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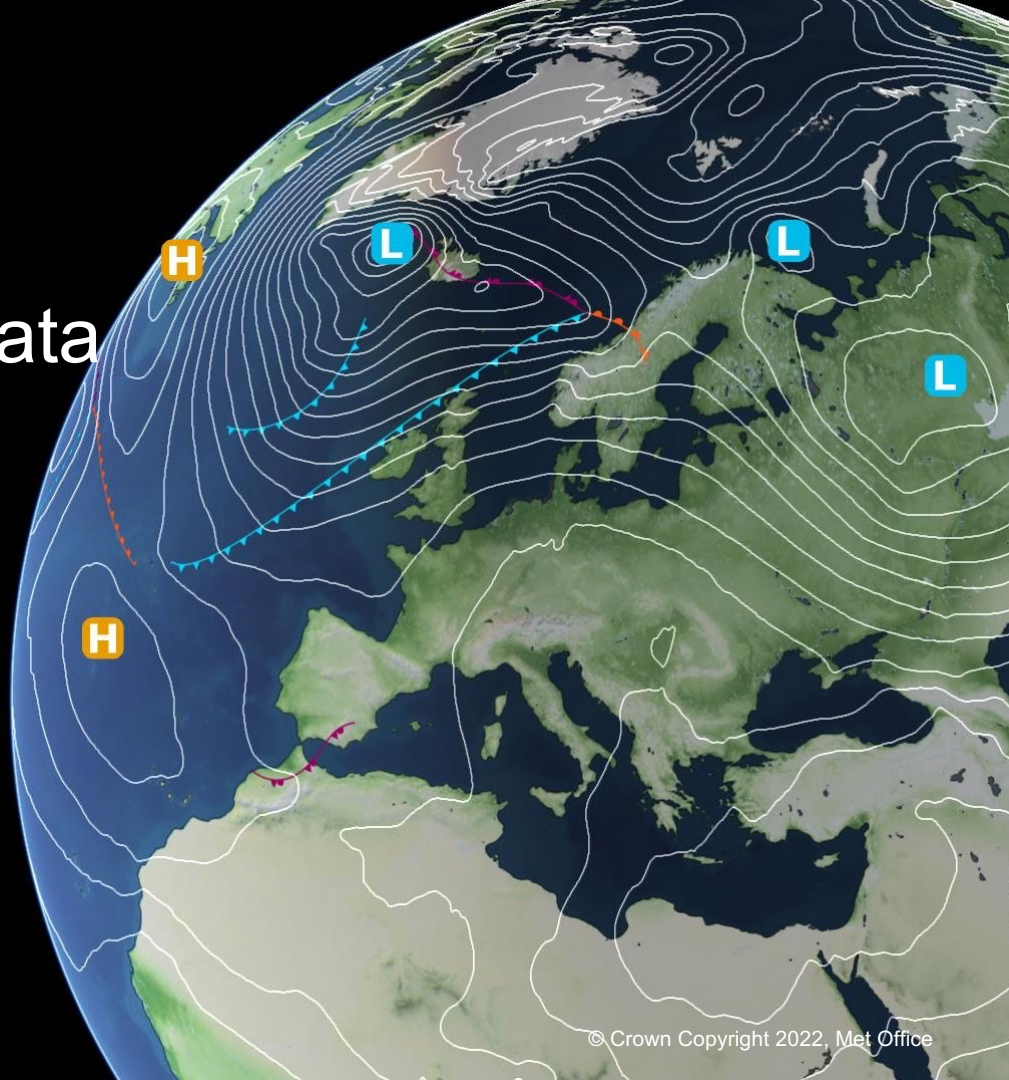
Regional implied heat transport from CERES data

