Imperial College London

MODELLING OF PERIODIC SALT FINGERS

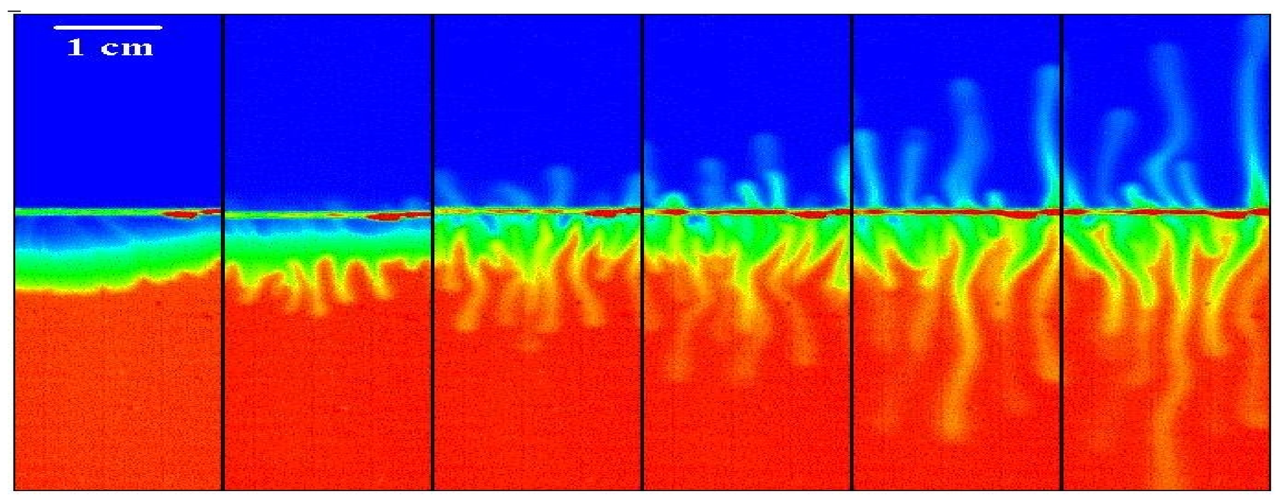
M. Joana Andrade and Daniel R. Moore

Department of Mathematics, South Kensington Campus, Imperial College London.

WHAT ARE SALT FINGERS?

Salt fingering is a mixing process that occurs when warm salty water overlies cold fresh water, with tall narrow convection cells or sheets growing from the interface between two homogeneously mixed layers of sea water.

