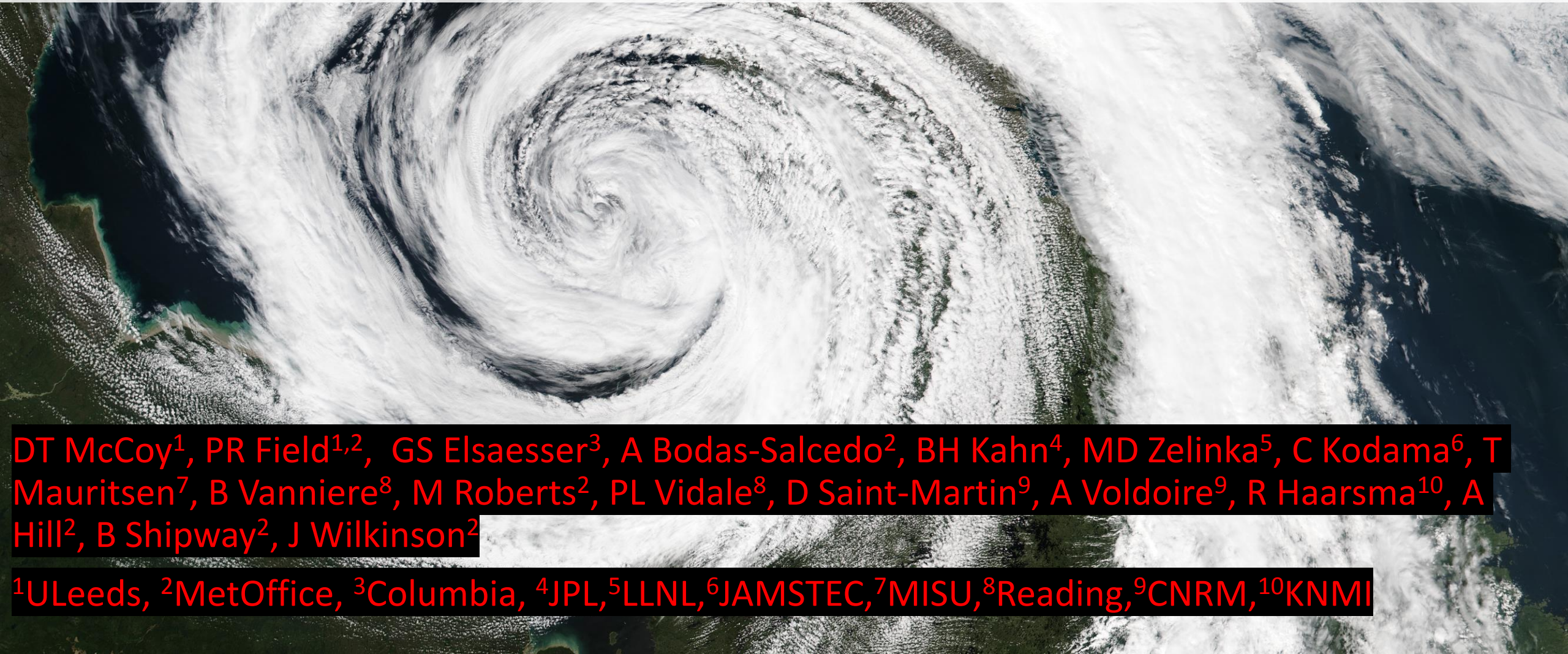
Extratropical cloud feedbacks across model resolutions