Francesca Pearce and Alejandro Bodas-Salcedo



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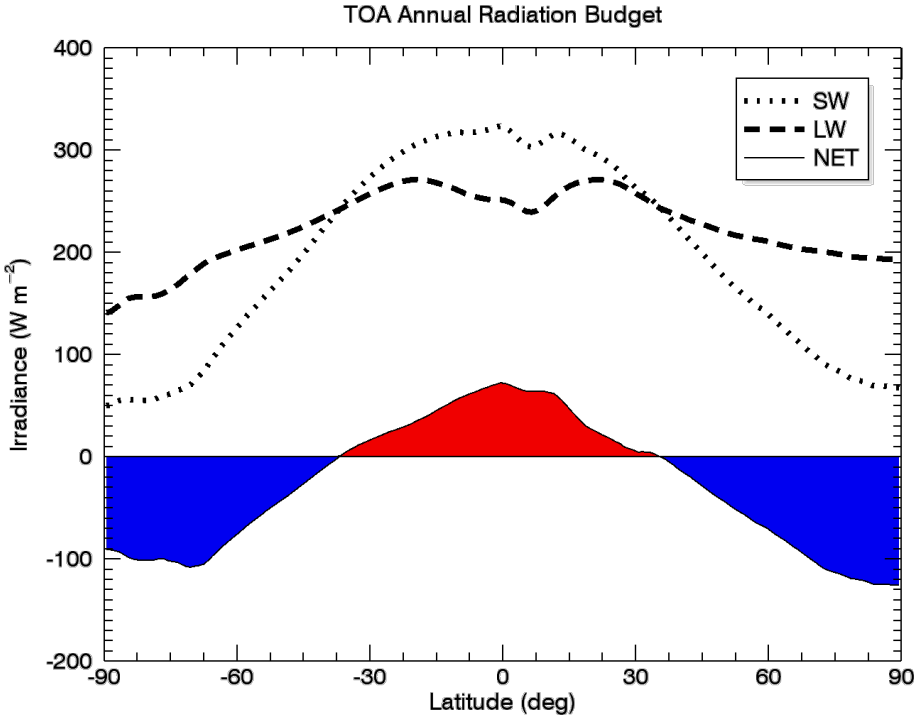
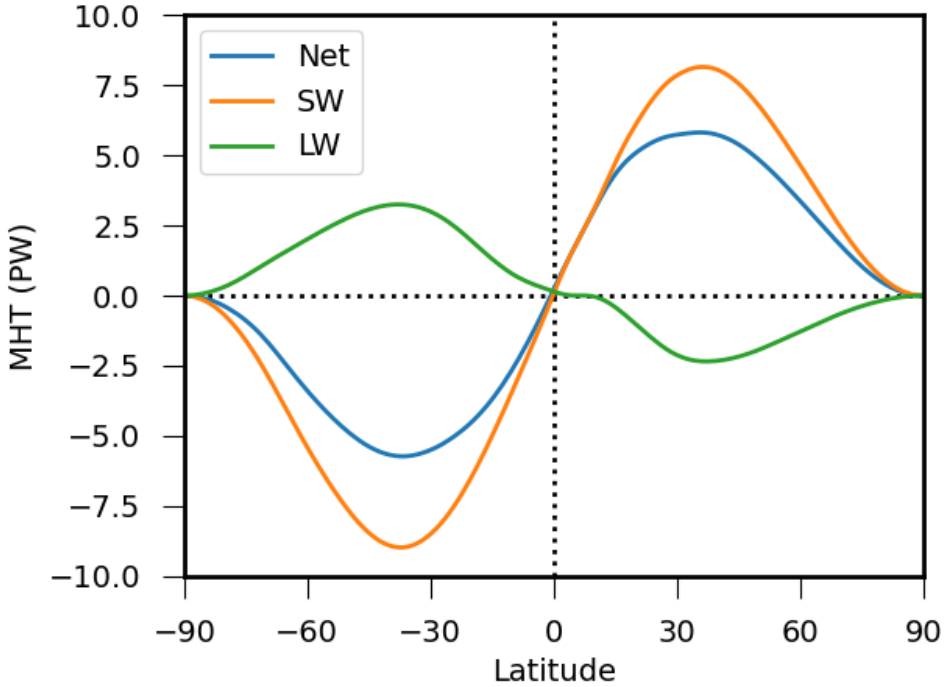
ERB and divergent transport



$$T_a(\theta) + T_o(\theta) = \int_{-\pi/2}^{\theta} 2\pi R^2 \cos\theta F_t \, d\theta$$



(after Vonder Haar and Suomi, 1971)

Local IHT from TOA radiation

- **CERES EBAF Ed4.1**
- **20-year annual climatology**

$$F_{\mathrm{TOA}} = \nabla \cdot \mathbf{T} + \frac{\mathrm{d(OHC)}}{\mathrm{d}t}$$

$$\mathbf{T} = \mathbf{T}_{\mathrm{rot}} + \mathbf{T}_{\mathrm{div}} = \nabla \times \mathbf{S} + \nabla P$$

