Long-term variability of shortwave absorption under abrupt-4xCO_2 climate forcing and its visible and near-IR contributions

Maria Z. Hakuba[1,2], Alejandro Bodas-Salcedo[3], Graeme Stephens[2]

[1]Colorado State University

[2]Jet Propulsion Laboratory

[3]Hadley Centre, Met Office

Libera

Understanding Earth's Energy Budget

LASP • JPL • LBL • UA • CSU • UM • NIST • NOAA • Ball • SDL

Libera (Li'be-ra), named for the daughter of Ceres in ancient Roman mythology

EVC-1 selected mission led by LASP in Boulder (PI: Peter Pilewskie)
In collaboration with Ball, NIST; science: JPL, LBL, UA, UM, CSU, NOAA

Overarching goals

1) Provides seamless continuity of the Clouds and the Earth's Radiant Energy System (CERES) Earth radiation budget (ERB).

- Measures integrated **shortwave** (0.3–5 μm), **longwave** (5–50 μm), **total** (0.3–>100 μm) and (new) **split-shortwave** (0.7–5 μm) radiance over **24 km** nadir footprint.

2) Advances the development of a self-contained, innovative & affordable observing system

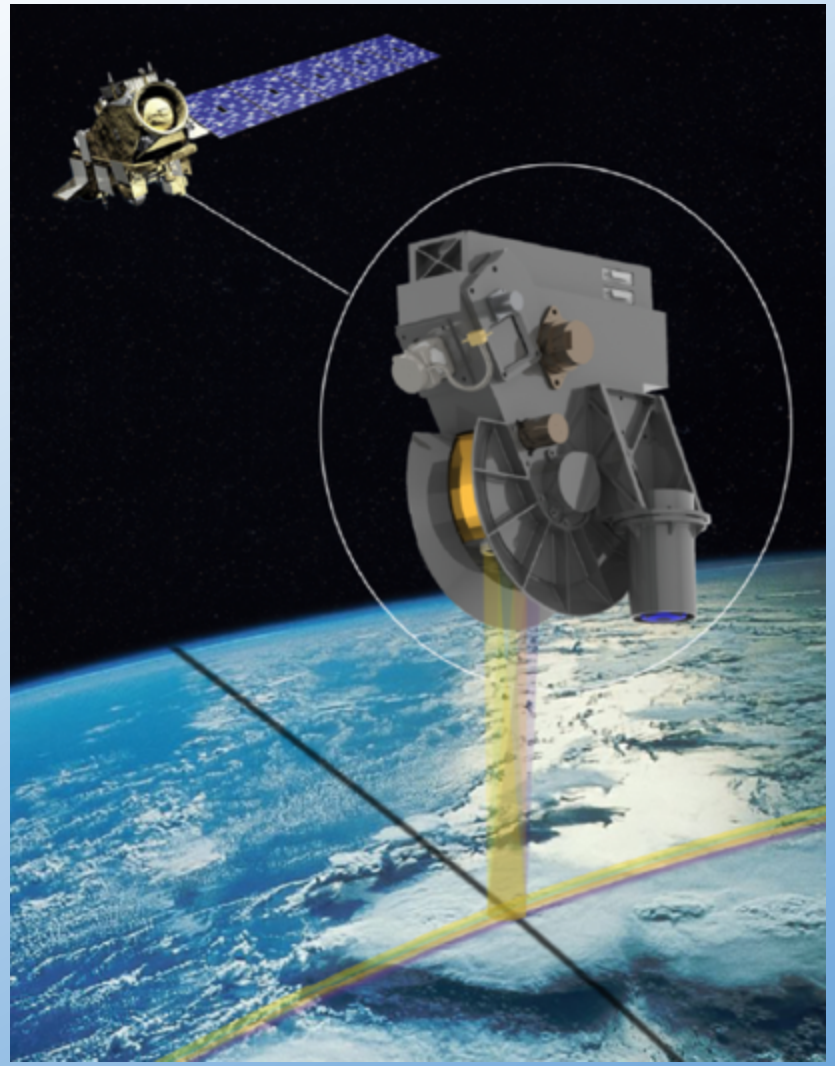
- Includes a WFOV camera for scene ID & simple ADM generation to pave way for future free-flyer ERB observing system.

3) Provides new and enhanced capabilities that support extending radiation budget science goals

- Employs Split-Shortwave channel to quantify energy deposition

Flight: JPSS-3, 2027 launch; 5-year mission

- Follows pattern of CERES hosted on JPSS-1.

