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Interactive comment on "Extending Square Conservation to Arbitrarily Structured C-grids with Shallow Water Equations" *by* Lilong Zhou et al.

Anonymous Referee #2

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General comments

This manuscript proposed a square conservation scheme for improving the TRiSK shallow water dynamic core on quasi-uniform grids. This scheme includes an anti-symmetrical spatial discrete operator and a temporal integral scheme with exact quadratic conservation in matematics. The improved dynamic core with the new scheme conserves three physical integrals including the total energy, total mass and total vorticity, and reduces the simulation errors in numerical tests comparing with the original dynamic core.

The method to implement the anti-symmetry of the spatial discrete operator of the improved dynamic core is unique and economical, which cleverly uses a simple combination of the original spatial discrete operator based on the IAP transformation. The

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temporal integration applies the improved Runger-Kutta scheme with exact quadratic conservation proposed by Wang et al (1996), and thus keeps the energy conservation law in physics that is equal to the square conservation in mathematics. As I know, the manuscript presents one of the earliest works of implementing the total energy conservation of a shallow water dynamic core on quasi-uniform grids in the way of quadratic conservation in mathematics, which is quite different from the available and similar works that use the energy equation to replace the continuity equation.

However, the presentation of the manuscript needs improvements because of some incorrect mathematic equalities and improper expressions in the text.

Specific comments

1) The necessity to conserve the resolved energy in numerical solutions to an energy conservation system is actually the same as that to conserve the resolved mass. To highlight the significance of constructing an energy conservation scheme for the TRiSK dynamic core, a clear explanation on the necessity should be provided in Section 1. 2) Line 19/Page 2: CRK is improperly used as the abbreviation of “a new class of Runger-Kutta scheme”, because the word “class” does not describe the main characteristics of this scheme. NRK is better. 3) I wonder why the title of Section 2 is exactly the same as that of Section 1 (Lin 22/Page 3). 4) The equality (3) (Line 4/Page 4) is not true, which missed the integration sign after the second equal mark. 5) The semi-discrete form of the shallow water equation set [Equations (4)-(5) on Lines 4-5/Page 5] should no longer be a partial differential equation set, but an ordinary differential equation set. 6) Line 6/Page 5: u and v are not the variables of Eqs.(4)-(5). 7) Line 20/Page 7: The equality is not true, because a negative sign is missed before(âĎŠðİŚ■, ðİŚ■).

Minor comments

8) Line 10/Page 1: “The square conservation theory is widely used on latitude-longitude grids” –> ”The square conservation law is maintained in the dynamic cores on latitude-longitude grids”. 9) Line 4/Page 2: “which is” –> “which are”. 10) Line 26/Page 2: “polar

problem" –> "polar instability" or "polar singularity".

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