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Pasadena, California

# Net surface water exchange rate estimated from remote-sensing observation , ECMWF, and MERRA

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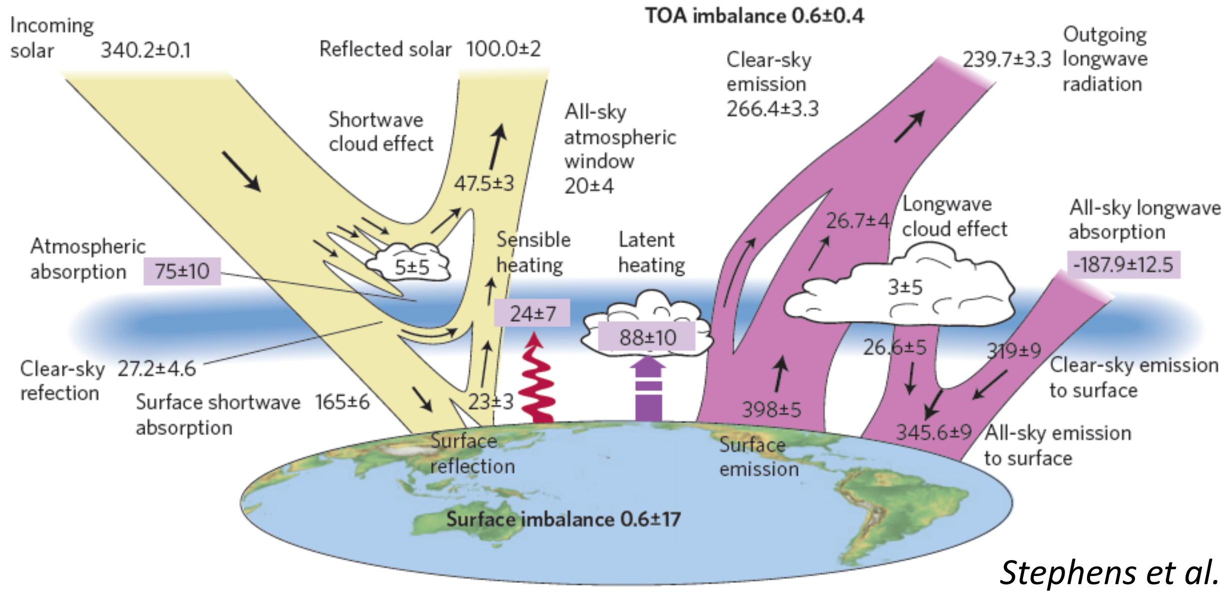
AIRS science team meeting 2014, Caltech, Pasadena, CA

# Energy balance perspective

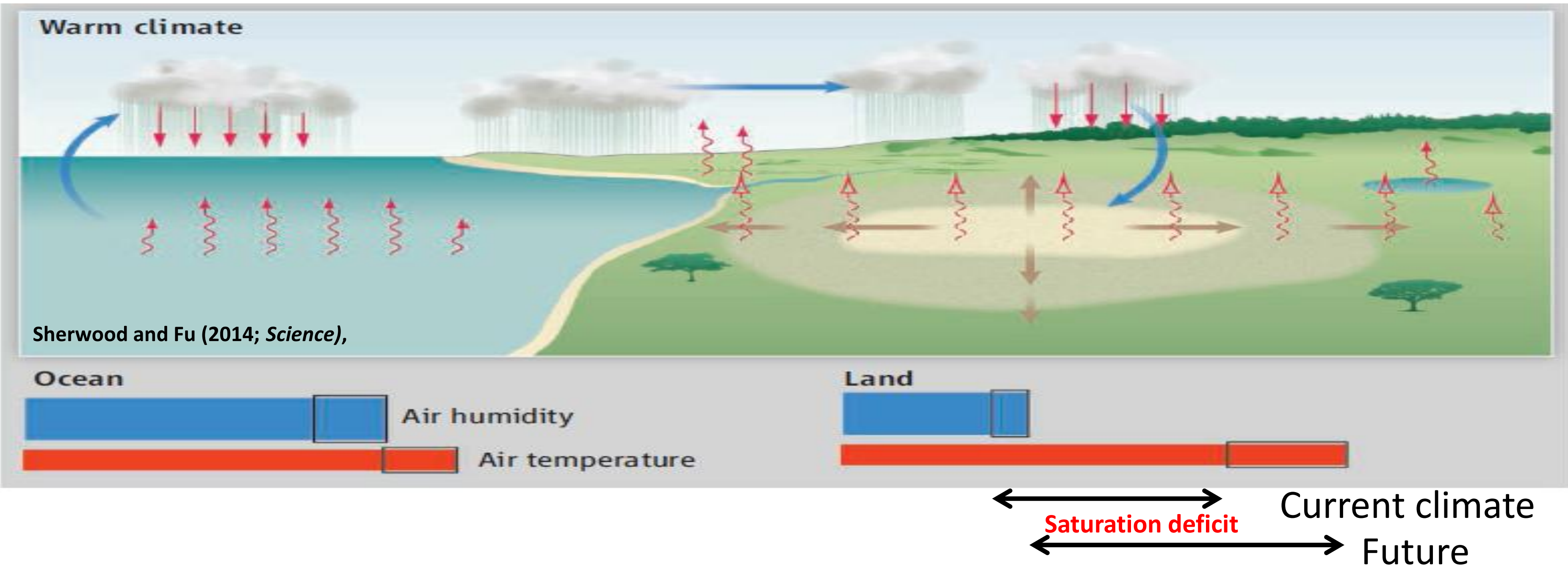



*Stephens et al. 2012; Nature Geoscience*

" The annual *global mean evaporation is balanced by the annual global precipitation amount*, and the common approach *to infer the latent heat flux is to use global precipitation measurements* (Trenberth et al. 2007). Thus an increase in precipitation implies an increase in evaporation to sustain it and hence a larger flux of energy from the surface associated with this evaporation"