FIGURE 1

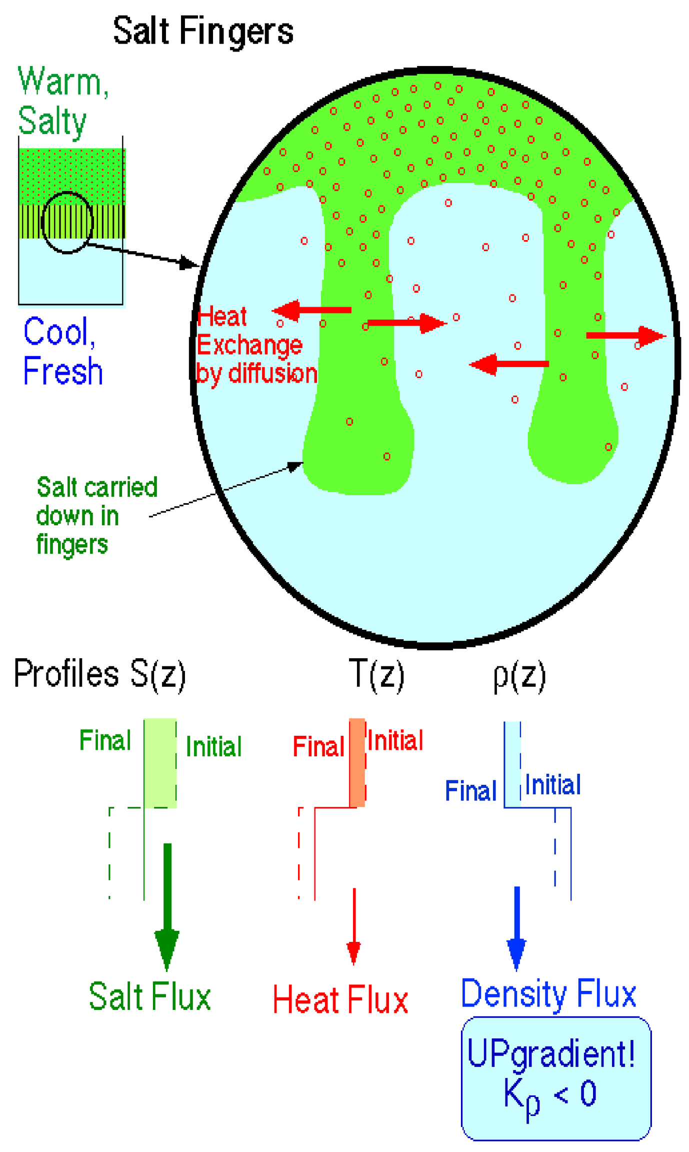


WHY IS SALT FINGERING AN IMPORTANT MIXING PROCESS?

- Salt fingers cause rapid vertical mixing in a stably stratified fluid
- Mixing by salt fingers is much more effective than turbulent mixing
- Its presence increases the vertical flux of heat any dissolved substances in a fluid (salt, iron, oxygen, plankton, etc...)

THE PHYSICS OF SALT FINGERING

FIGURE 2



Salt fingers are an example of double-diffusive convection. The salt makes the water "heavy on top" in the saline stratification, but the overall stratification is kept gravitationally stable by the "warm on top" temperature. Heat diffuses about 100 times faster than salt which allows for the release of the potential energy contained in the unstable saline stratification.

A downward moving finger of warm saline water cools off via molecular diffusion of heat, and therefore becomes more dense. This provides the downward buoyancy force that drives the finger. Similarly, an upward-moving finger gains heat from the surrounding fingers, becomes lighter, and rises.

Many laboratorial experiments and field observations in a wide variety of contexts suggest that fingering occurs in a fluid even when $\tau = K_S/K_T$, the ratio of the diffusivities of the slow diffusing destabilizing agent S and the fast diffusing stabilizing agent T, is much bigger than 0.01, with the fingers being able to release the potential energy contained in the S stratification to grow in size and maintain vertical T and S fluxes.

However the qualitative aspects and durations of the fingers' life cycles, as well as the rate of transport and mixing, can be startling different, even if the initial potential energy in the S stratification is kept constant.

