Changes in the seasonal cycle of precipitation under global warming

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Research Center for Environmental Changes

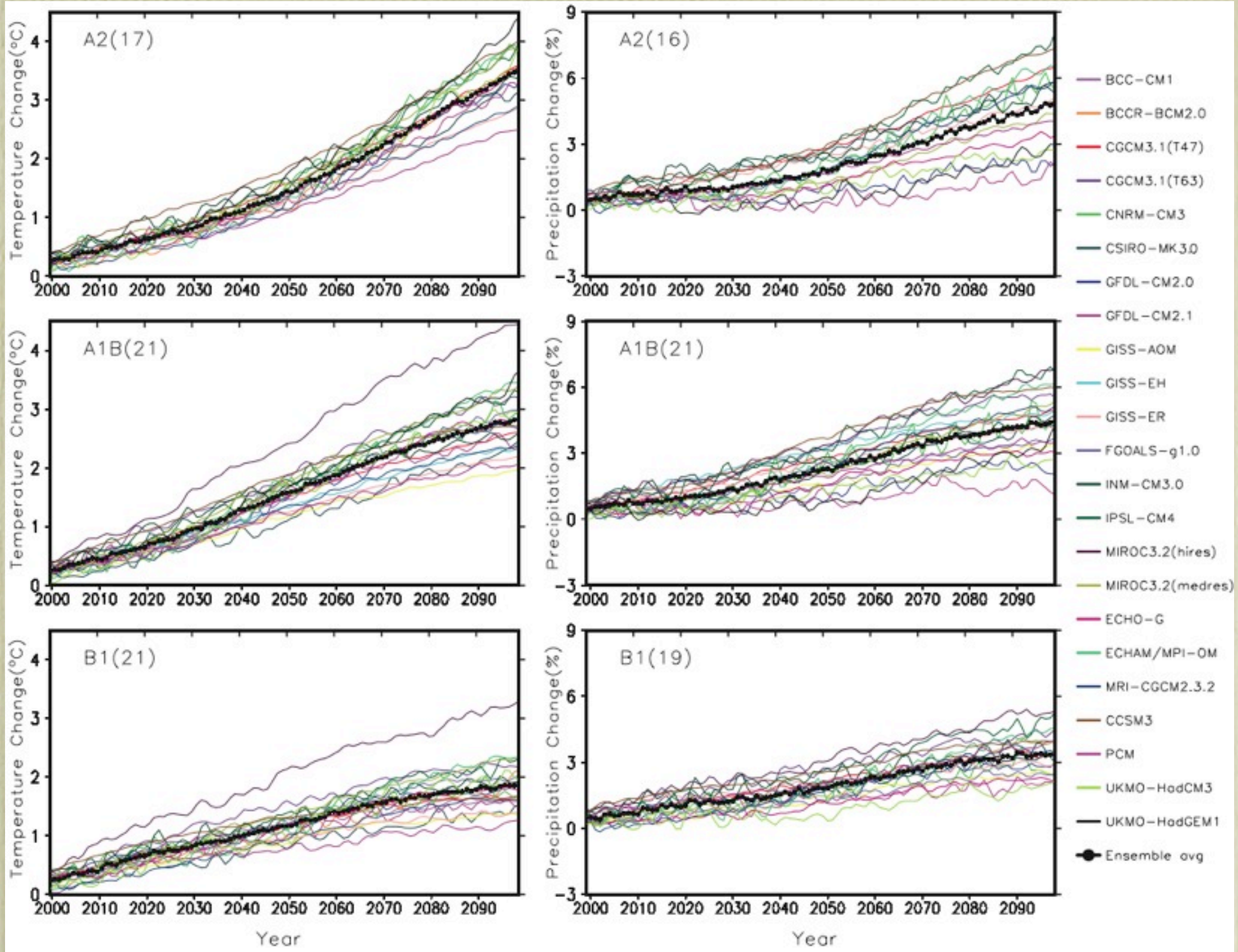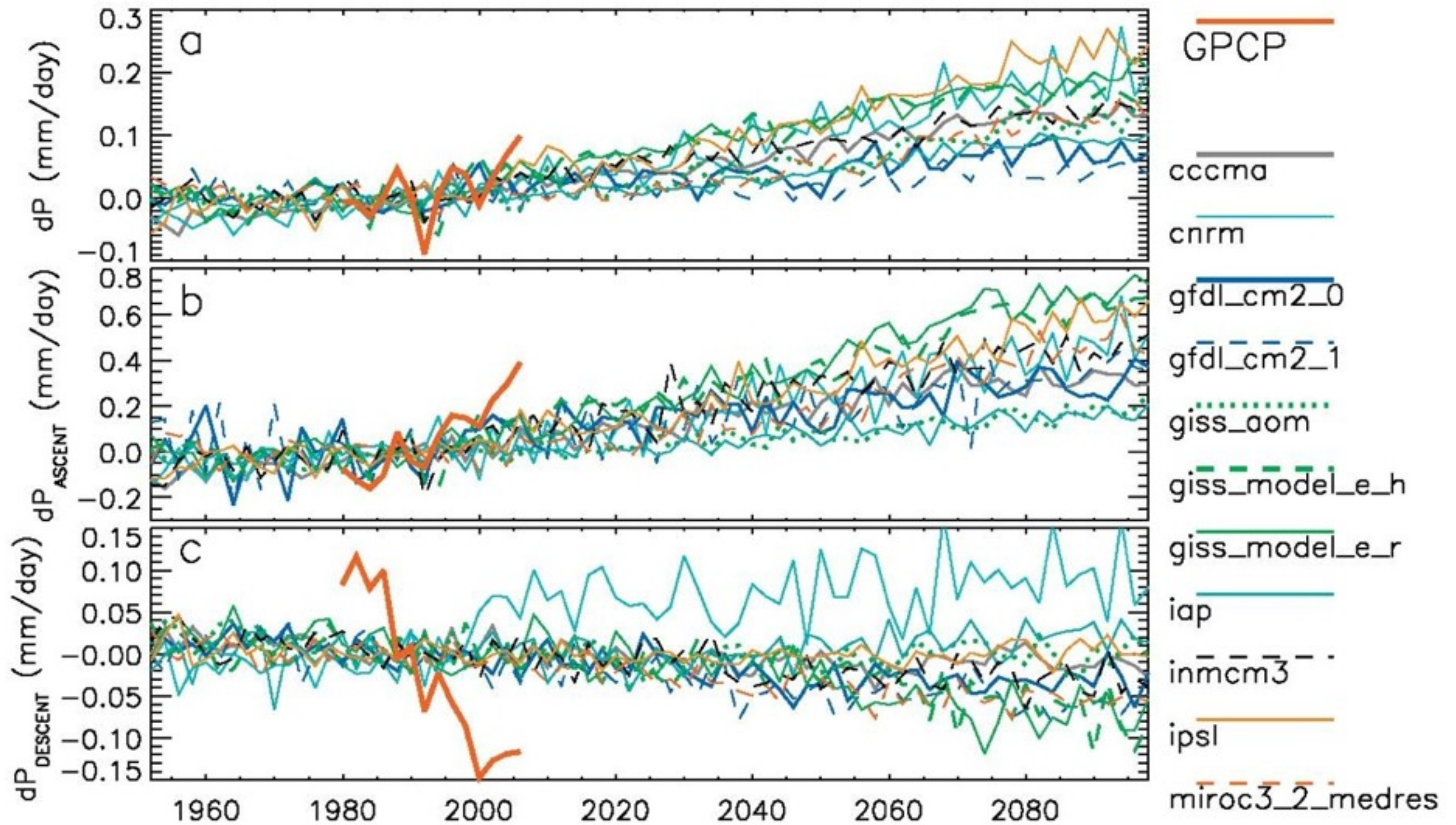*Academia Sinica*