# Motivation ……

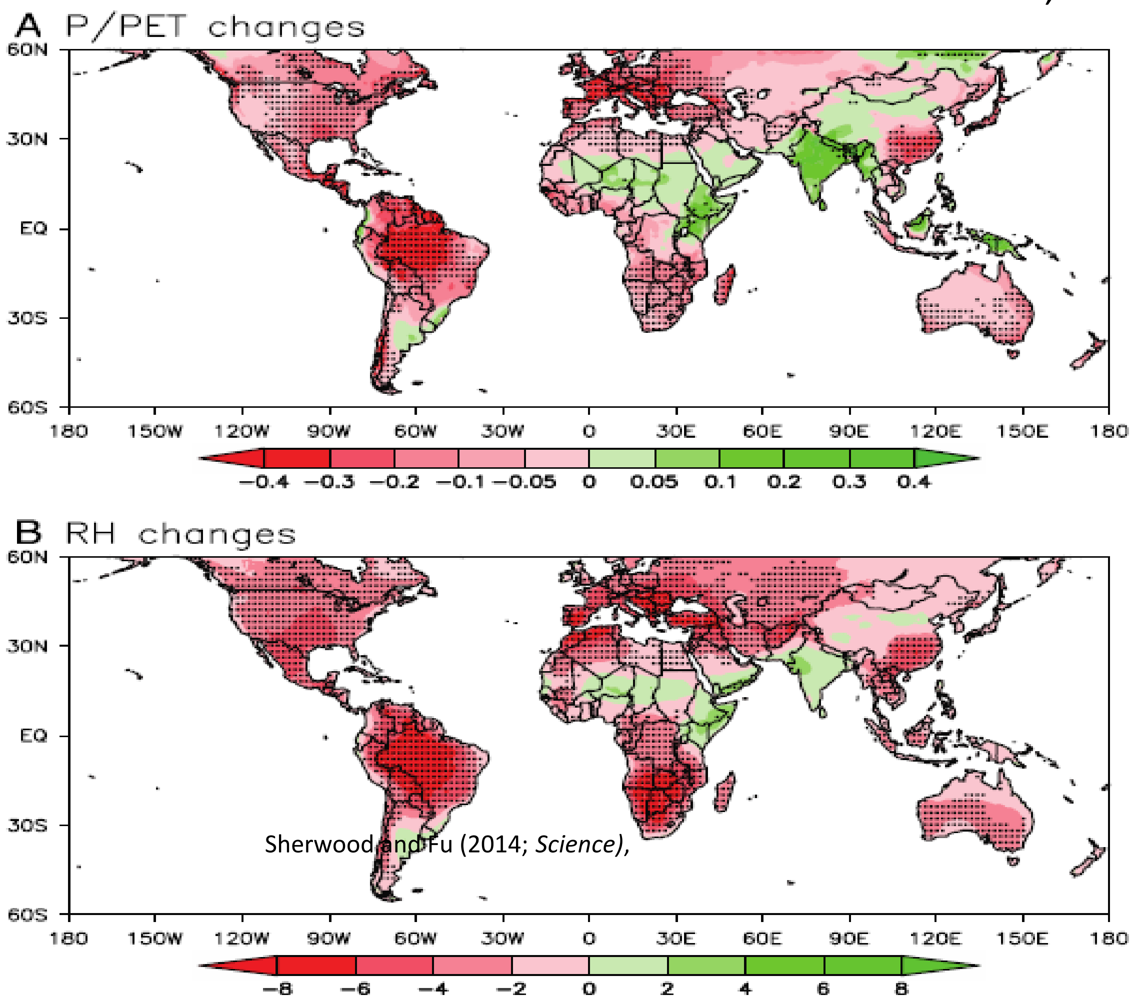
The key factor causing drying is that land surfaces (and the air just above them) warm, on average, about 50% more than ocean surfaces (M. M. Joshi *et al*. 2008).




Sherwood and Fu (2014; *Science*),

Focusing in changes in precipitation is not enough to understand the water availability trend (e.g., drought)!!!
***Many regions will get more rain, but it appears that few will get enough to keep pace with the growing evaporative demand.***

If **P/PET ratio falls**, conditions get **drier,** and if **rises**, conditions get **wetter**.




Sherwood and Fu (2014; *Science*),

*These changes imply increased water stress*

2100 under a business-as-usual (RCP8.5) scenario (27 CMIP5 models)

**We need to make sure we are able to quantify the hydrologic components correctly, seasonally and regionally, evaluate the models, then trust them for future, ….**

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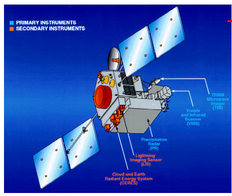
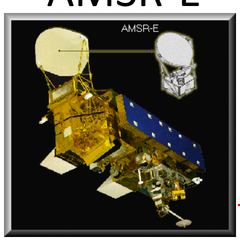
# Issues with PRECIPITATION over OCEAN, …, improvement

