Eyjafjallajokull	April 2010	63.63 ^{o}N, 19.60 ^{o}W	4
16	Merapi	November 2010	7.54^{o}S, 110.44 ^{o}E	4
17	Grimsvotn	May 2011	64.42 ^{o}N, 17.33 ^{o}W	4
18	Nabro	June 2011	13.37 ^{o}N, 41.70 ^{o}E	4
19	Puyehue-Cordon Caulle	June 2011	40.59 ^{o}S,72.12 ^{o}W	5
20	Etna	April 2013	37.89 ^{o}N, 137.48 ^{o}E	3

Impact of volcanic aerosols on AOD

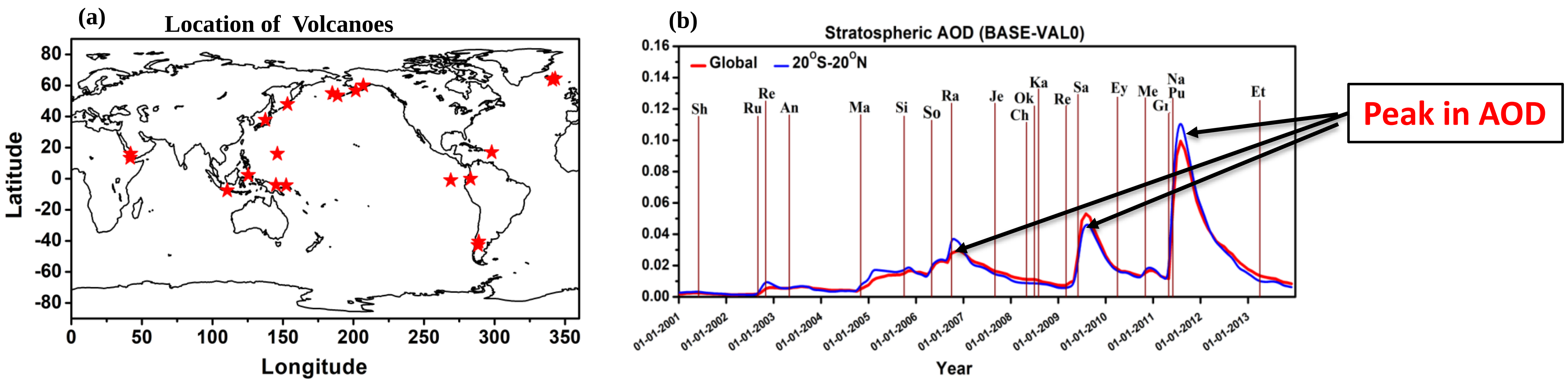


Figure : (a) Location of moderate to large (VEI≥3) volcano. (b) Global mean stratospheric Aerosol Optical Depth (AOD) during 2001-2013 from model simulation (red line) and AOD averaged for 20ºS-20ºN (blue line). Solid vertical lines show the eruption month of the volcano.

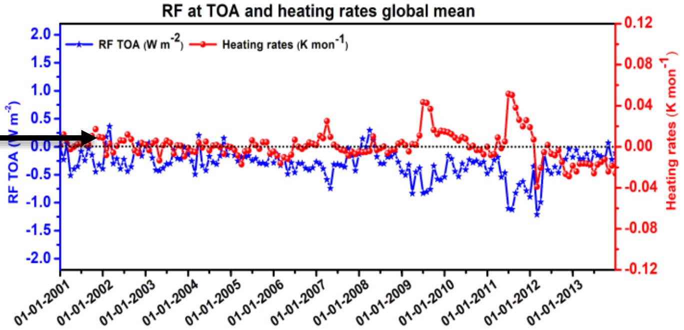
- **There are total of 20 volcanoes.**
  10 in the tropics,
  8 in the northern extra-tropics (30N-90N)
  2 in the southern extra-tropics (30S-90S)

- **SAOD enhanced by 0.0013 to 0.11 in tropical region.**
- **Peak in SAOD in 2006 due to the Soufrière Hills (0.029), in 2009 due to Sarychev (0.045), and in 2011 due to Nabro (0.11).**

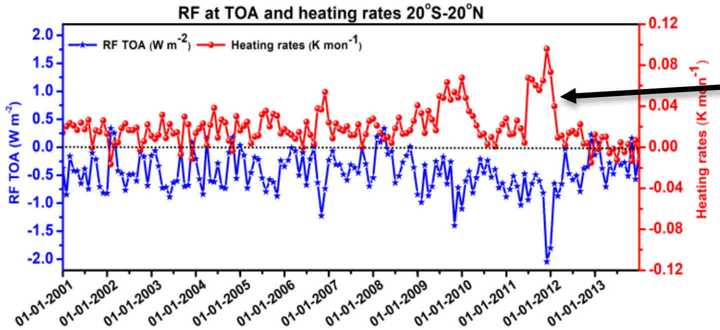
Impact of volcanic aerosols on RF and Heating rates