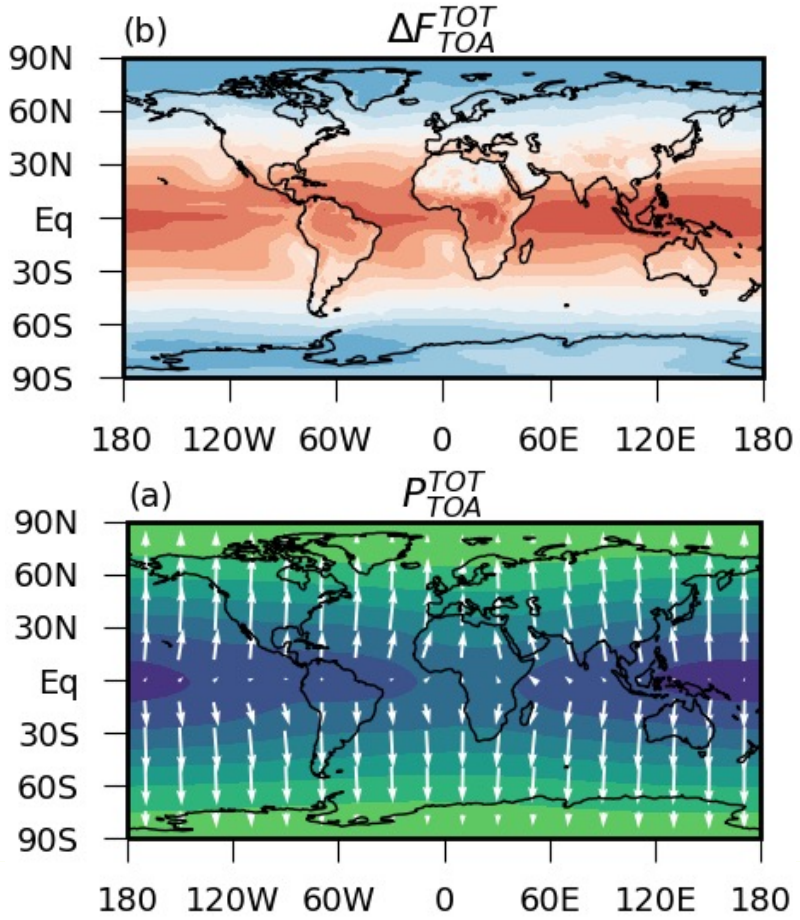
$$\nabla \cdot \mathbf{T} = \nabla \cdot \mathbf{T}_{\mathrm{div}} = \nabla^2 P$$

$$\nabla^2 P = F_{\mathrm{TOA}} - \frac{\mathrm{d(OHC)}}{\mathrm{d}t}$$

$$\nabla^2 P = F_{\mathrm{TOA}} - \langle F_{\mathrm{TOA}} \rangle$$

$$\mathbf{T}_{\mathrm{div}} = \nabla P$$

(Boer, 1986;
Trenberth and Solomon, 1994;
Boos and Korty, 2016;
Forget and Ferreira, 2019)