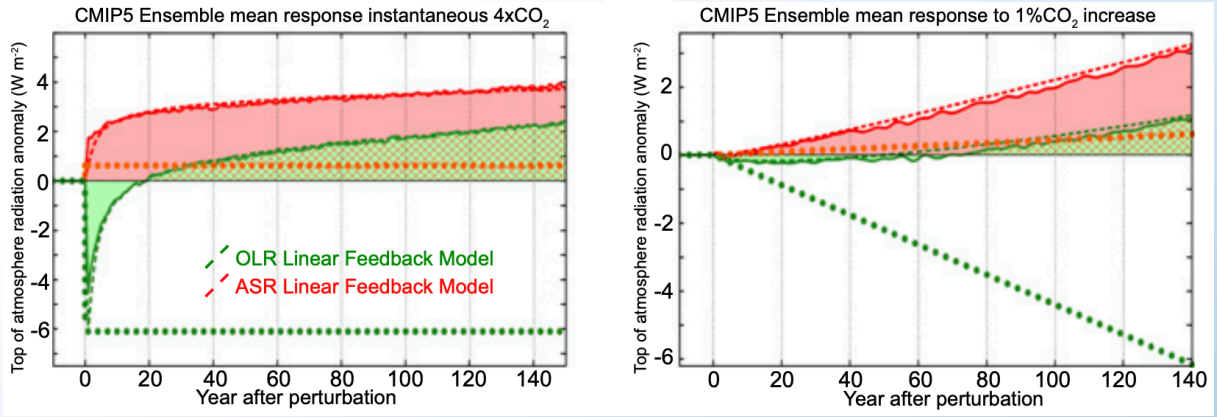


Libera Science Objective 3

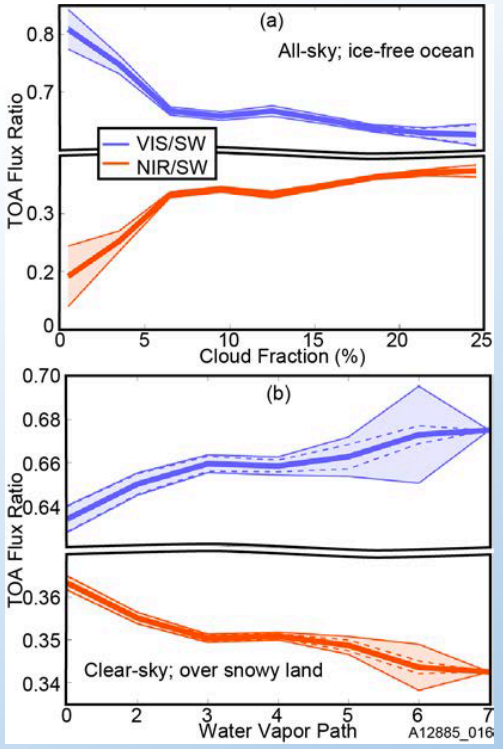
MOTIVATIONS for Science Objective 3:

Revolutionize our understanding of spatio-temporal variations in SW, VIS & NIR fluxes

Characterize NIR & VIS signatures of processes that control absorption of solar radiation, SW climate feedbacks, and the hemispheric symmetry of planetary albedo.



Motivation 1) CMIP5 Ensemble mean response to instantaneous 4xCO_2 (left) and to 1%CO_2 increase (right): SW absorption sustains global warming on centennial time scales; positive SW climate feedbacks are set into motion by OLR decrease in response to forcing (Donohoe et al., 2014). Separation into NIR and VIS will help to better understand process contributions.

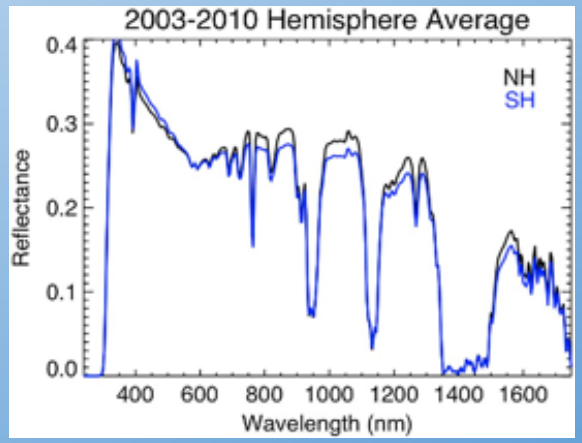


3) Example processes controlling 1) & 2)

a) The effect of changing cloud fraction over oceans preferentially enhances NIR reflected flux compared to VIS, while total SW (VIS+NIR) flux increases.