10.26.2011

WCRP

surface temperature   precipitation
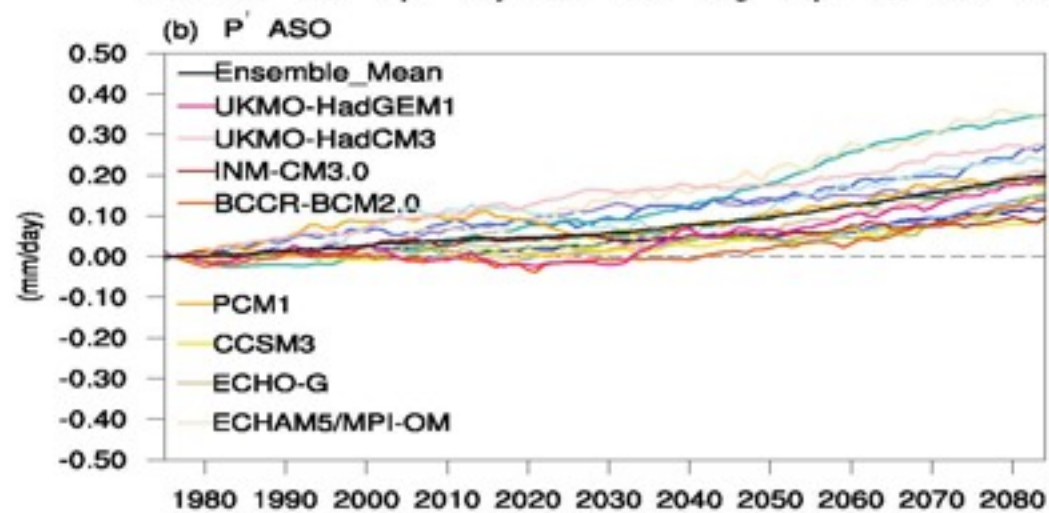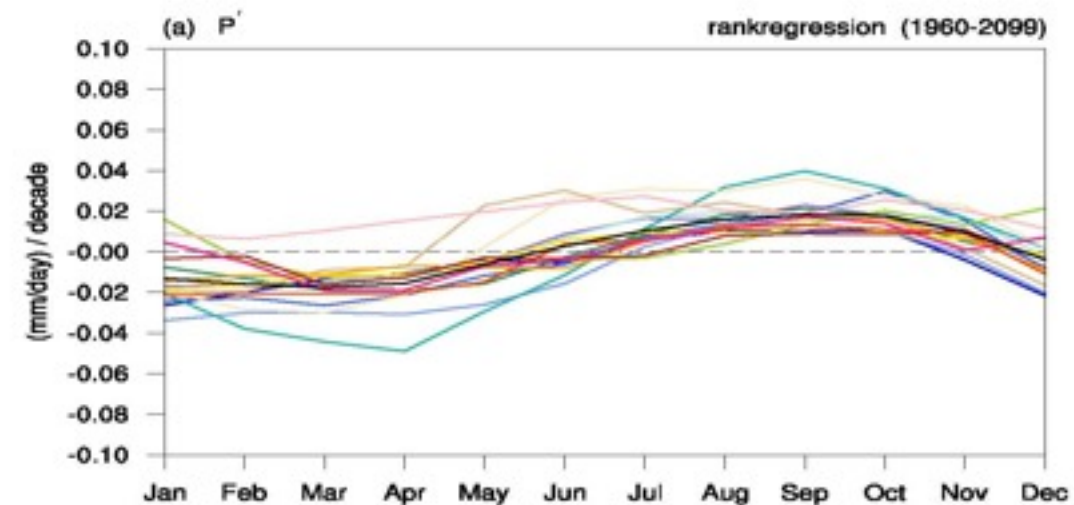
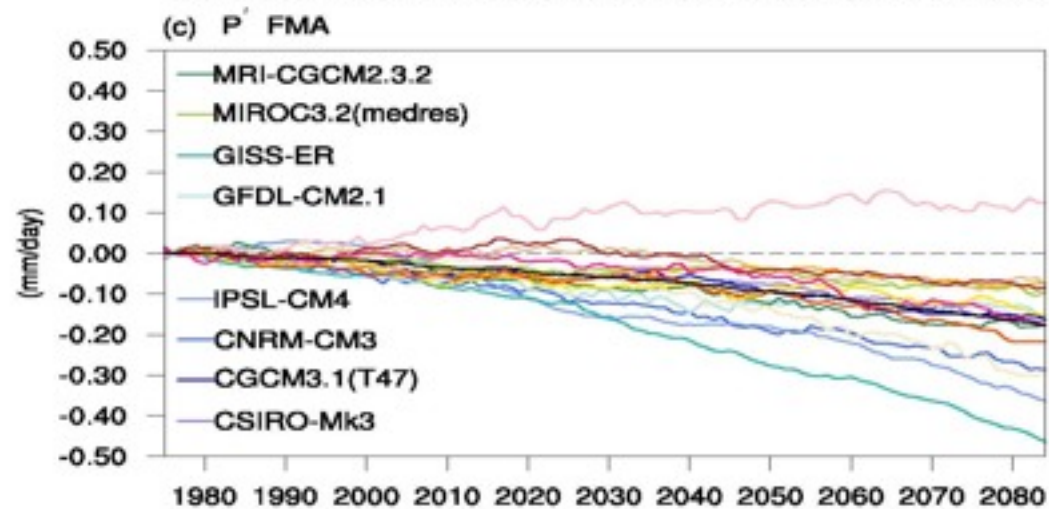# Wet (dry) regions get wetter (drier)