Global mean Enhanced HR

(a)



(b)



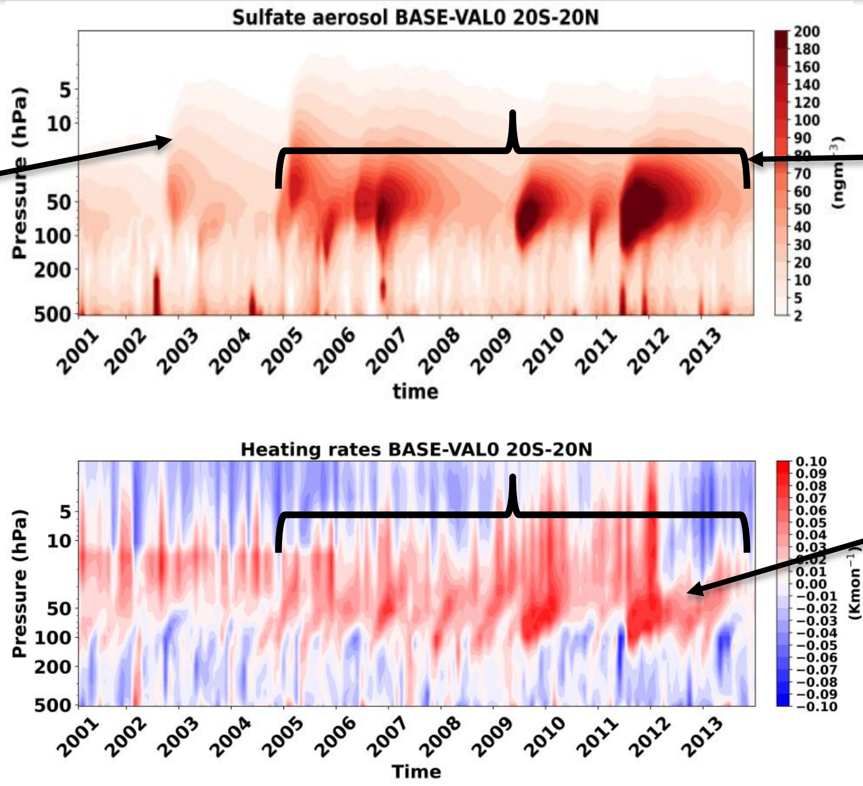
Enhanced HR in the tropical region

- **The peak in decrease in RF at TOA in the tropical region due to Soufrière Hills in 2006 (-0.65 W m^{-2}) , Sarychev in 2009 (-0.80 W m^{-2}), and Nabro in 2011 (-2.04 W m^{-2})**
- **There is a peak enhancement in heating rate in the tropical region due to the Soufrière Hills in 2006 (0.05 K mon^{-1}), (2) in 2009 due to Sarychev (0.06 K mon^{-1}) , and (3) in 2011 due to Nabro (0.095 K mon^{-1})**

- **This suggests that volcanic aerosols led to a more pronounced warming effect, particularly within the tropical region.**

Impact of volcanic aerosols into the tropical stratosphere

Less enhancement of sulfate aerosols In tropical pipe region due to volcanic quiescent period



Significant enhancement of sulfate aerosols In tropical pipe region due to series of large and moderate volcano

Enhancement in heating rates

Figure : Time series of volcanic sulfate aerosol (ng m^{-3}) anomaly (BASE-VAL0) (averaged over 0-360, 20S-20N) from ECHAM-HAMMOZ module simulation, (b) same as (a) but for heating rates (K mon^{-1}).

