Evaluating material models in TensorMechanics, re: finite strain, and comparing to SolidMechanics, both in 2D and 3D

Problem setup:
Mesh: generated mesh, 1x1 in 2D (1x1x1 in 3D)
Coordinate system: xy(z)
AuxVariables: strain_yy, stress_yy (TM = RankTwoAux; SM = MaterialTensorAux)
BCs: FunctionPresetBC, disp_y = -0.2*t on top, sides (+ back/front) constrained
Time: end_t = 4.0

in SM: Material = Elastic, NonlinearPlaneStrain

in TM: Material = ComputeIsotropicElasticityTensor, ComputePlaneStrain (ComputeFiniteStrain in 3D), ConputeFiniteStrainElasticStress

Theory:

The disp_y at the end of four seconds should be -0.8. This is correct in all four simulations. Based on this displacement, the final strain_yy should be:

strain_yy	'= ln(1+disp_y)	-1.6094379124

Results:

– Requires small time step: default **dt = 1.0**, strain_yy (and therefore stress_yy) results very incorrect:

	TM, 2D	**TM, 3D**	**SM, 2D**	**SM, 3D**
Material	CPFS	CFS	Elastic	Elastic
	CIET	CIET	--	--
	CFSES	CFSES	--	--
Formulation	--	--	NLPS	NLPS
disp_y	-0.8	-0.8	-0.8	-0.8
strain_yy	0.0758222415	0.0758222415	-1.3495648341	-1.3495648341
stress_yy	1.02E+05	1.02E+05	-1.82E+06	-1.82E+06
E	1.00E+06	1.00E+06	1.00E+06	1.00E+06
poisson	0.3	0.3	0.3	0.3
stress / strain	1.35E+06	1.35E+06	1.35E+06	1.35E+06

Where material definitions are:

CPFS	ComputePlaneFiniteStrain
CFS	ComputeFiniteStrain
CIET	ComputeIsotropicElasticityTensor
CFSES	ComputeFiniteStrainElasticStress
NLPS	NonlinearPlaneStrain

– With small time step, strain results are correct (**dt = 0.01**):

	TM, 2D	**TM, 3D**	**SM, 2D**	**SM, 3D**
Material	CPFS	CFS	Elastic	Elastic
	CIET	CIET	--	--
	CFSES	CFSES	--	--
Formulation	--	--	NLPS	NLPS
disp_y	-0.8	-0.8	-0.8	-0.8
strain_yy	-1.6093732473	-1.6093732473	-1.6093745699	-1.6093745699
stress_yy	-2.17E+06	-2.17E+06	-2.17E+06	-2.17E+06
E	1.00E+06	1.00E+06	1.00E+06	1.00E+06
poisson	0.3	0.3	0.3	0.3
stress / strain	1.35E+06	1.35E+06	1.35E+06	1.35E+06

These strain values are very close to the expected value based on theory (-1.6094379124341).

Conclusions:

– Model is accurate for strain with small time step (dt=0.1), in both SM and TM.
– Model is very inaccurate for strain with larger time step (dt=1.0), in both SM and TM.
– To resolve time step issue, model used to evaluate strain would need to be changed (currently Rashid, 1993).
– Using dt=0.1 also yields relatively accurate results (-1.6023377300219 for strain_yy in 2D TM).