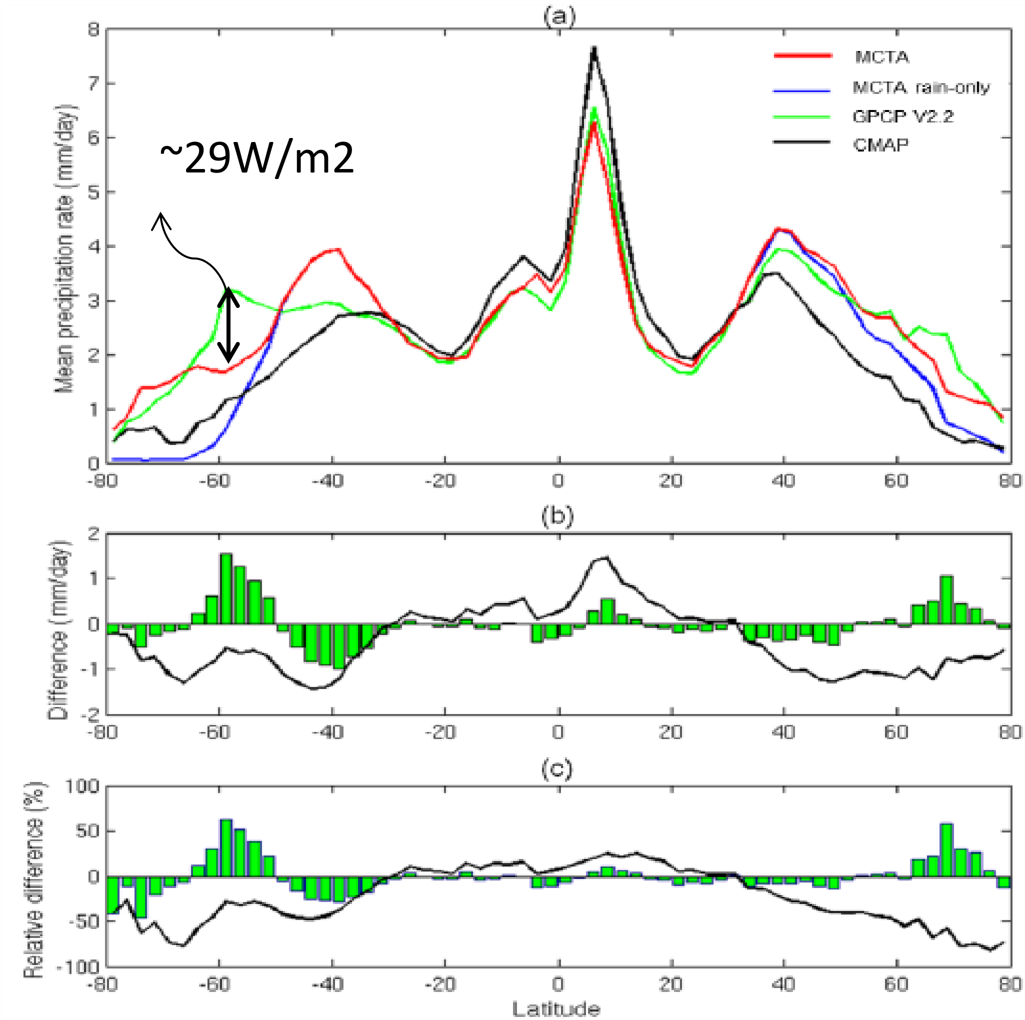
TRMM



CloudSat

AMSR-E




Behrangi, A., G. Stephens, R. F. Adler, G. J. Huffman, B. Lambrigtsen, and M. Lebsock, *An update on oceanic precipitation rate and its zonal distribution in light of advanced observations from space*. Journal of Climate, 2014.

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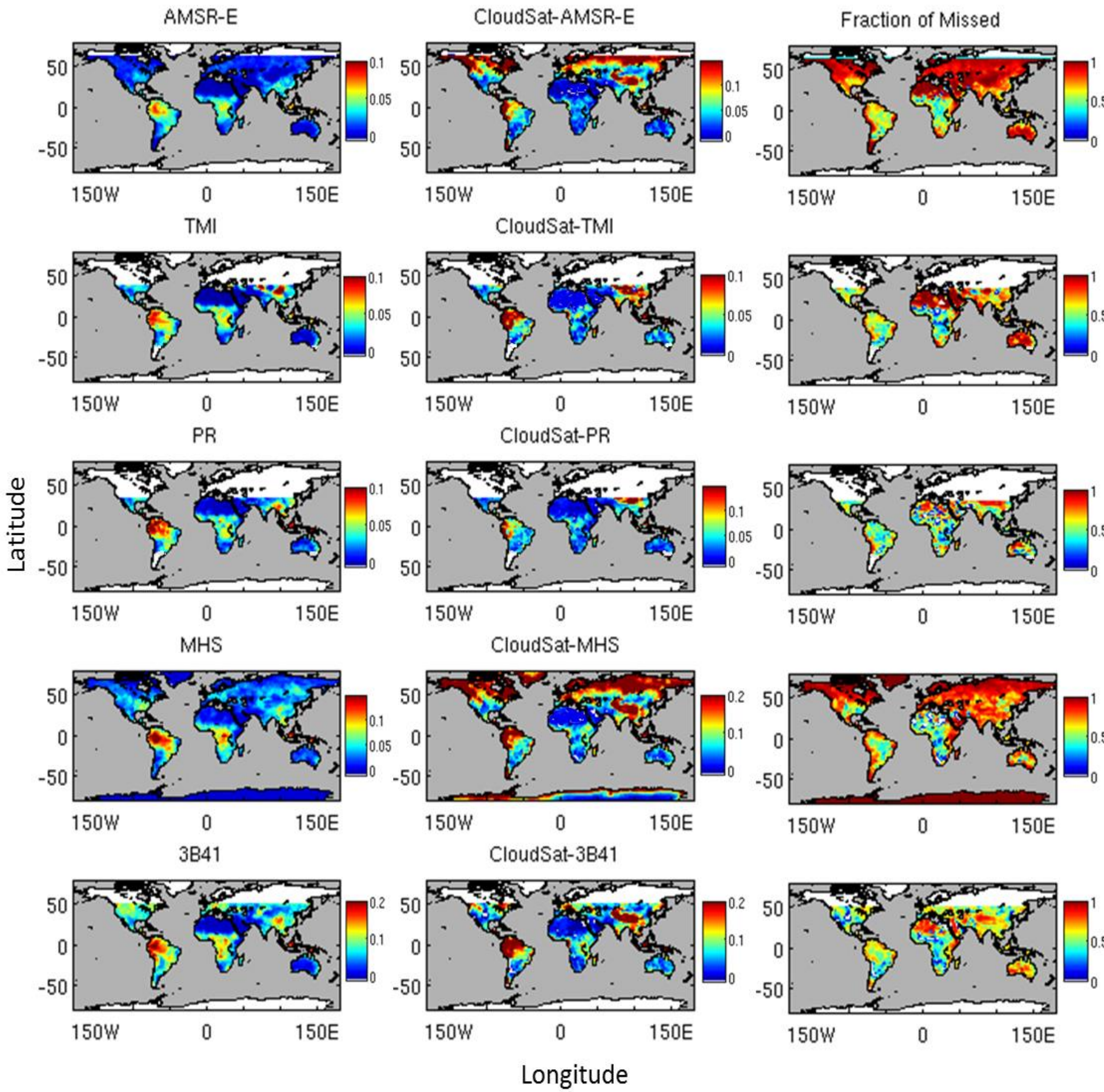
# Issues with PRECIPITATION over LAND