Allan and Soden 2007

Hemispheric asymmetry

summer

winter

(from Chou et al. 2007)

Annual range of precipitation

Annual range of precipitation

Definition: Precipitation differences between wet and dry season

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Definition: Precipitation differences between wet
and dry season

➡ Wet and dry seasons: fixed in time and space
e.g., JJA and DJF

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➡ Wet and dry seasons: fixed in time, but not in
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➡ Maximum minus minimum precipitation:
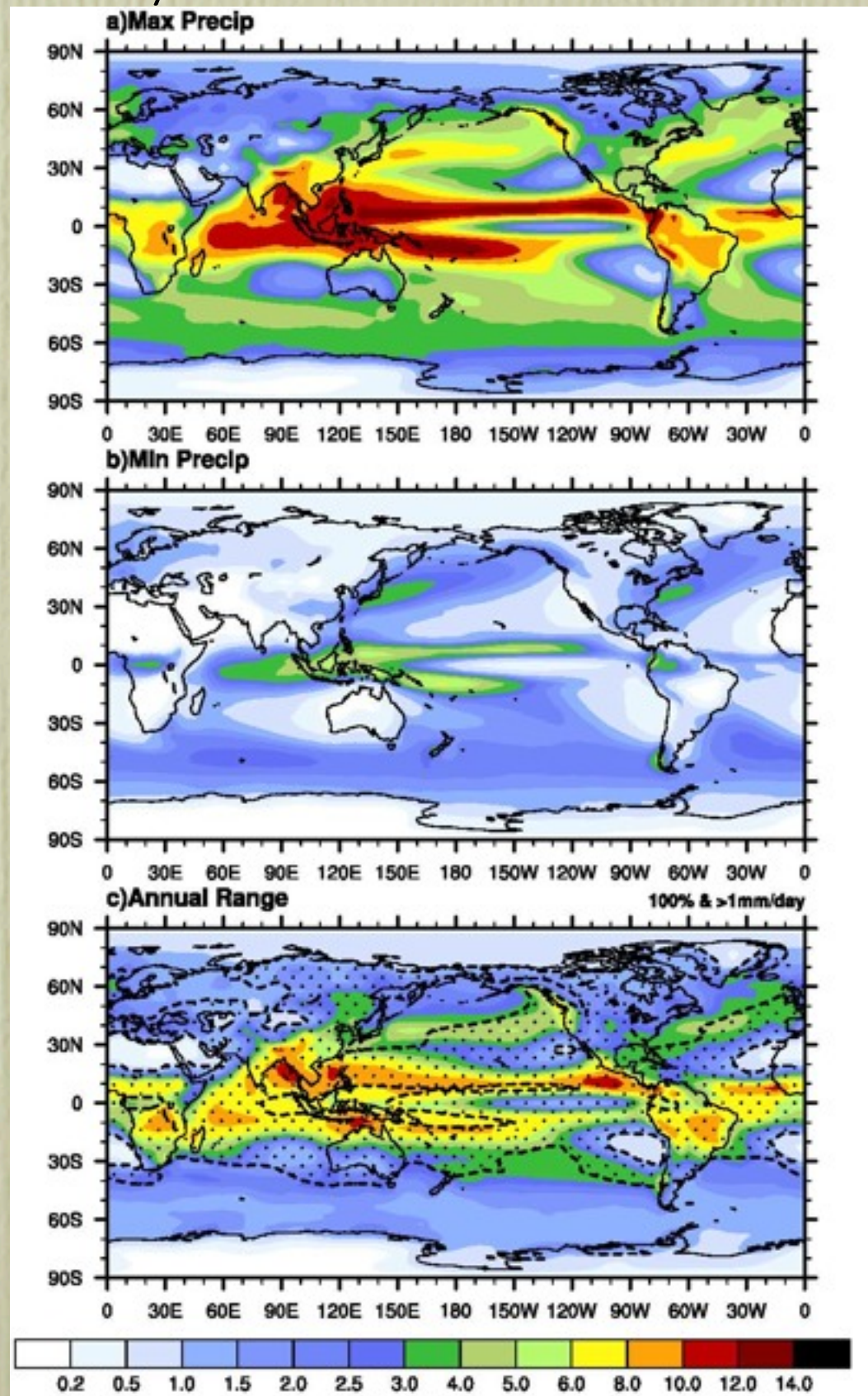varied with time and space