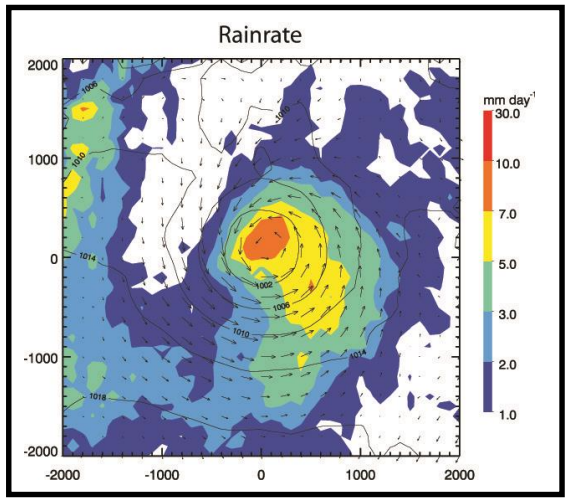


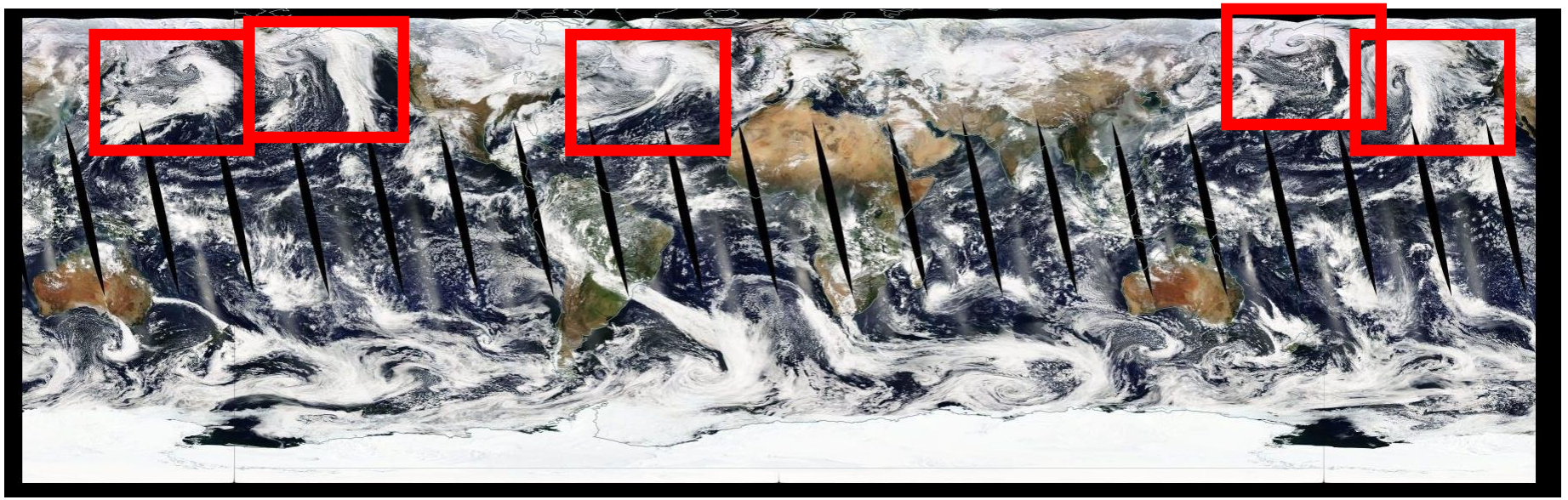
DT McCoy[1], PR Field[1,2], GS Elsaesser[3], A Bodas-Salcedo[2], BH Kahn[4], MD Zelinka[5], C Kodama[6], T Mauritsen[7], B Vanniere[8], M Roberts[2], PL Vidale[8], D Saint-Martin[9], A Voldoire[9], R Haarsma[10], A Hill[2], B Shipway[2], J Wilkinson[2]

[1]ULeeds, [2]MetOffice, [3]Columbia, [4]JPL,[5]LLNL,[6]JAMSTEC,[7]MISU,[8]Reading,[9]CNRM,[10]KNMI