Impact of volcanic aerosols on QBO phase

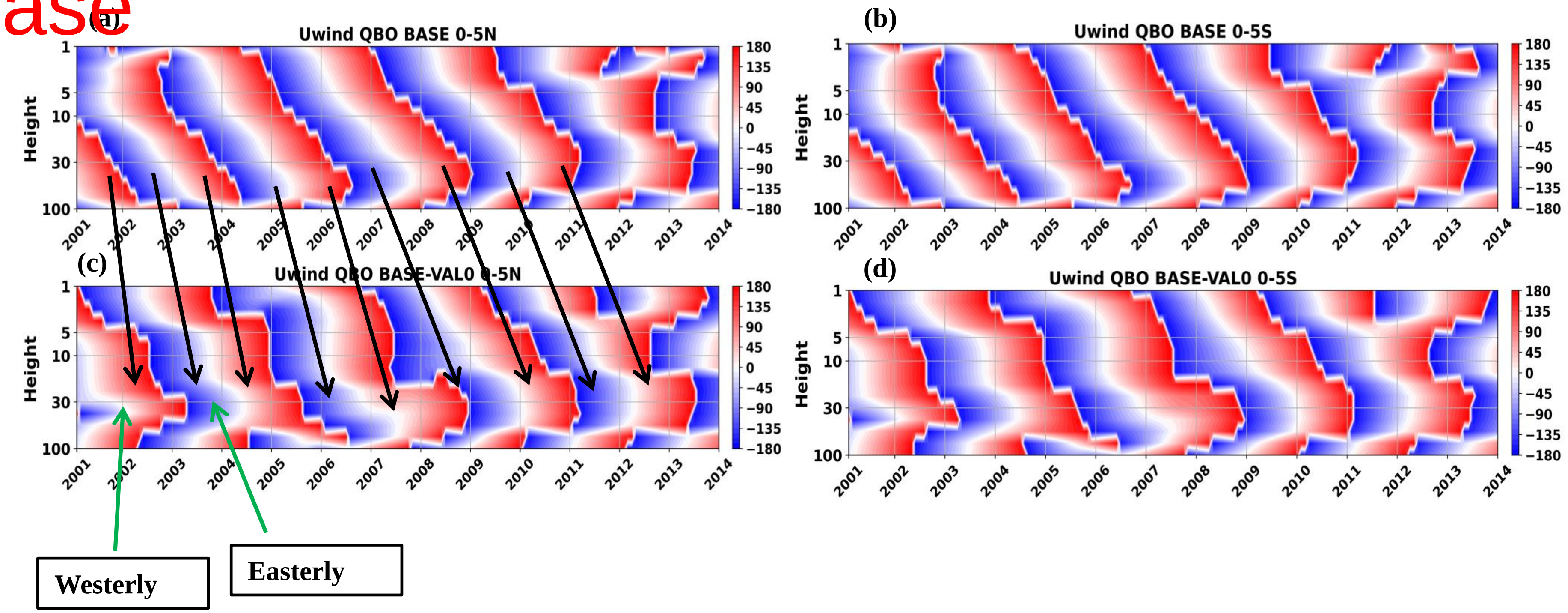


Figure :Time height cross section of Uwind Phase , (a) zonally averaged over 0-5°N form BASE simulation, (b) same as (a) but averaged over 0-5°S, (c) anomaly of Uwind phase zonally averaged over 0-5°N form BASE-VAL0 simulation, (d) same as (c) but averaged over 0-5°S.

- The downward propagation of both **westerly and easterly** winds suggests completion of one oscillation within **24 to 26 months** over the period 2001-2013.
- substantial increases in heating due to stratospheric volcanic aerosol can induce remarkable alterations in the QBO, which is completing one oscillation within 32 to 38 months, prolonging easterly by 12 to 20 months and westerly phases by 16 to 24 months (shown in figures c and d) compared to the control simulation (figures a and b).