b) The effect of changing water vapor path above snow covered land conversely decreases NIR and increases VIS reflected flux, while total SW flux decreases. (OSSE simulations)

2) Planetary albedo is symmetric across hemispheres, but NIR & VIS contributions differ. What are the processes controlling this stabilization? Hypothesis: SH clouds vs. NH land. (Stephens et al., 2015)

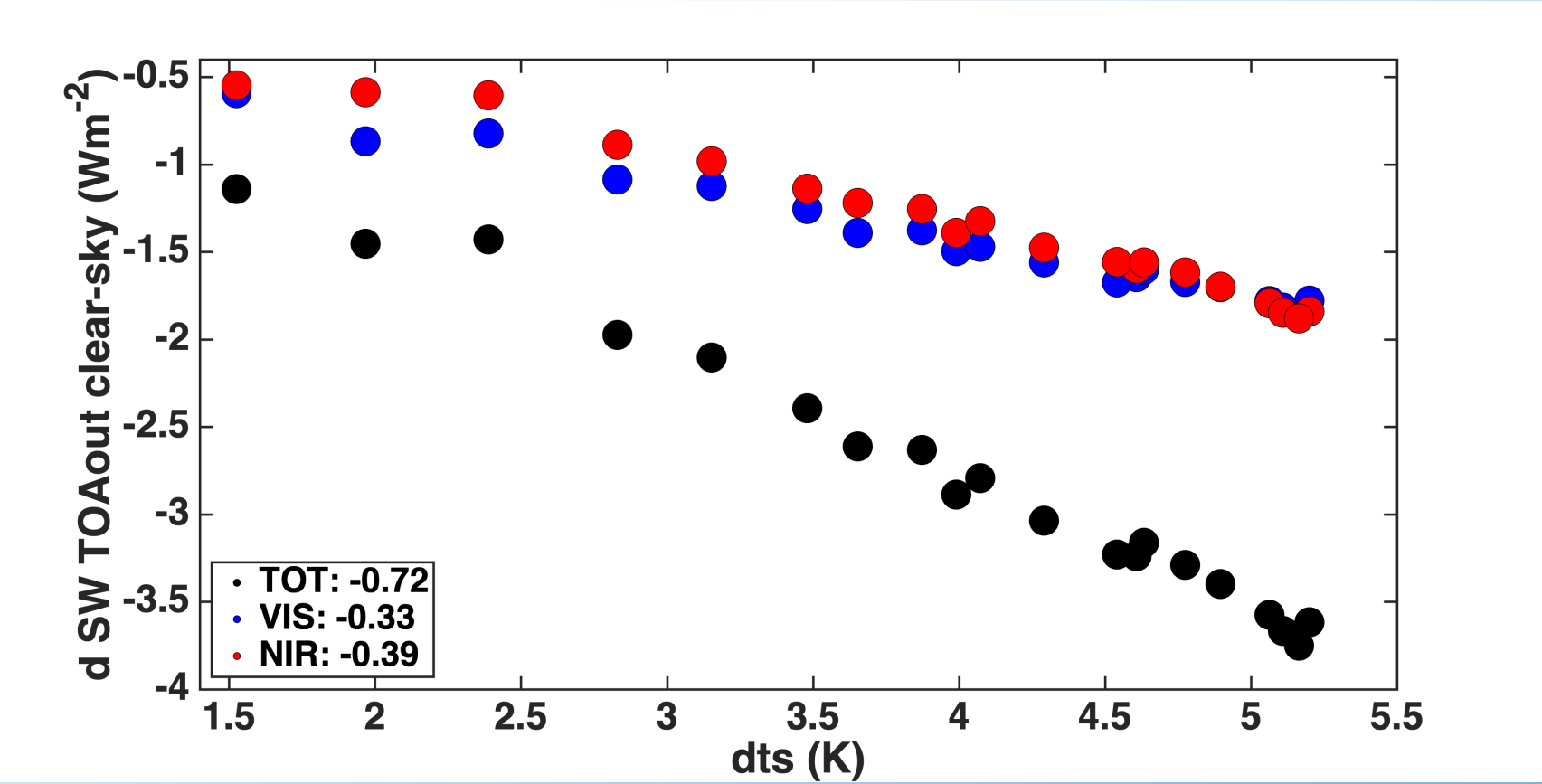