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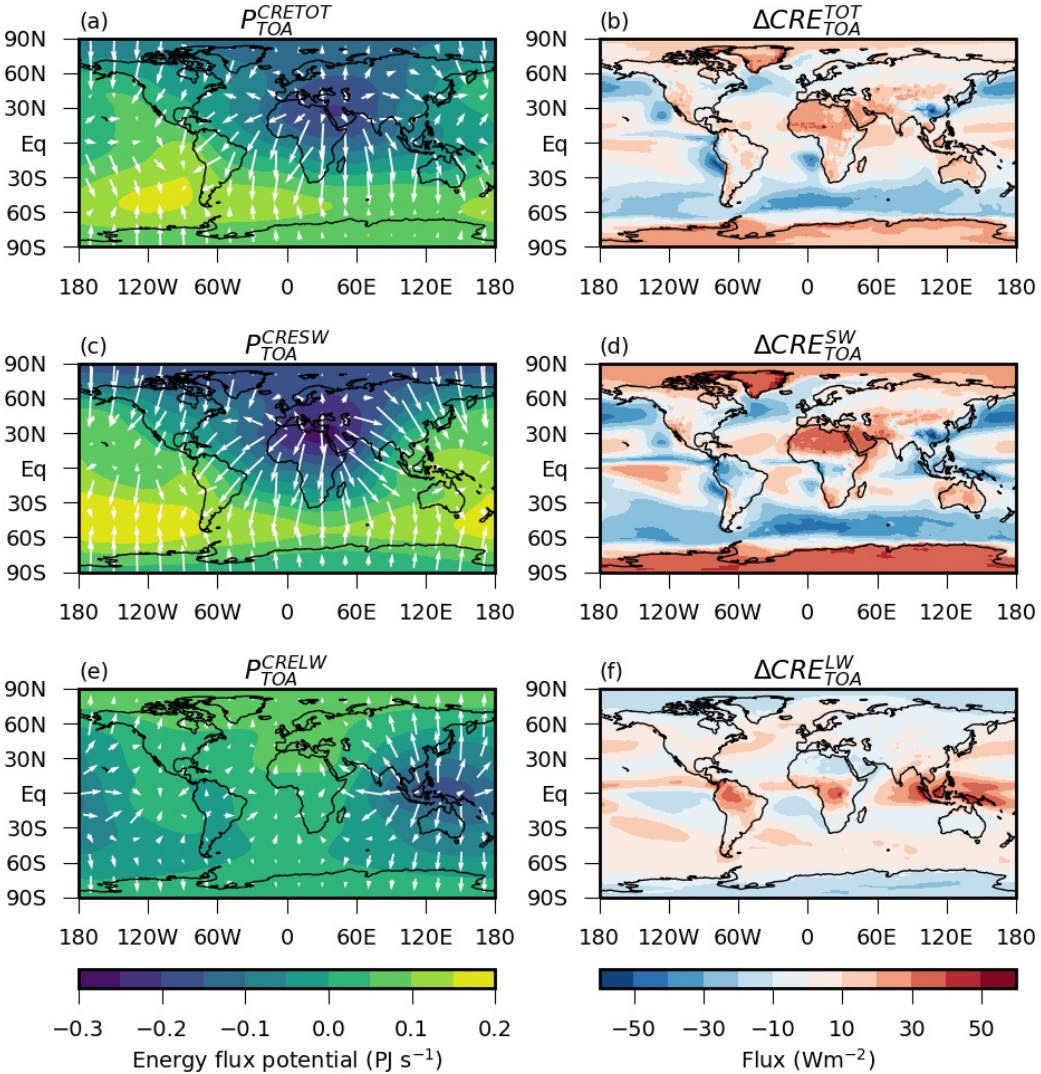