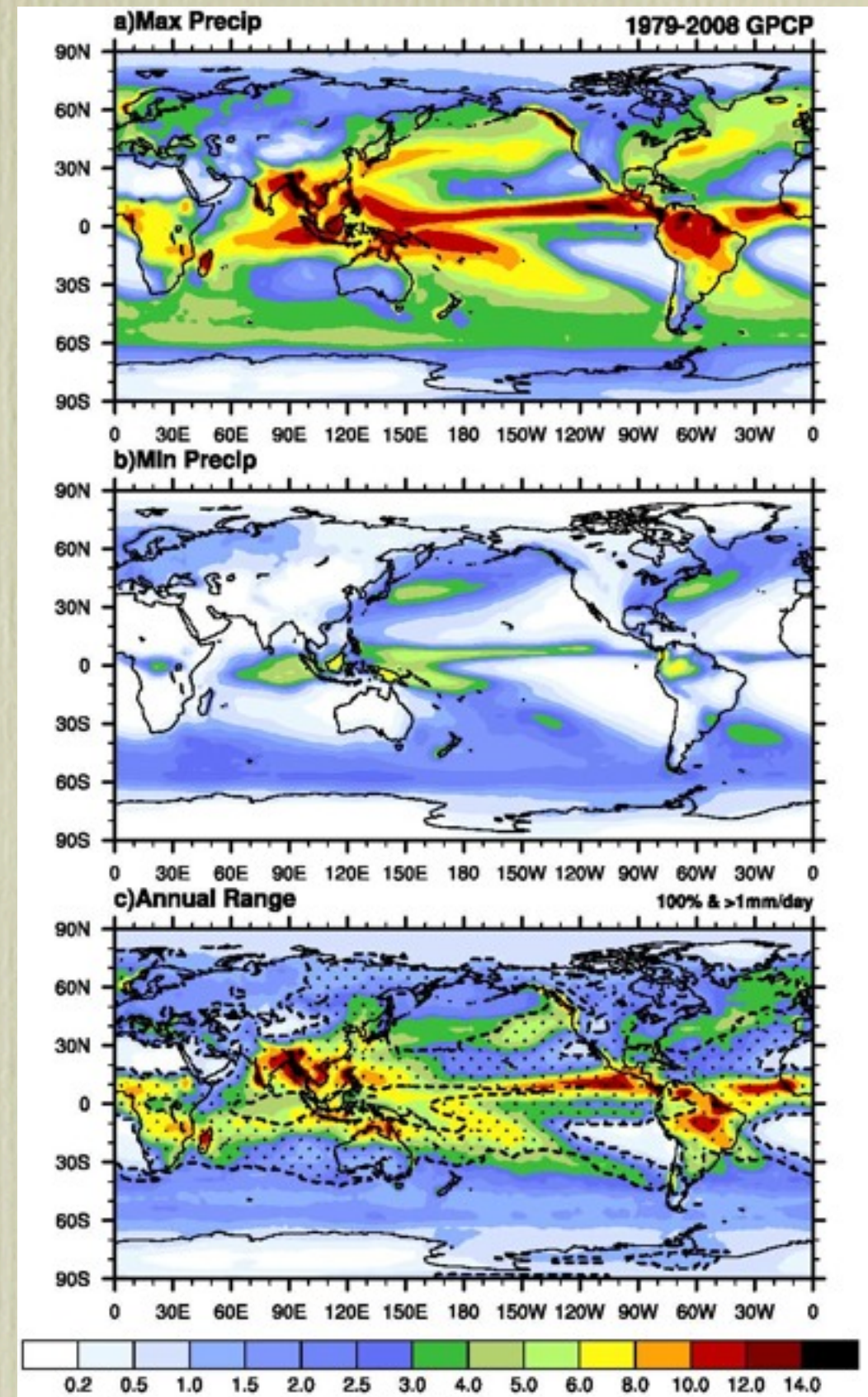# Annual range of precipitation (17 model ensembles)
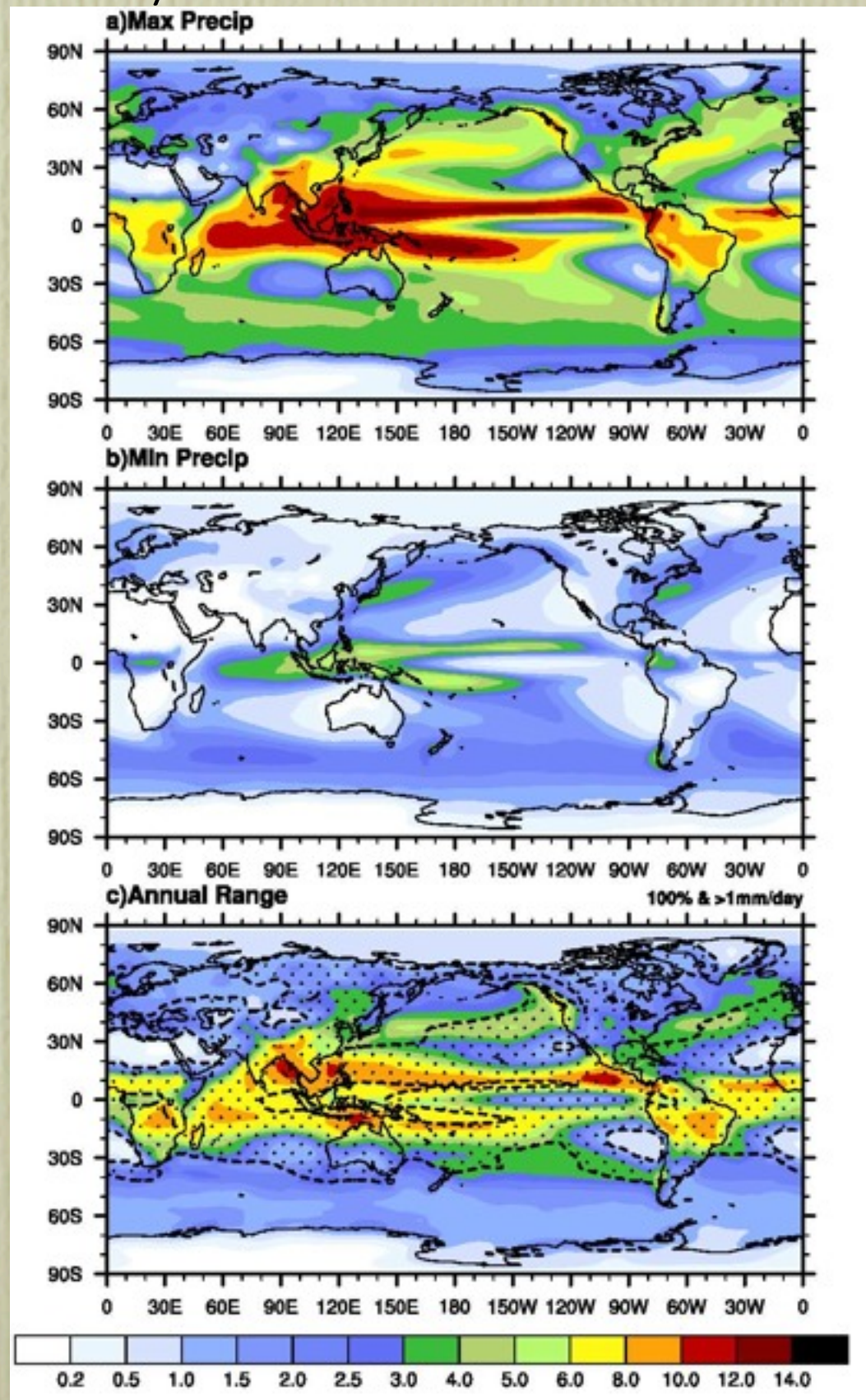