UKESM1 simulations

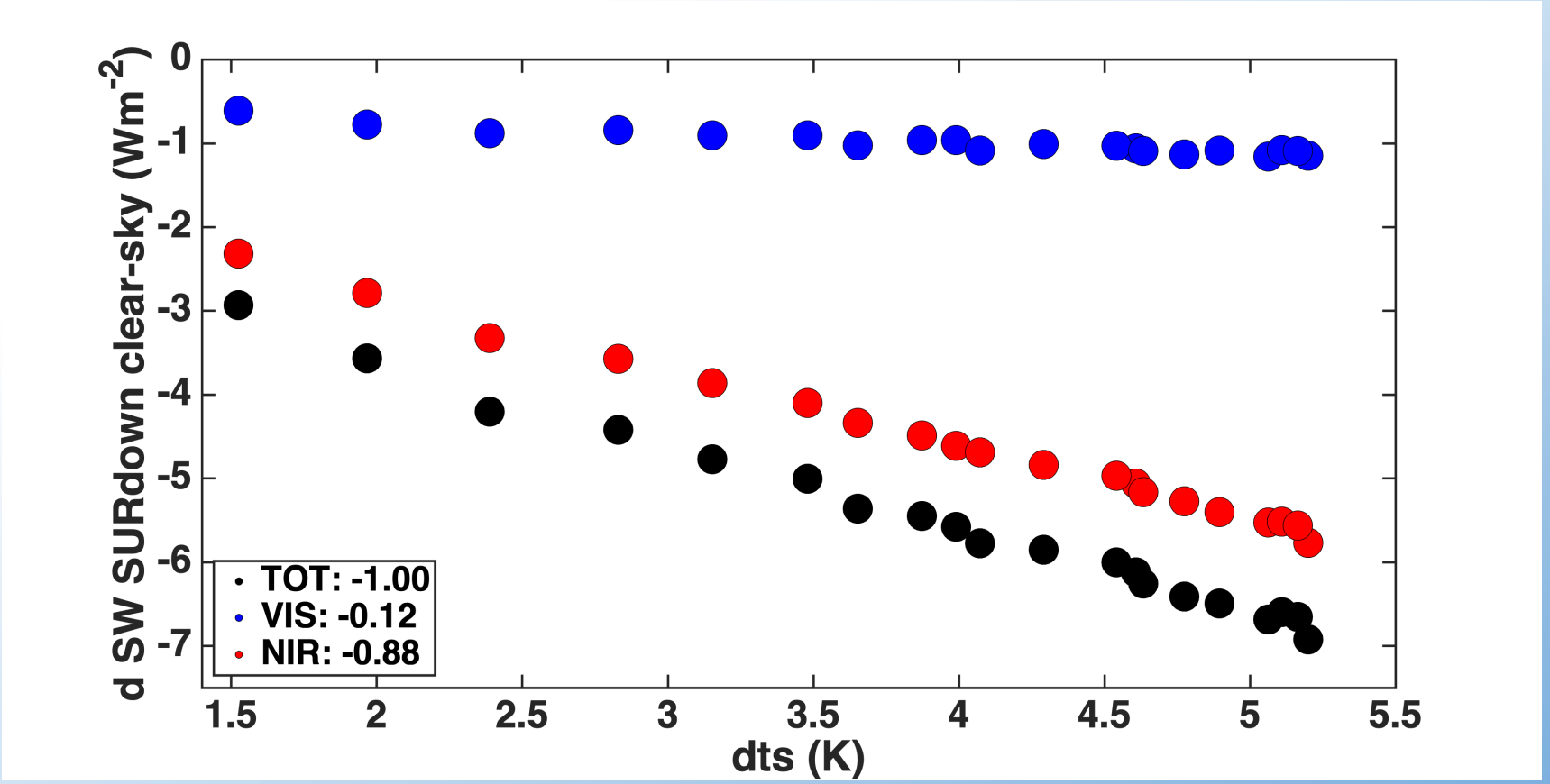
- 20 years abrupt4xCO_2 and PI control
- Output includes 6 bands in the SW, split at 700nm
- “Gregory plot” for global mean shortwave (SW), near-IR (NIR), and visible (VIS) radiation flux as function of change in global annual mean surface temperature. We show annual means of the abrupt-4xCO_2 simulation minus the climatological mean of the piControl (preindustrial forcings).