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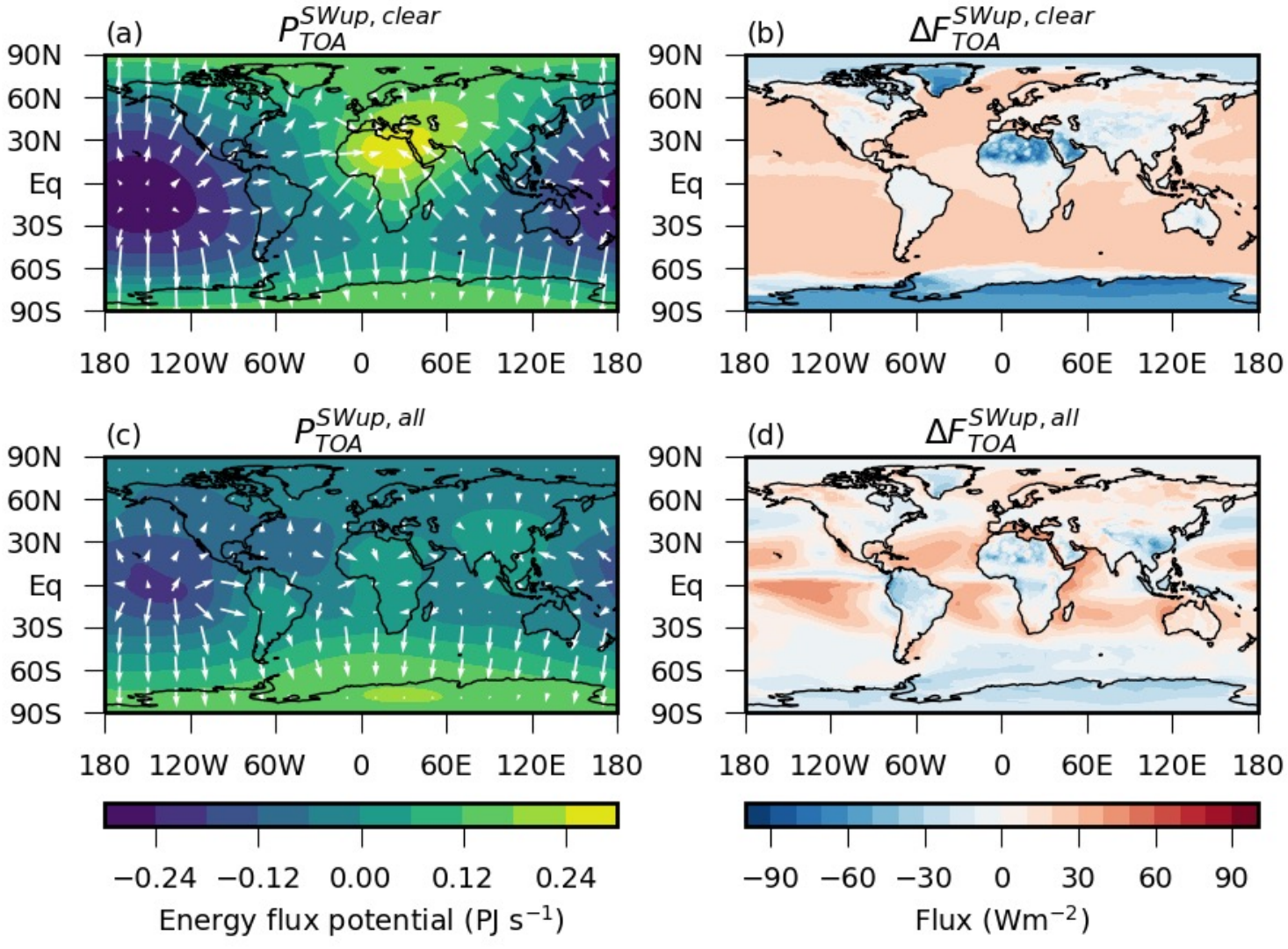
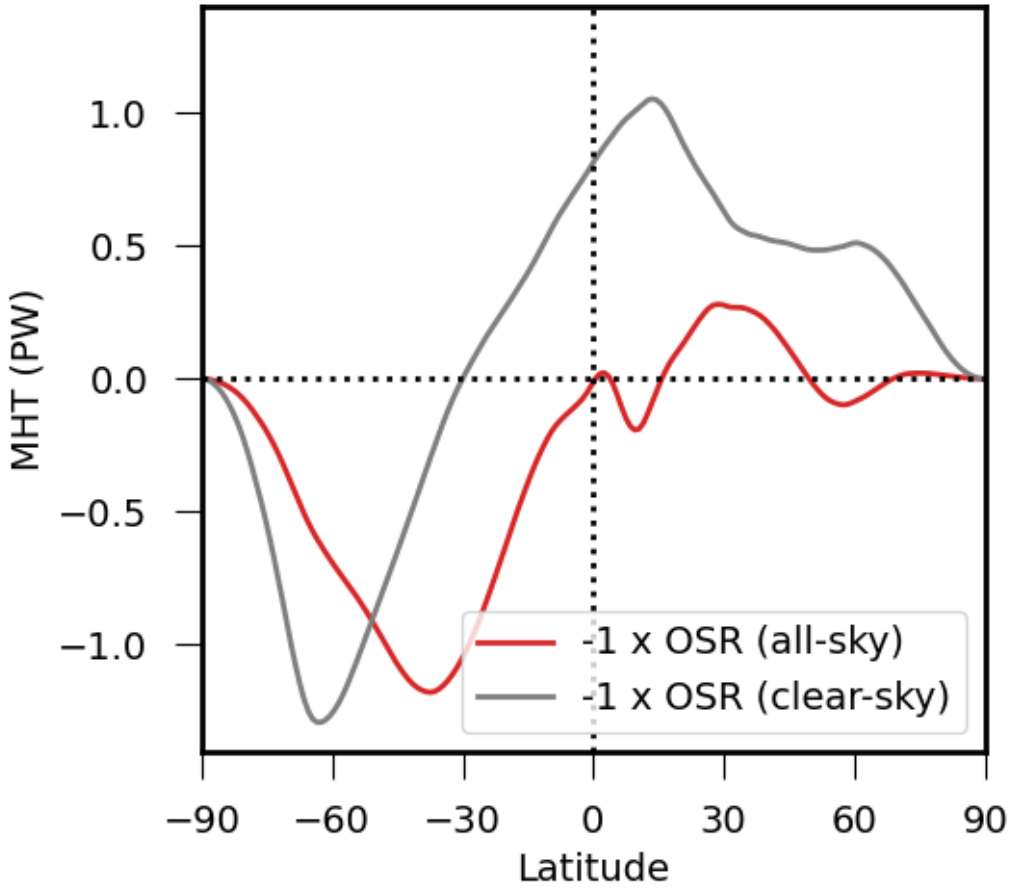