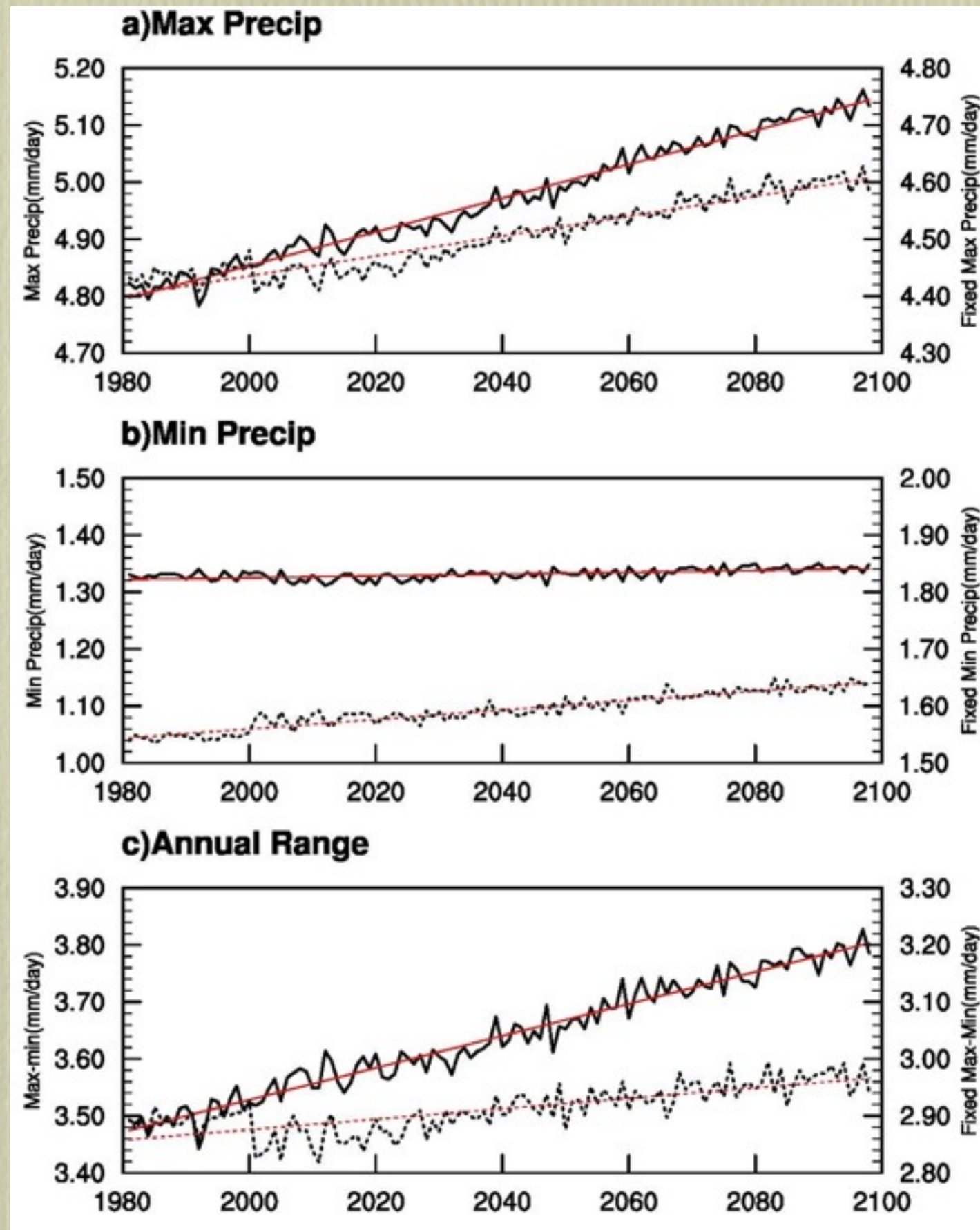# Annual range of precipitation (17 model ensembles)