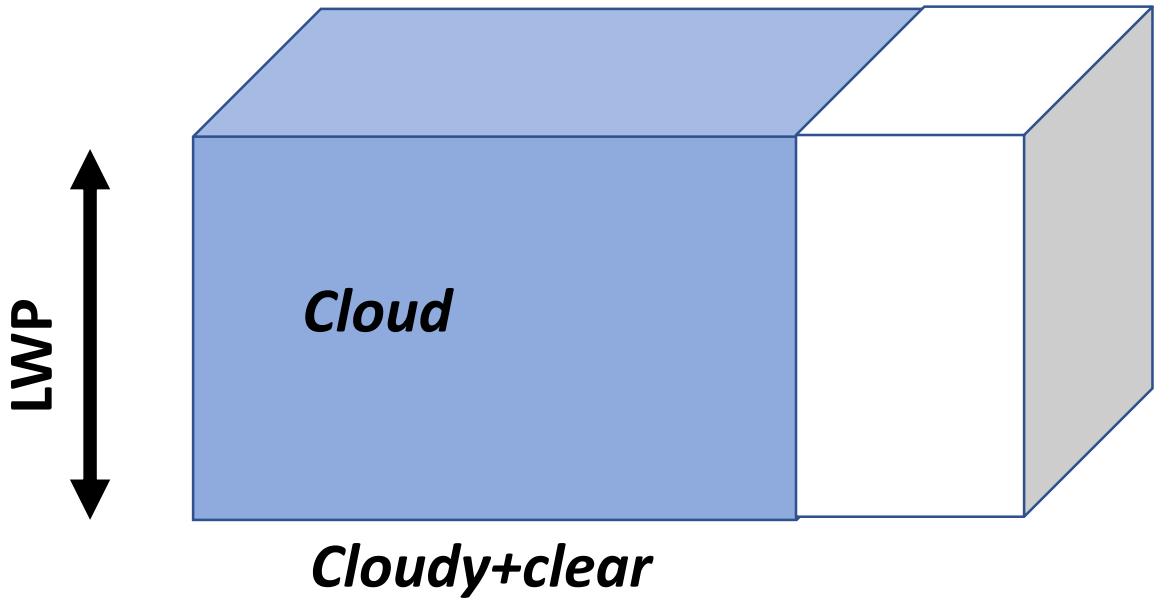
Mid-latitude cyclone compositing

Cyclone compositing algorithm from Field and Wood 2007 based on sea level pressure.