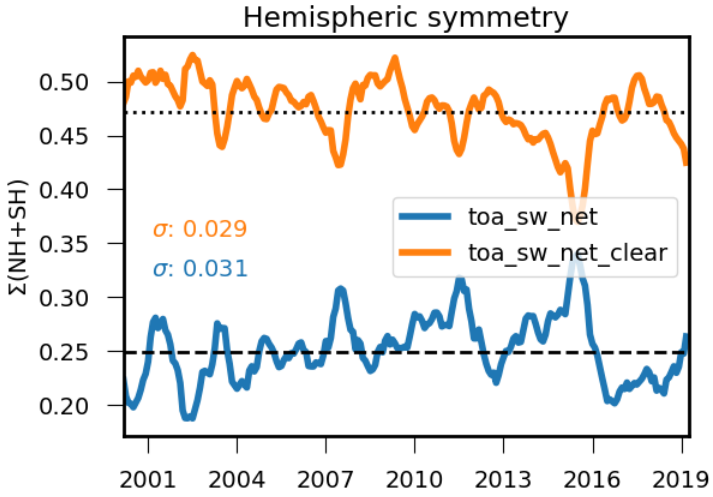
Symmetry: albedo and IHT

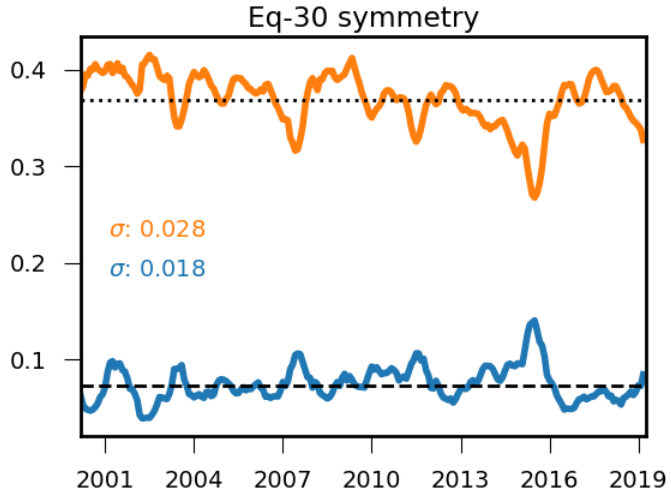
(Vonder Haar and Suomi, 1971;
Voigt et al., 2013, 2014;
Stephens et al., 2016;
Haywood et al., 2016;
Bender et al., 2017;
Datseris and Stevens, 2021)