- Note: **Very** preliminary analysis

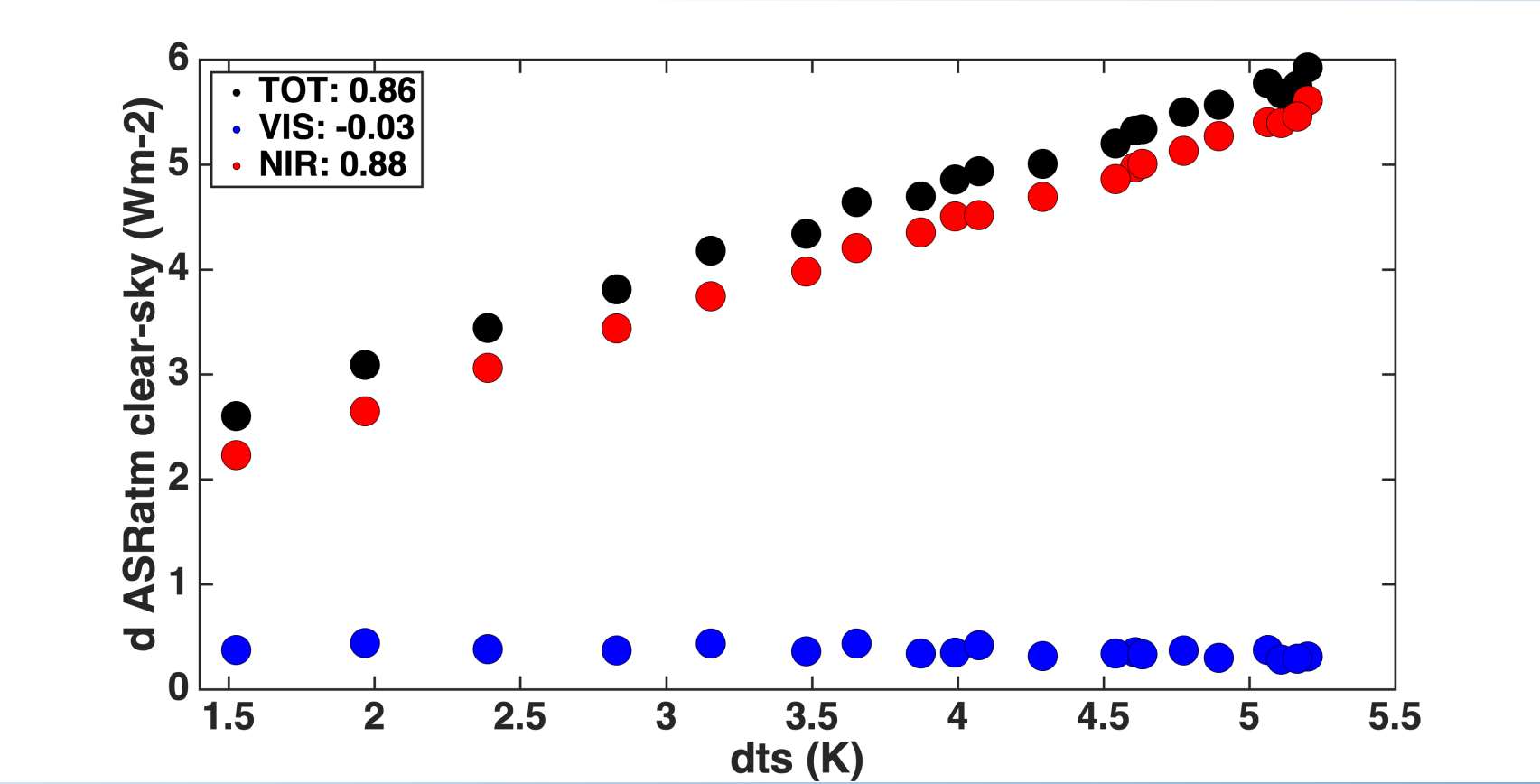
TOA reflection in the clear-sky decreases with increasing temperature: more absorption in the climate system almost equally in the NIR and VIS