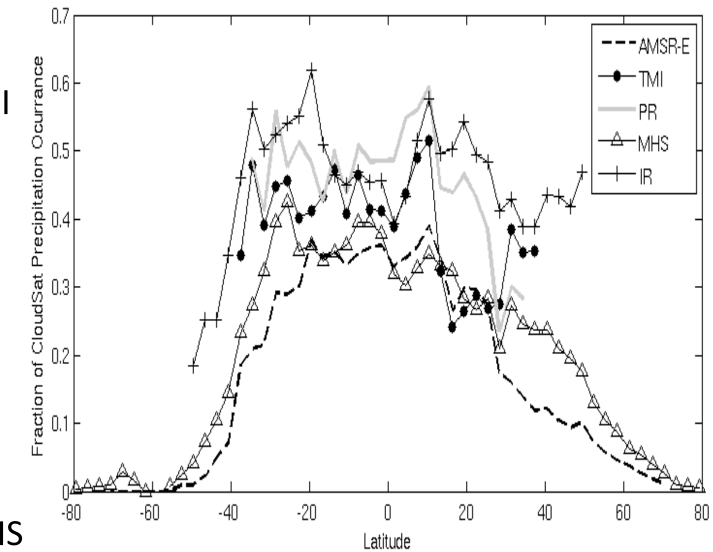

AMSR-E

TMI

PR

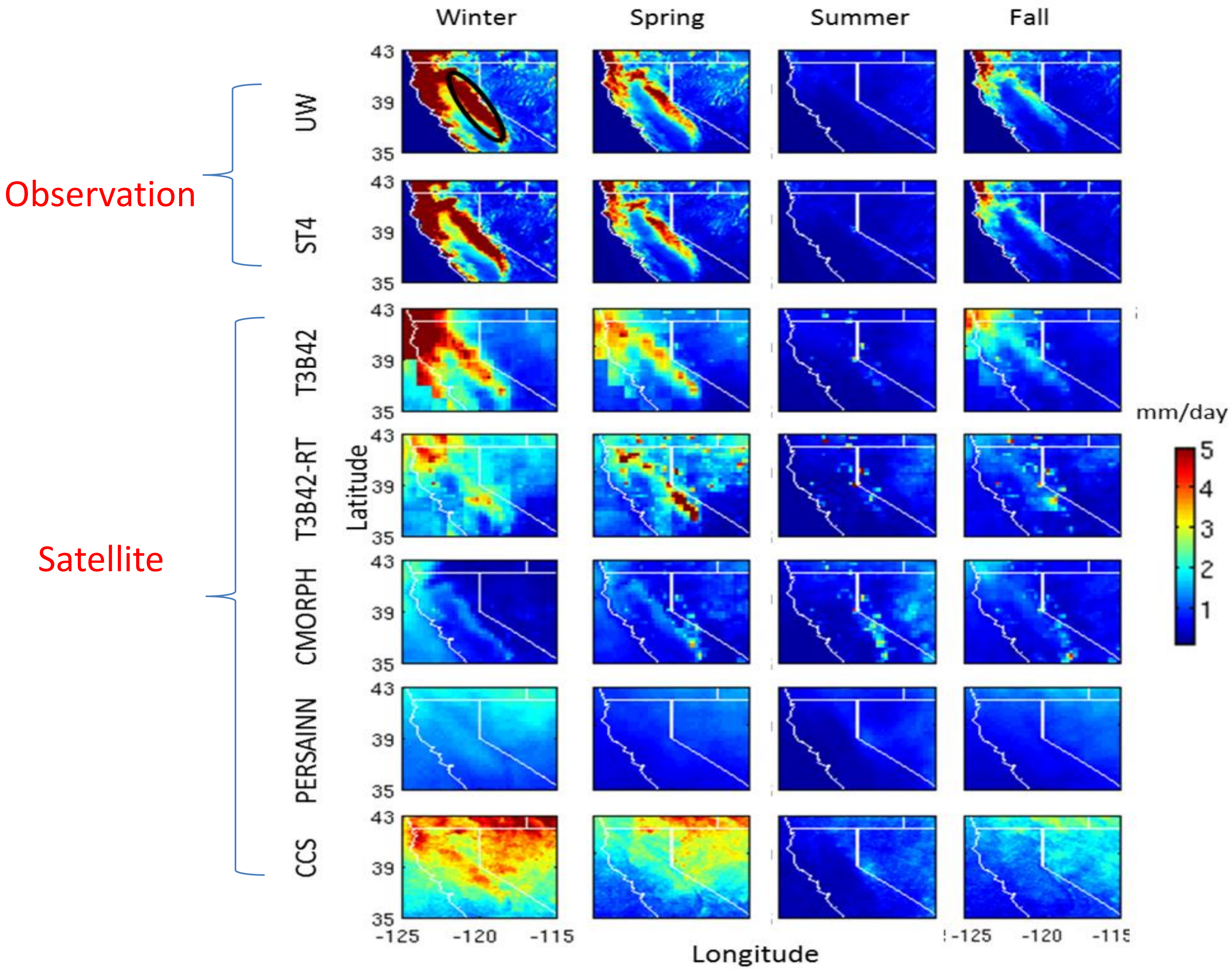
MHS

IR (calibrated with TRMM combined instrument)