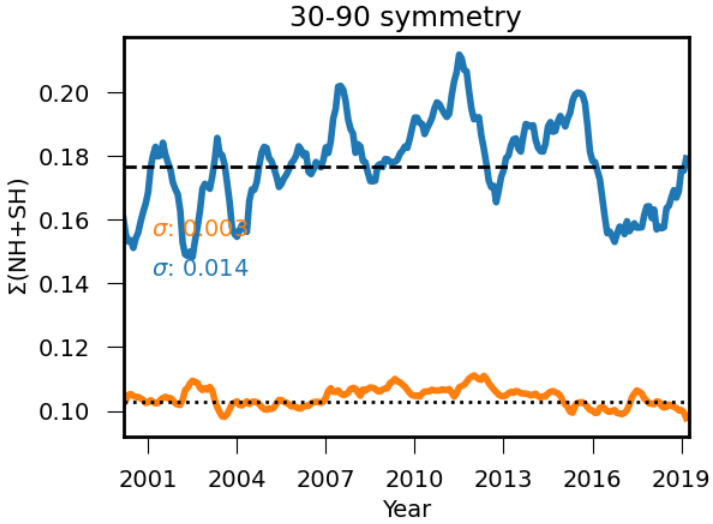
SW HT_{EQ} = 0.02 PW

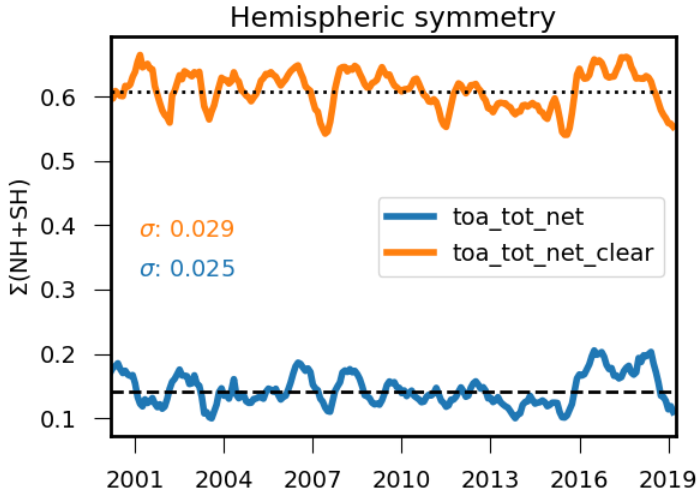
(Loeb et al., 2016)

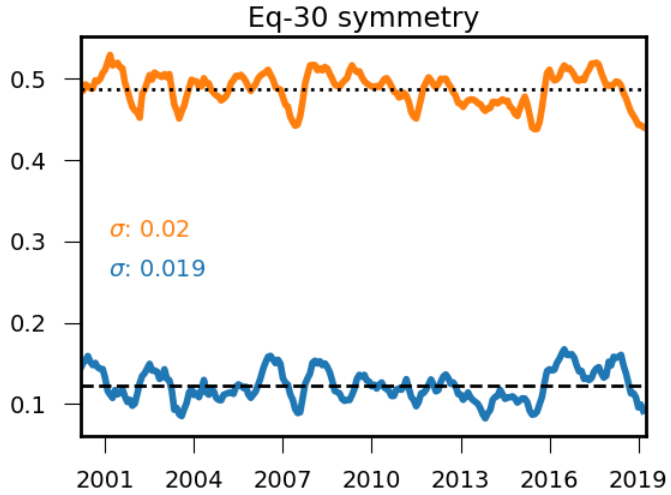


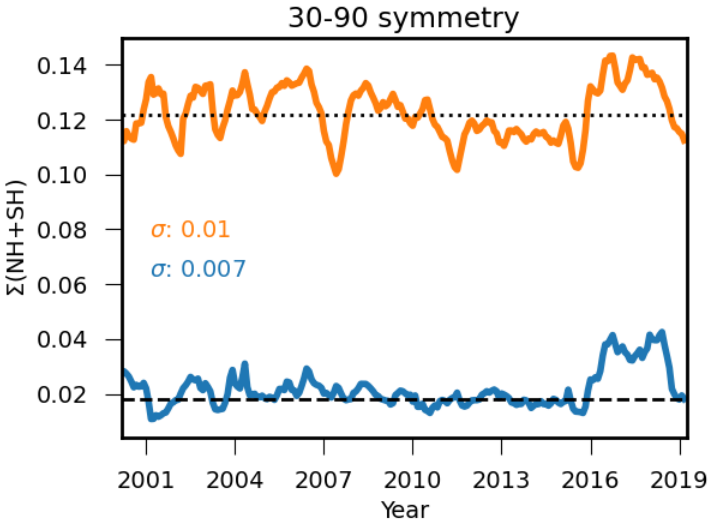

Hemispheric symmetry
Σ(NH+SH)
0.50
0.45
0.40
0.35
0.30
0.25
0.20
σ: 0.029
σ: 0.031
toa_sw_net
toa_sw_net_clear
2001
2004
2007
2010
2013
2016
2019


Eq-30 symmetry
0.4
0.3
0.2
0.1
σ: 0.028
σ: 0.018
2001
2004
2007
2010
2013
2016
2019


30-90 symmetry
Σ(NH+SH)
0.20
0.18
0.16
0.14
0.12
0.10
σ: 0.008
σ: 0.014
2001
2004
2007
2010
2013
2016
2019
Year


Hemispheric symmetry
Σ(NH+SH)
0.6
0.5
0.4
0.3
0.2
0.1
σ: 0.029
σ: 0.025
toa_tot_net
toa_tot_net_clear
2001
2004
2007
2010
2013
2016
2019