Finger height as a function of τ for fixed T

τ	0.01	0.1	0.32	0.5	0.8
height	317.66	26.90	4.93	1.35	No finger

heights normalized using L, the width of the τ=0.01 finger

Finger height as a function of τ for fixed S

τ	0.01	0.1	0.32	0.5	0.8
height	317.66	28.06	6.13	2.42	0.18

heights normalized using L, the width of the τ=0.01 finger

Maximum of RMS of velocity as a function of τ for fixed T

τ	0.01	0.1	0.32	0.5	0.8
VRMS max	15.85	7.13	2.66	1.04	No finger

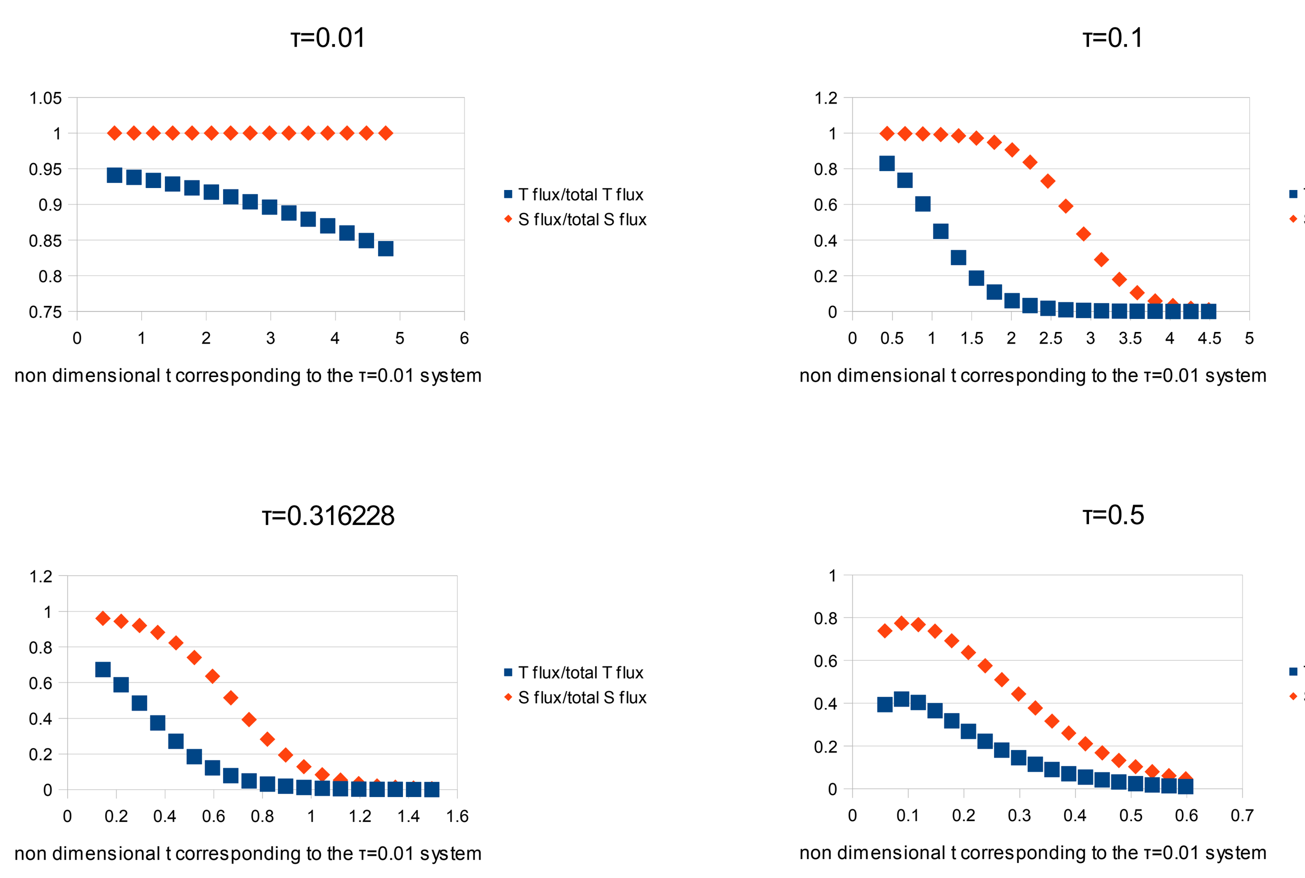
VRMS expressed in non dimensional units corresponding to the τ=0.01 system