Some nomenclature

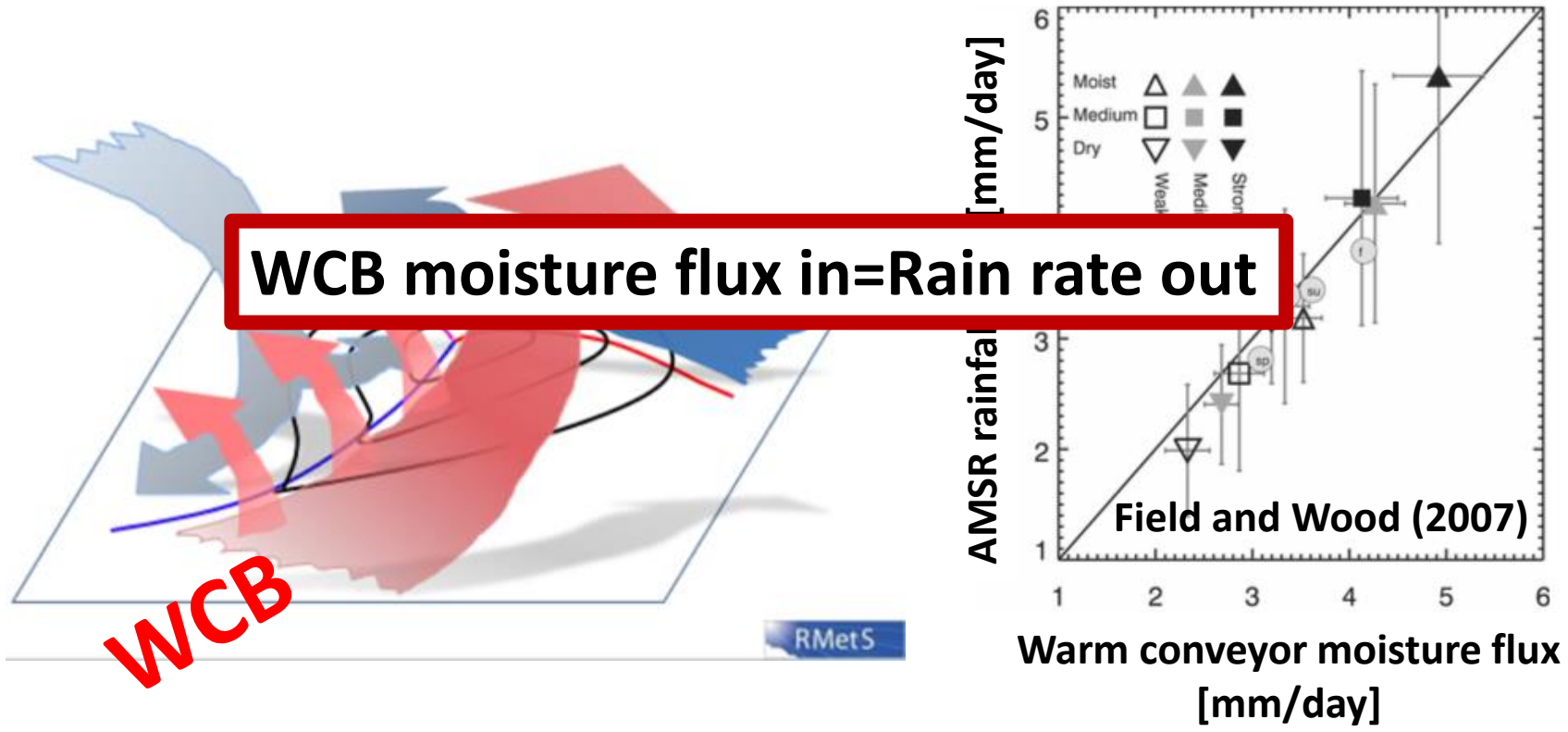


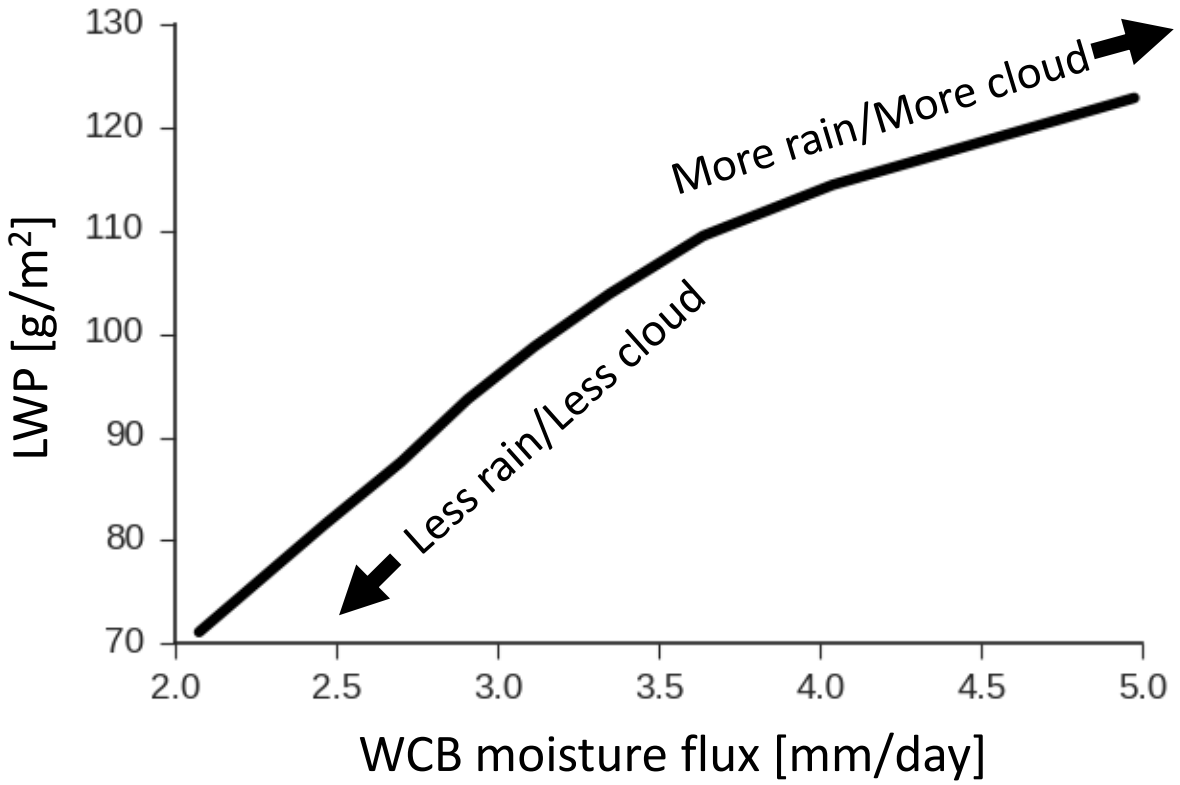
Stratify by meteorological set up

- Warm conveyor belt (WCB) moisture flux a good predictor of rain rate in observations where

$$\mathbf{WCB}_{flux} = \mathbf{WS}_{10m} \times \mathbf{WVP} \times \text{const}$$