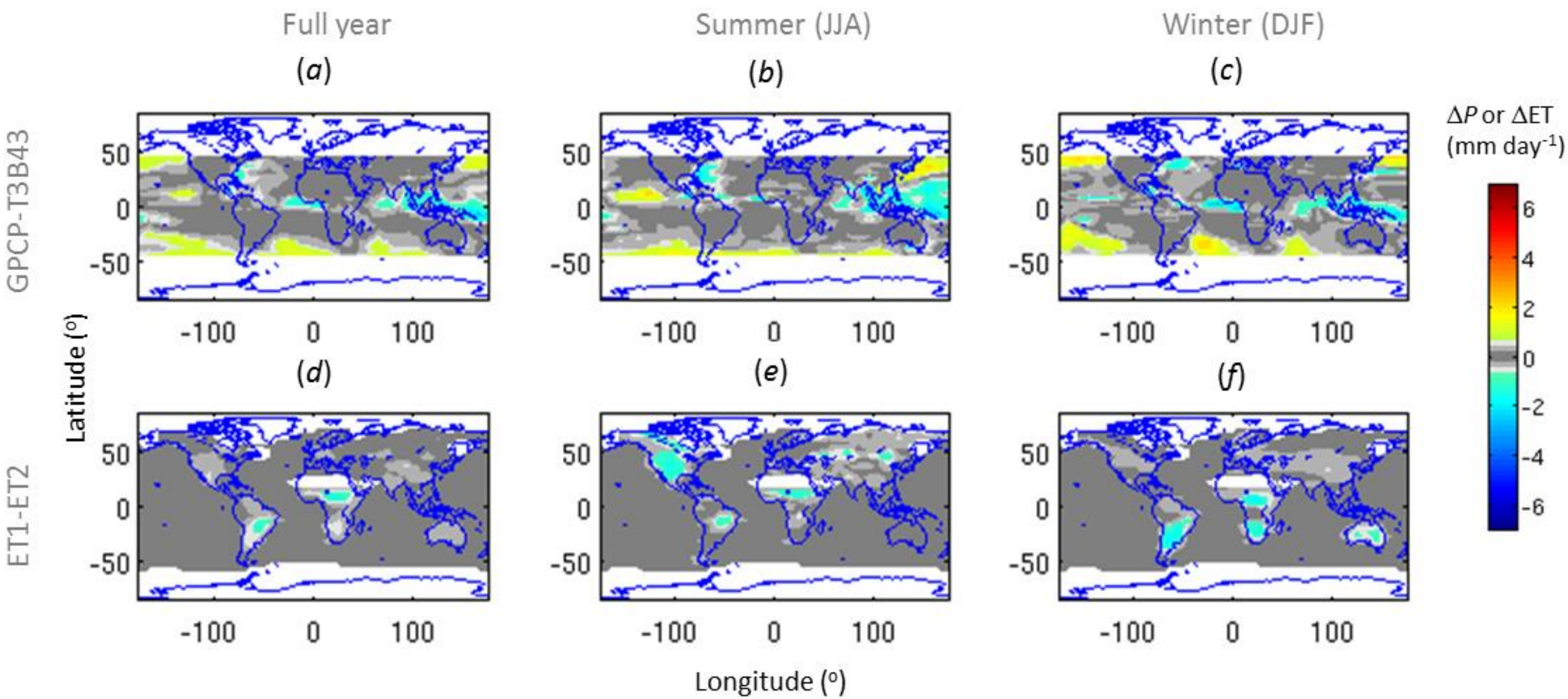



Behrangi , A. Y. Tian, B. Lambrigtsen, G. Stephens ,(2014) What does CloudSat reveal about global land precipitation detection by other space-borne sensors? *J. Water resources research (WRR*)

# Issues with PRECIPITATION over MOUNTAINOUS regions




Behrangi et al. 2014, JAMC (submitted)




Maps of climatological differences between the two precipitation (GPCP minus T3B43) and evapotranspiration (ET1-ET2) products. Annual, summer, and winter averages are shown in (*a*), (*b*), and (*c*) for precipitation and (*d*), (*e*), and (*f*) for evapotranspiration. ET2 uses evapotranspiration data from PT-JPL instead of MOD16 over land.

E over ocean is obtained from GSSTF2c

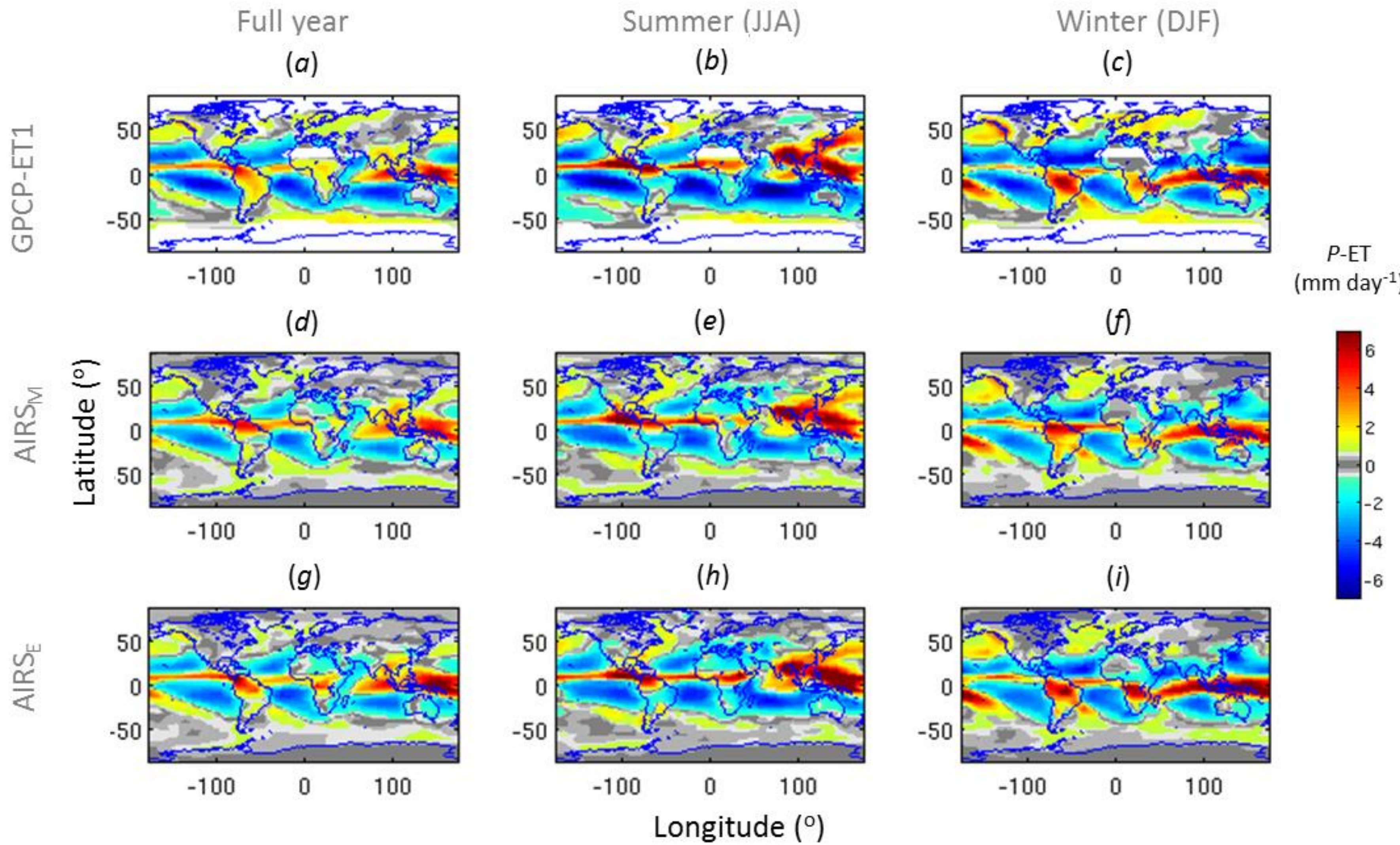
# How can AIRS contribute ?....