Maximum of RMS of velocity as a function of τ for fixed S

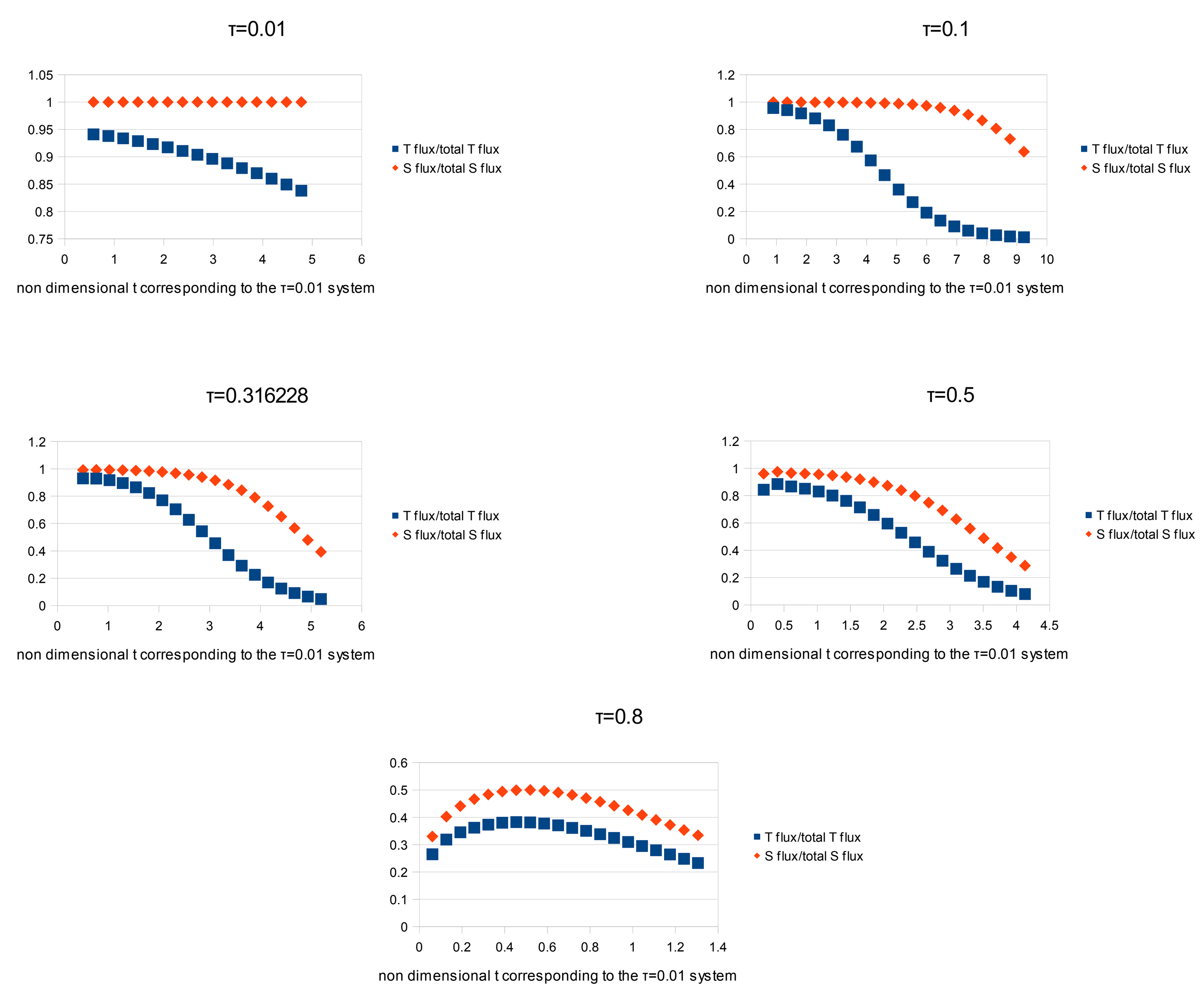
τ	0.01	0.1	0.32	0.5	0.8
VRMS max	15.85	1.73	0.32	0.11	0.01

VRMS expressed in non dimensional units corresponding to the τ=0.01 system

Fixed T



Fixed S



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AKNOWLEDGMENTS:

Figure 1 is taken from the website of the Sandia National Laboratories, USA

Figure 2 is taken from the website of the Department of Oceanography of Dalhousie University, Halifax, Canada