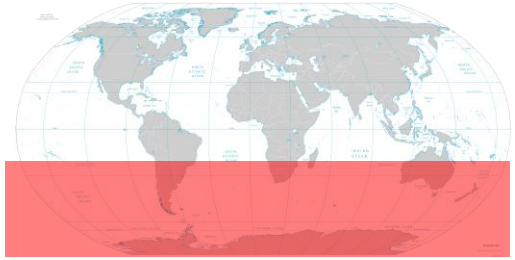
(quantities are cyclone-mean, e.g. within 2000km of cyclone center)



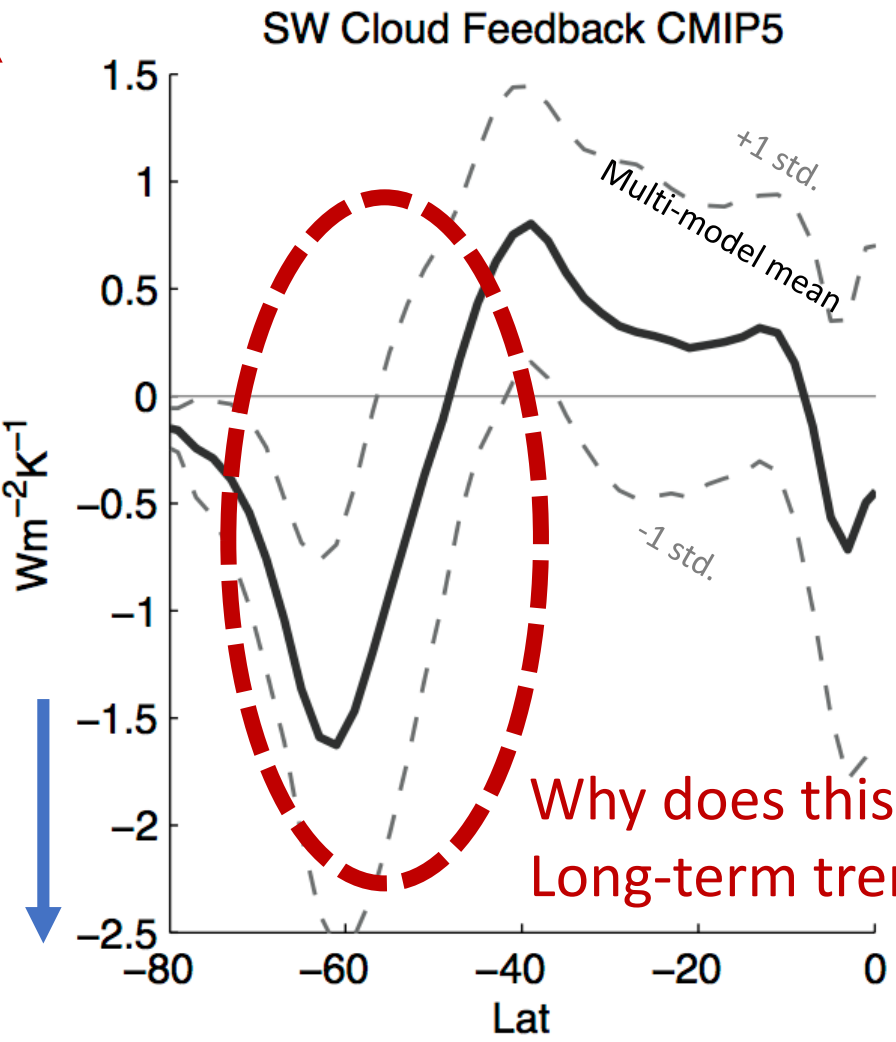

130
120
110
100
90
80
70
LWP [g/m²]
2.0
2.5
3.0
3.5
4.0
4.5
5.0
WCB moisture flux [mm/day]
More rain/More cloud
Less rain/Less cloud