Independent estimate of P–ET is obtained from the column-integrated water vapor sinks

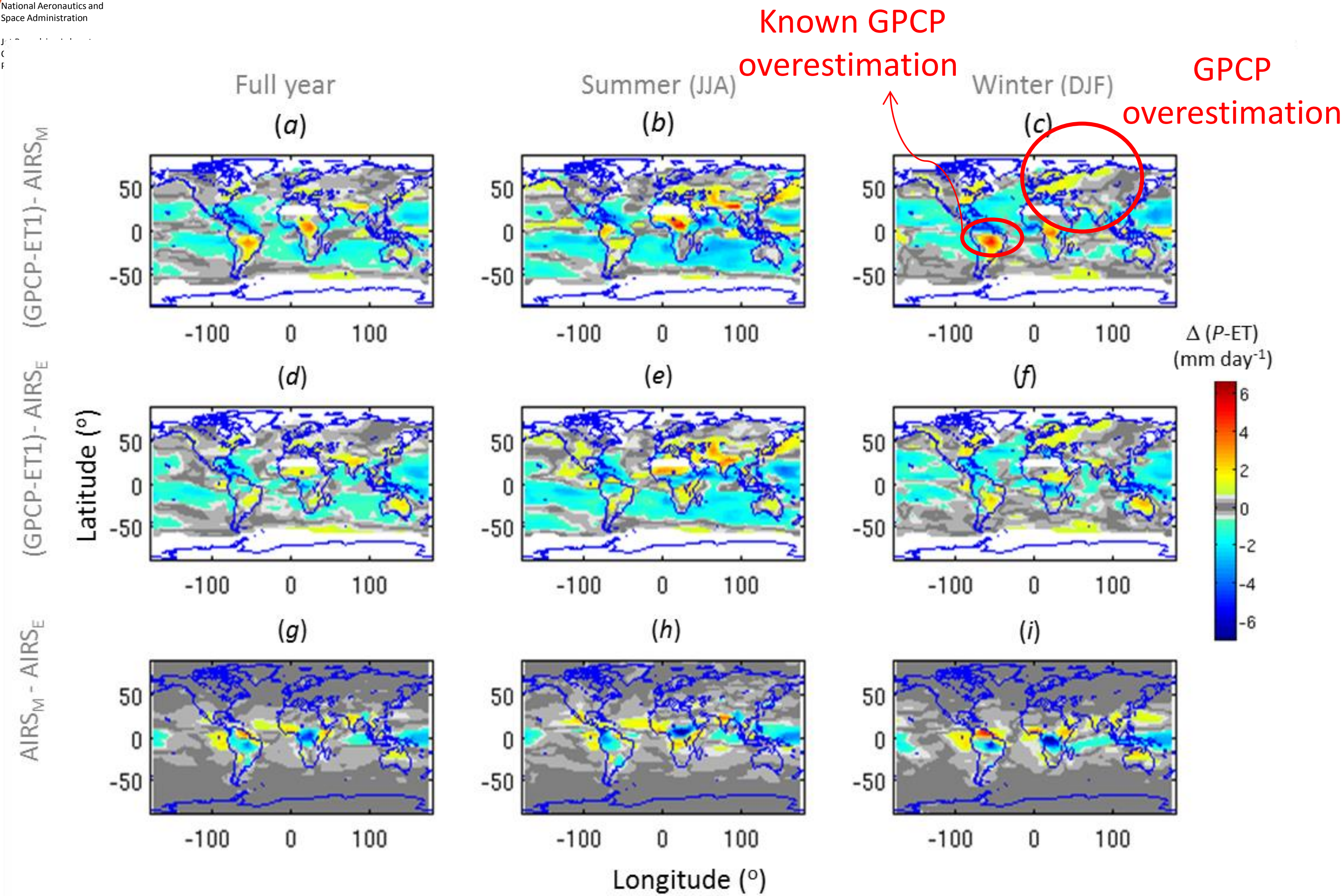
$$P - E = -\int_{p_1}^{p_n} \left( \frac{\partial q}{\partial t} + u \frac{\partial q}{\partial x} + v \frac{\partial q}{\partial y} + w \frac{\partial q}{\partial z} \right) \frac{\mathrm{d}p}{g},$$

where $P$ is precipitation, $E$ is surface evaporation, $t$ is time, $q$ is specific humidity, ($u$, $v$, $w$) are wind velocities along $x$, $y$, and $z$ directions, $p_1$ is the top of the atmosphere pressure, $p_n$ is the surface pressure, and g is the gravitational constant. In this study, we choose $p_1$ = 200 hPa, above which water vapour concentration is negligible in contributing to column integration.