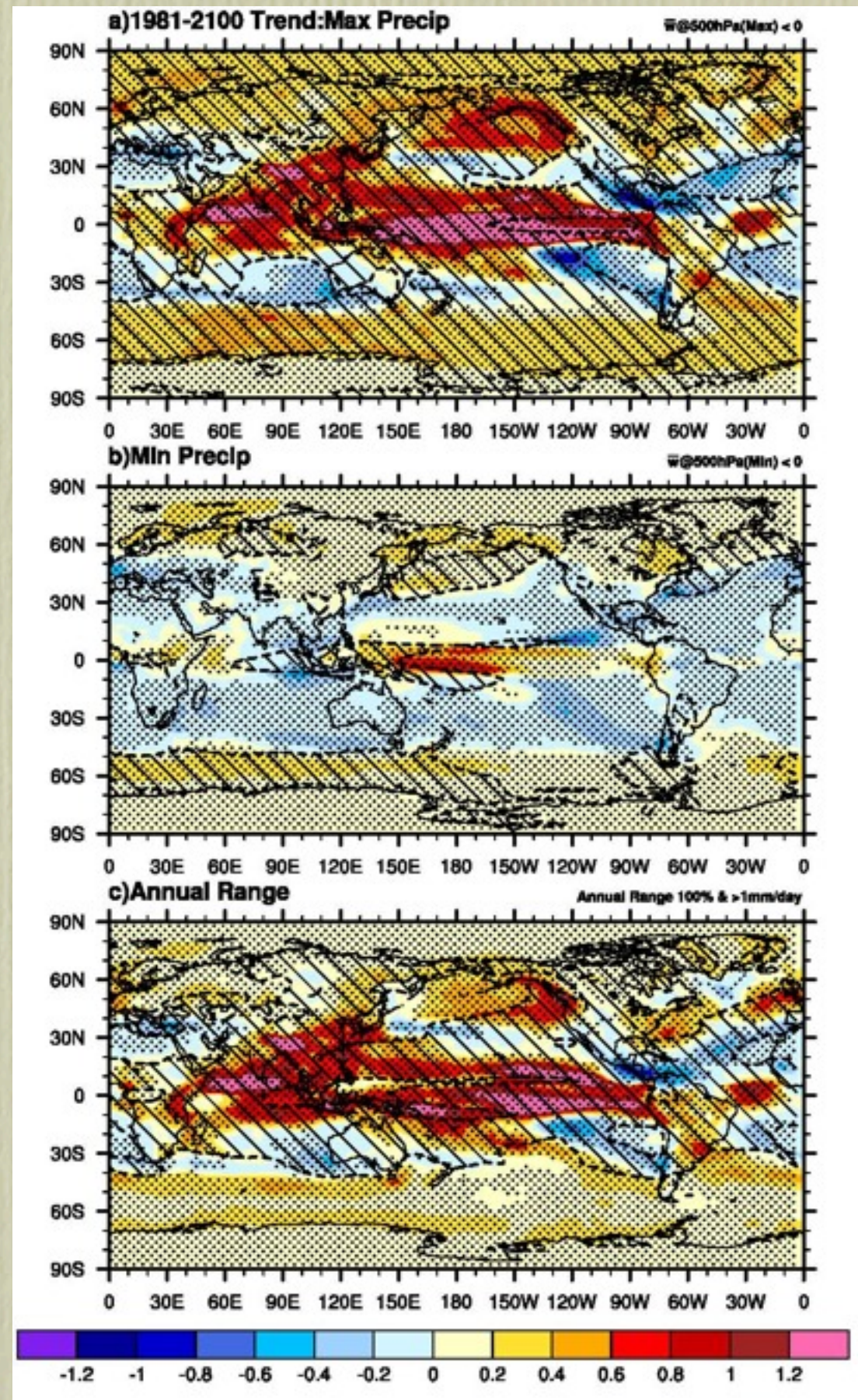# Annual range of precipitation (GPCP observation)