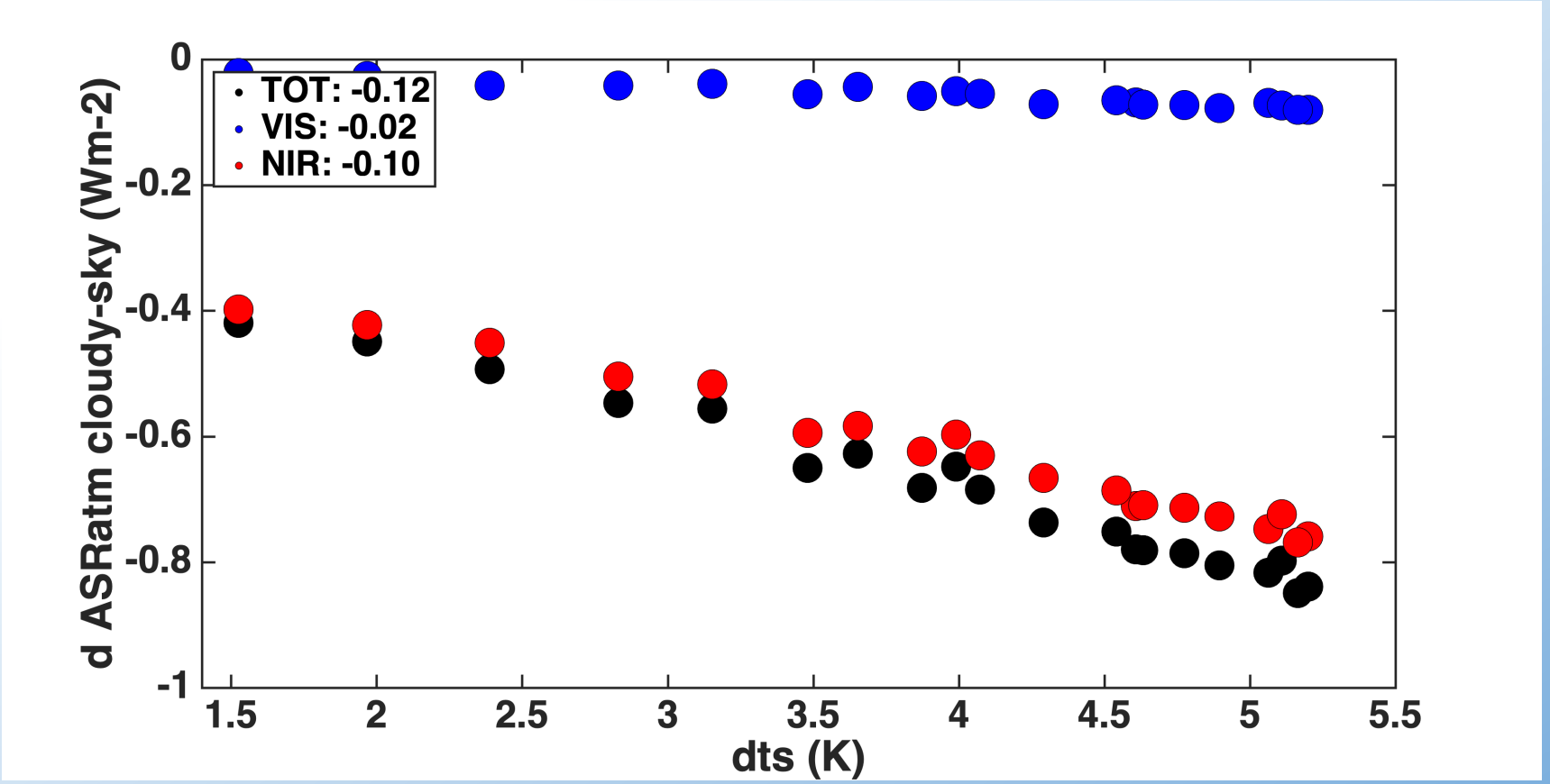
Surface downward SW radiation in the clear-sky decreases with increasing temperature although more absorption by the total Earth-atmosphere system. Reduction is dominated by the NIR contribution.



Atmospheric absorption of SW radiation increases in the clear-sky with increasing temperature: this increase is dominated by the NIR contribution, likely associated with enhanced water vapor absorption.



Atmospheric absorption of SW radiation decreases slightly under cloudy conditions (CRE), slightly competing with the clear-sky effects, and also mostly in the NIR.



Take home & Outlook

- Very preliminary and limited analysis indicates water vapor effects may significantly affect the SW radiation budget in the NIR yielding enhanced SW absorption by the climate system while reducing the surface flux.
- Waiting for centennial runs to assess long-term variations against OLR changes
- Study processes affecting VIS and NIR related to water vapor, albedo, cloud changes in the model world
- Hemispheric analysis to better understand nature of hemispheric symmetry in albedo (problem: models do not exhibit this symmetry)
- Ask more modeling centers to output SW NIR and VIS to do more robust assessment
- These model data will also serve for more probing evaluation against new *Libera* NIR & VIS data expected in 2017 and onwards.