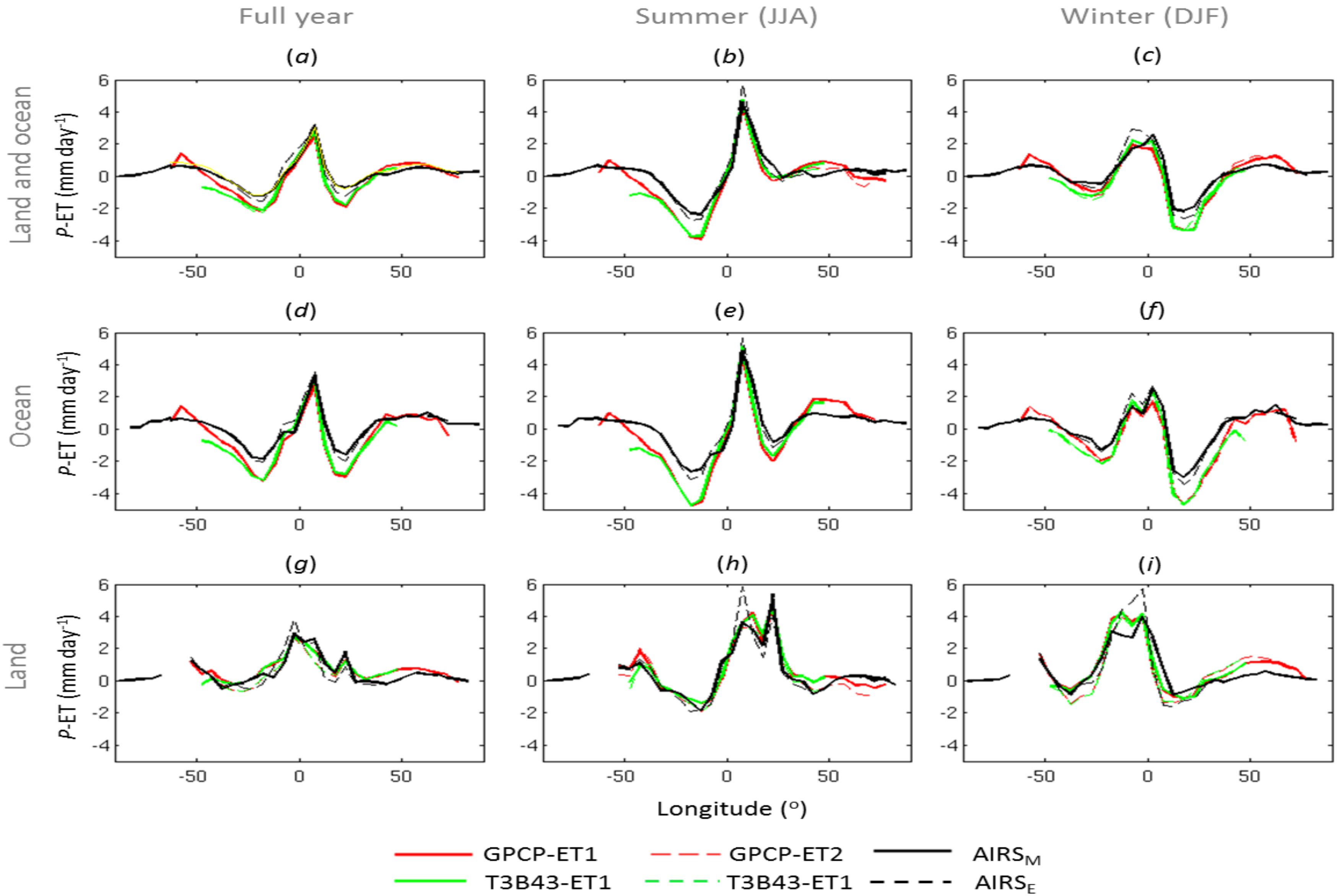
**Need a 3D WIND mission !!!**




Maps of climatological average of *P*-ET from GPCP-ET1, $AIRS_M$, and $AIRS_E$.




Maps of climatology difference between (GPCP-ET1) and AIRS$_E$, (GPCP-ET1) and AIRS$_M$, and AIRS$_M$ and AIRS$_E$.




Zonal distribution of mean *P*-ET computed from $AIRS_E$, $AIRS_M$, GPCP-MOD16, GPCP-PT/JPL, T3B43-MOD16, and T3B43-PT/JPL for annual, winter, and summer over land and ocean, ocean, and land.