Annual range of precipitation

Annual range of precipitation

water vapor budget

$$P \approx E - \langle \nabla \cdot \mathbf{v} q \rangle$$

$$\approx E - \langle \omega \partial_p q \rangle - \langle \mathbf{v} \cdot \nabla q \rangle$$

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$$\approx E' - \langle \overline{\omega} \partial_p q' \rangle - \langle \omega' \partial_p \overline{q} \rangle - \langle \mathbf{v} \cdot \nabla q \rangle',$$
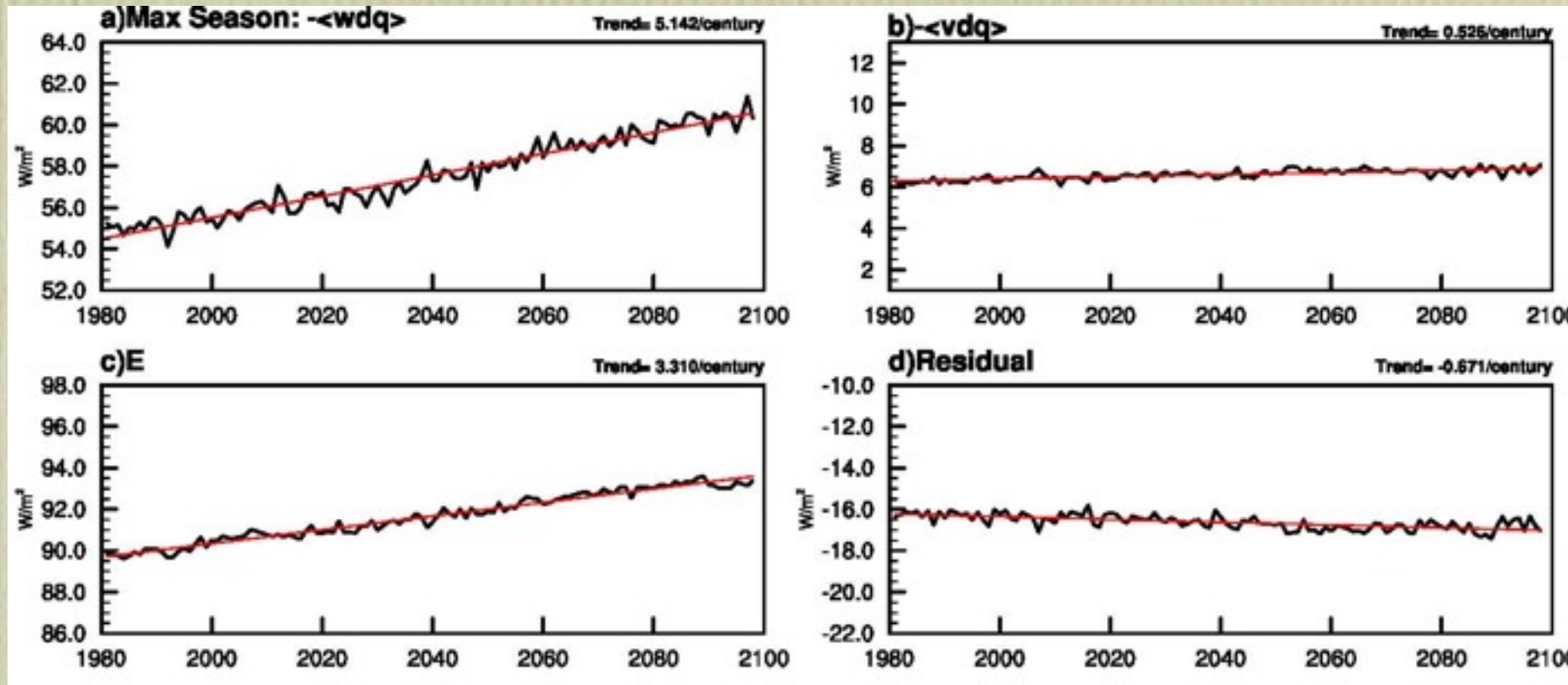
water vapor budget