Motivation: the shortwave cloud feedback dipole

Clouds reflect less with warming

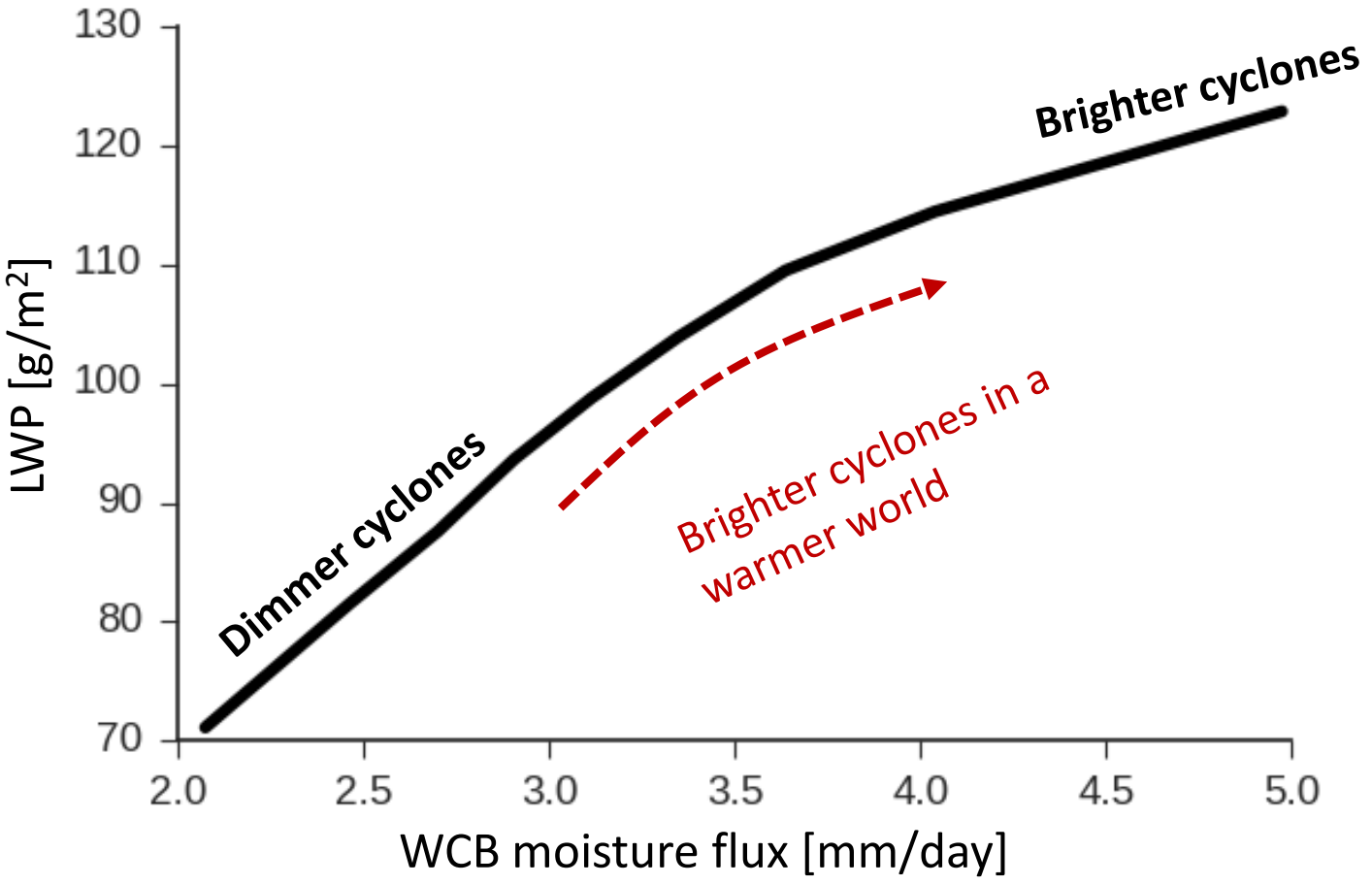


Clouds reflect more with warming



Why does this happen?