Impact of volcanic aerosols on QBO amplitude

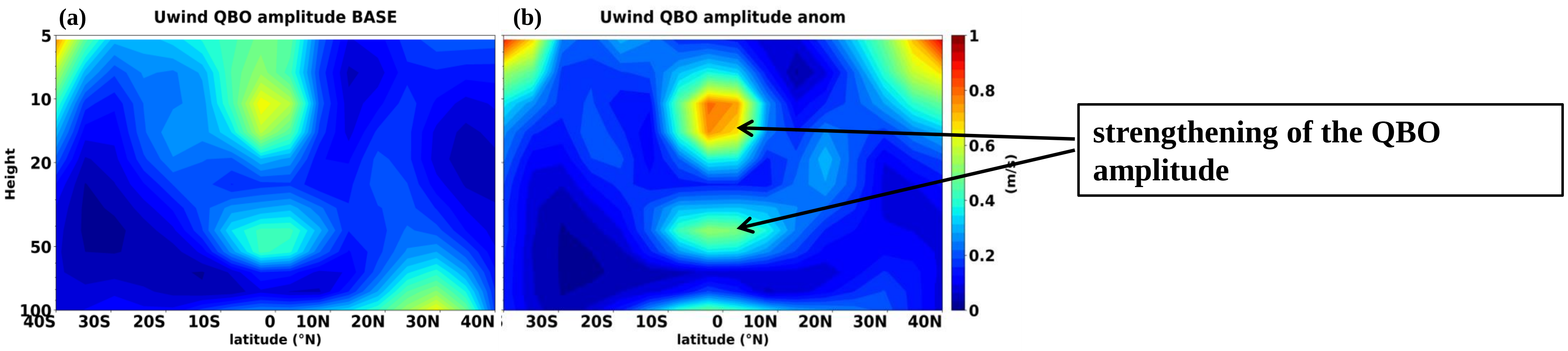
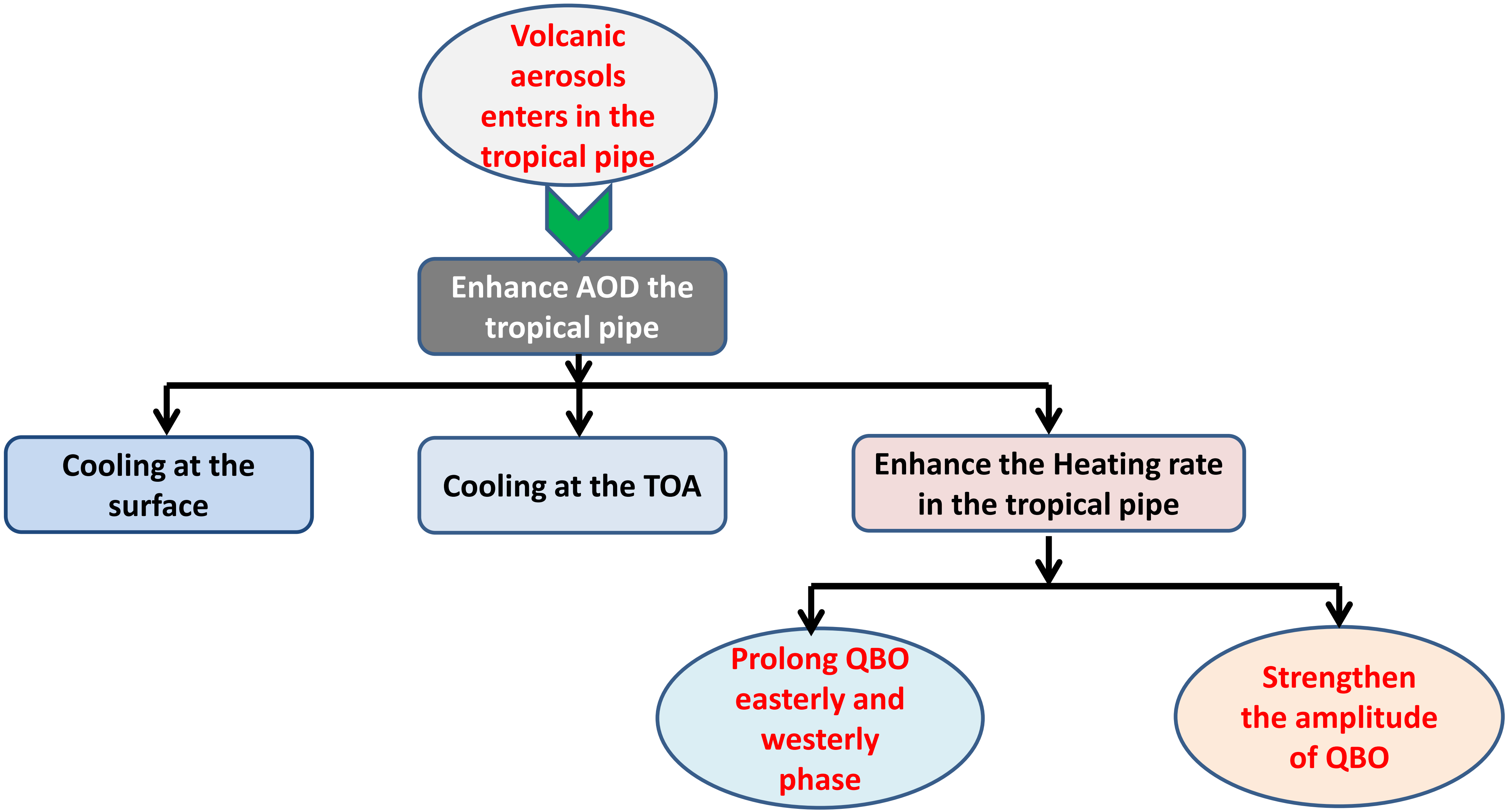


Figure : (a) Latitude pressure cross section of amplitude of U wind QBO (m s^{-1}) averaged over 0-360° for period 2001-2013 form BASE simulation, (b) same as (a) but for BASE-VAL0.

- The BASE simulation shows a double-peak maximum near the equator at 10hPa, and 50hPa.
- Figure b (BASE-VAL0) indicates a notable strengthening in the QBO amplitude near the equator at 10hPa and 50hPa.
- This strengthening of the QBO amplitude could be attributed to volcanic sulphate aerosols into the tropical pipe, leading to heating in the tropical stratosphere.

Conclusion



Volcanic aerosols enters in the tropical pipe
Enhance AOD the tropical pipe
Cooling at the surface
Cooling at the TOA
Enhance the Heating rate in the tropical pipe
Prolong QBO easterly and westerly phase
Strengthen the amplitude of QBO

Thank You

email id: prashant.chavan@tropmet.res.in