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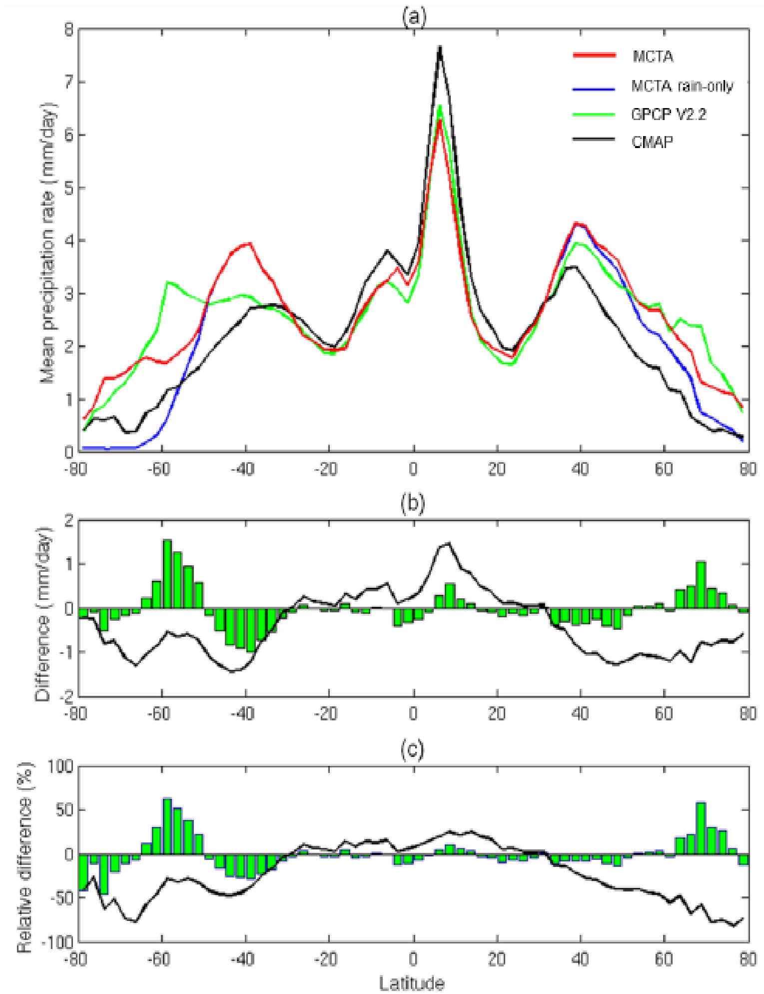
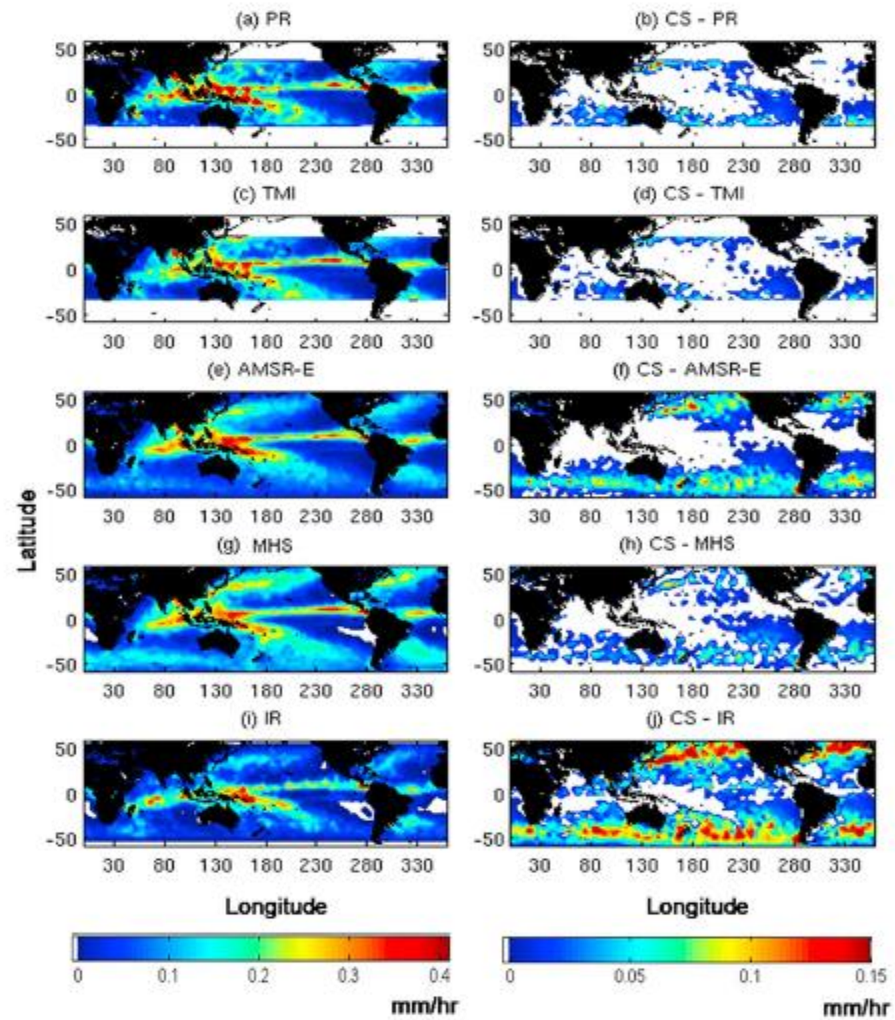
# Part of the differences can be explained by biases in precipitation estimates




1.2 2.4 3.6
mm/day

# Summary of the average *P*-ET values from different methods discussed in this study.

| | P-ET (mm day$^{-1}$) | | | | | |
|---|---|---|---|---|---|---|
| | Land and Ocean | | Ocean | | Land | |
| Method | Global | 50$^o$S-50$^o$N | Global | 50$^o$S-50$^o$N | Global | 50$^o$S-50$^o$N |
| GPCP-ET1 | - | -0.37 | - | -0.86 | - | 0.88 |
| GPCP-ET2 | - | -0.43 | - | -0.86 | - | 0.53 |
| 3B43-ET1 | - | -0.41 | - | -0.93 | - | 0.84 |
| 3B43-ET2 | - | -0.47 | - | -0.93 | - | 0.50 |
| $AIRS_M$ | 0.18 | 0.10 | 0.04 | -0.13 | 0.60 | 0.67 |
| $AIRS_E$ | 0.14 | 0.05 | 0.02 | -0.14 | 0.51 | 0.55 |
| MERRA | 0.23 | 0.13 | 0.06 | -0.11 | 0.72 | 0.77 |
| ERA-interim | 0.20 | 0.07 | 0.05 | -0.16 | 0.67 | 0.71 |

## Concluding remarks:

- Need better quantification of P, E, ET from space for water/energy balance studies
- AIRS can provide an independent insight on P-E/ET
- Need a 3D wind mission ….
- GRACE and CloudSat can help a lot in quantifying snow and light rain climatology, which are challenging tasks (efforts are underway)
- GPM will help

Need further model/observation comparison to know how much we can trust models ?