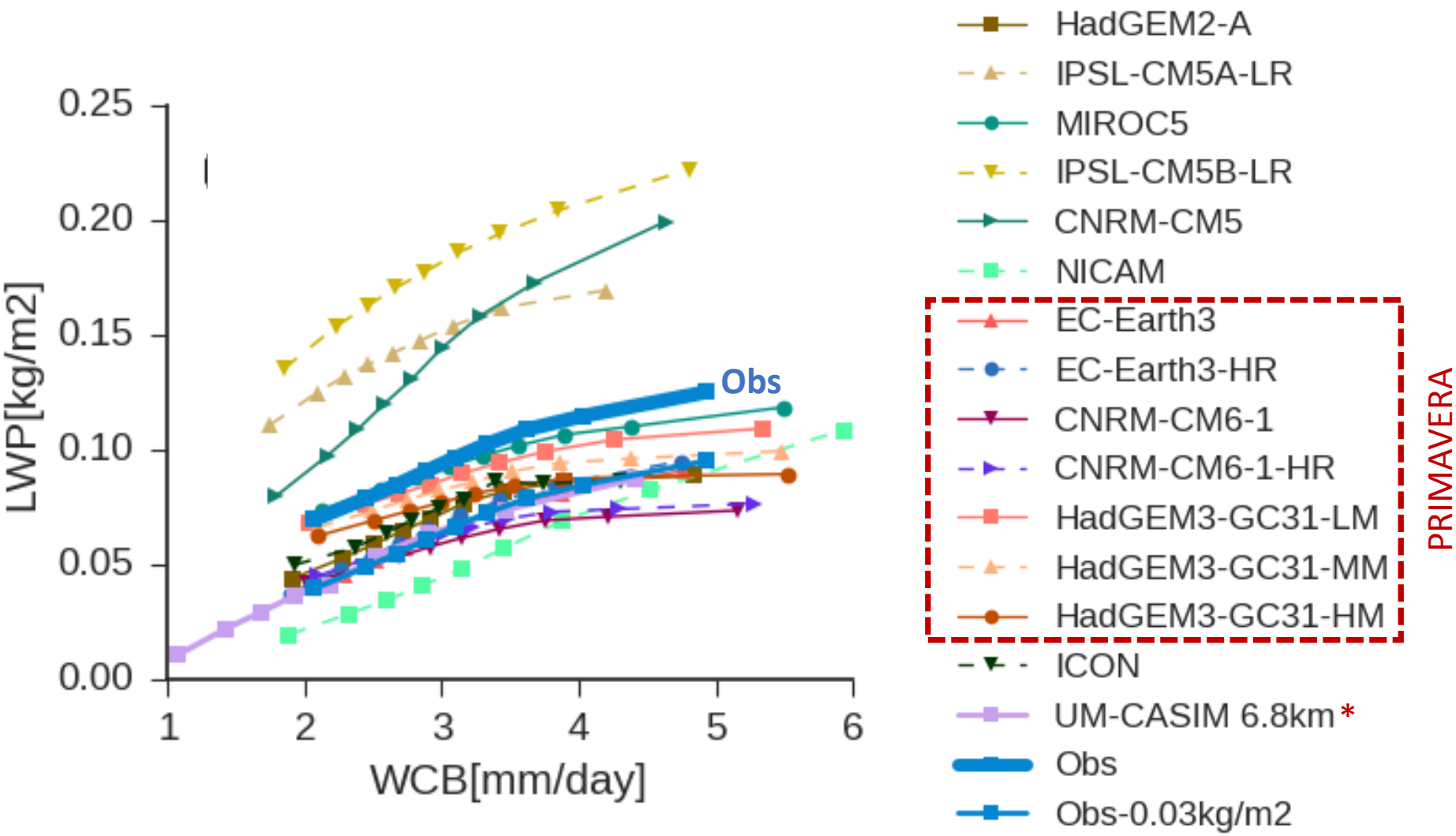
Long-term trends support this.