Eq-30 symmetry
0.5
0.4
0.3
0.2
0.1
σ: 0.02
σ: 0.019
2001
2004
2007
2010
2013
2016
2019


30-90 symmetry
Σ(NH+SH)
0.14
0.12
0.10
0.08
0.06
0.04
0.02
σ: 0.01
σ: 0.007
2001
2004
2007
2010
2013
2016
2019
Year

Conclusions

- Implied heat transport provides a complementary view to radiative fluxes that could be useful as diagnostic tool
- Direct effect of clouds: reduce horizontal transport with respect to clear-sky
- Hemispheric symmetry
  - SW: increase symmetry in tropics and decrease symmetry in extratropics
  - TOT: increase symmetry in poleward transport at all latitudes
- Framing symmetry in terms of transport provides a complementary view
- Future work
  - Split ATM/SFC using DEEP-C fluxes
  - Compare against models

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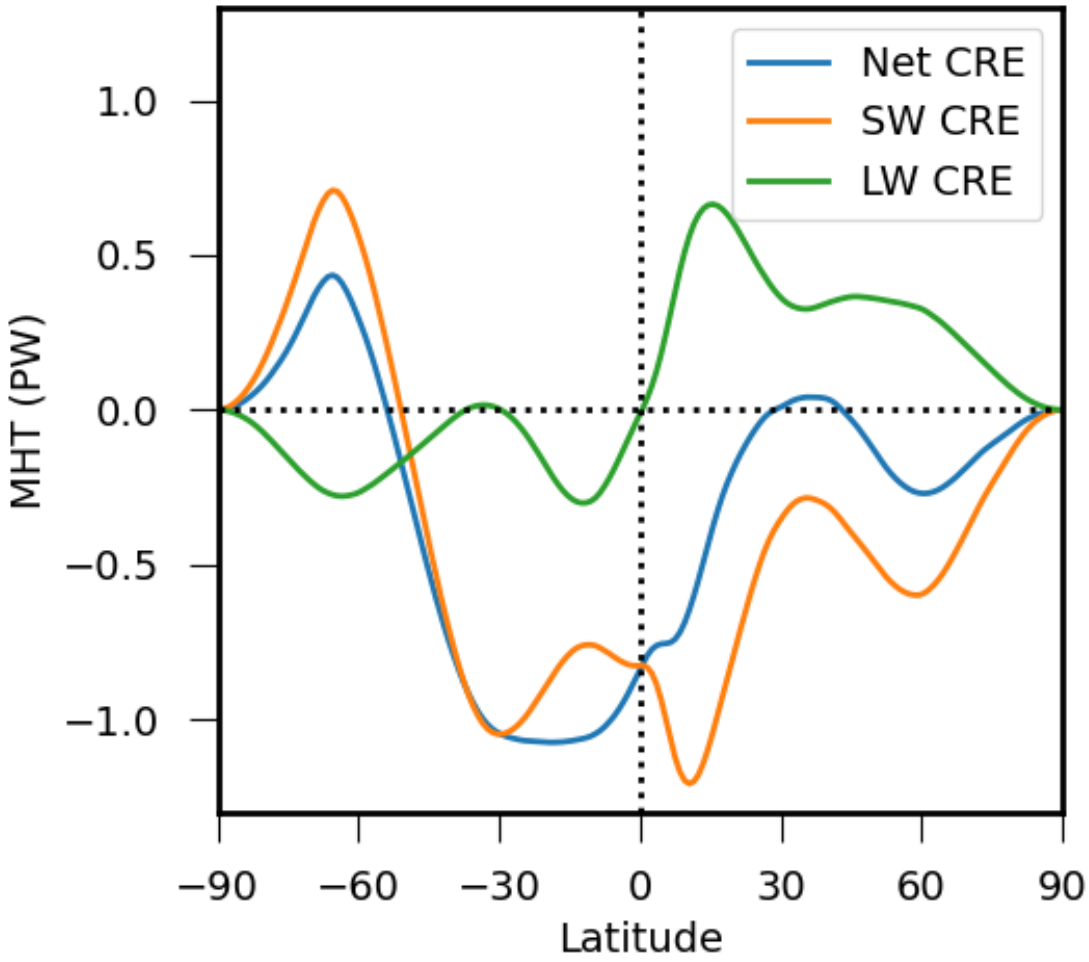

(Zhang and Rossow, 1997; Kato et al., 2008)