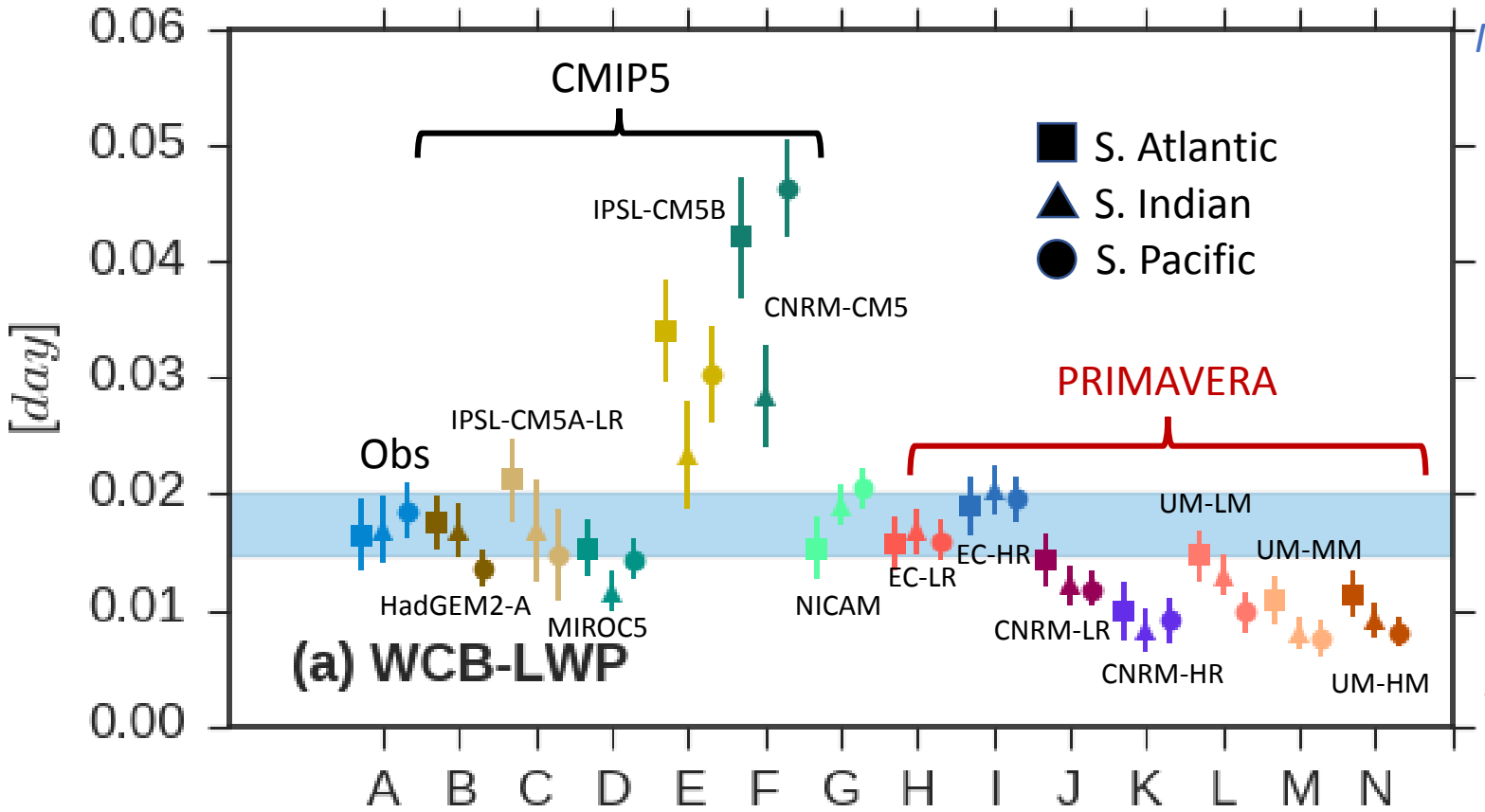
$$\mathbf{WCB}_{flux} = \mathbf{WS}_{10m} \times \mathbf{WVP} \times \text{const}$$

$\mathbf{WVP} \propto \boldsymbol{T}$ Clausius-Clapeyron

What do the models look like?



Linearized relationship between WCB and LWP



Stronger LWP-WCB relationship

More negative shortwave cloud feedback

Weaker LWP-WCB relationship

More positive shortwave cloud feedback

Results:

- WCB moisture flux can be used to predict the change in LWP in cyclones between the current climate and a warmed climate (see paper). A negative feedback.
- Model resolution doesn't appear to have a significant impact on this feature, although WCB-LWP relationship tends to become shallower as resolution increases in a given model.
- Bonus: cyclone wind speed always underrepresented in models regardless of resolution. Possibly due to not capping surface drag over oceans (see paper).

Cloud feedbacks in extratropical cyclones: insight from long-term satellite data and high-resolution global simulations
Atmos. Chem. Phys., 19, 1147-1172, 2019
https://doi.org/10.5194/acp-19-1147-2019