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thermodynamic

water vapor budget

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dynamic

water vapor budget in wet (max.) season

$-\langle\omega\partial q\rangle$

Evap

$-\langle v \cdot \nabla q\rangle$

Residual

water vapor budget in wet (max.) season

$-\langle\omega\partial q\rangle$

Evap

thermo

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$\langle q \rangle$

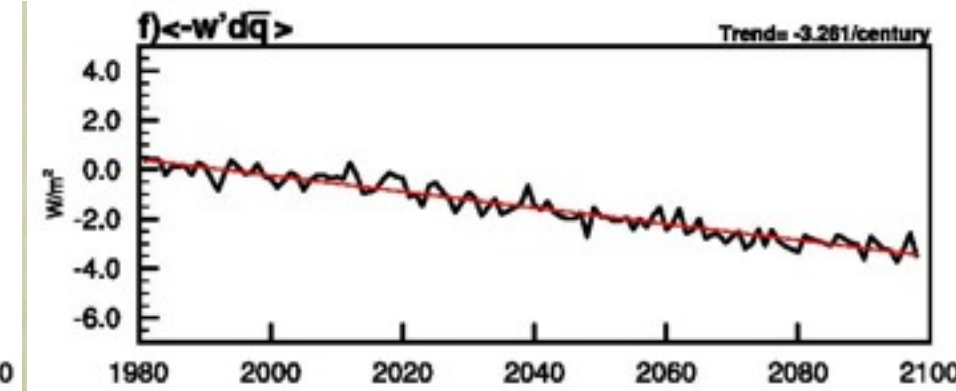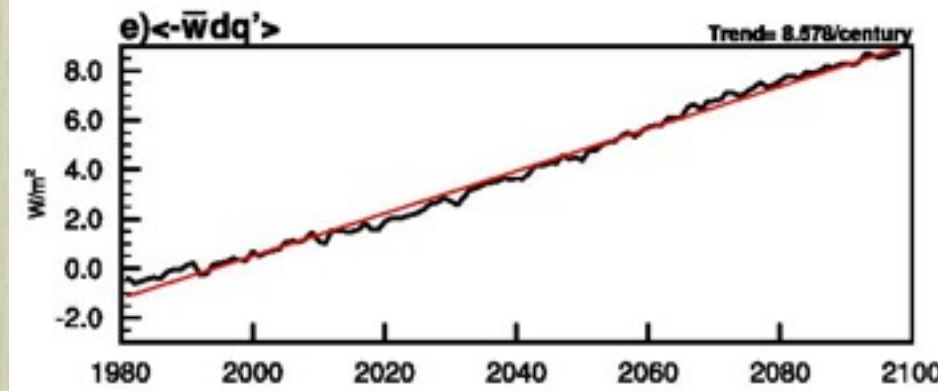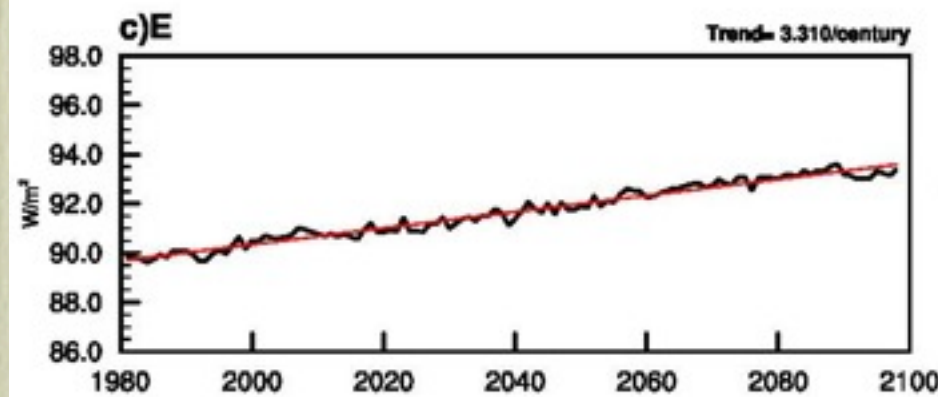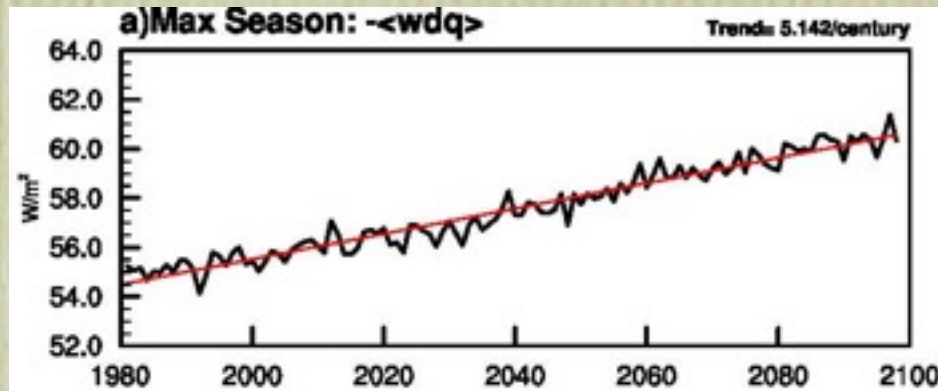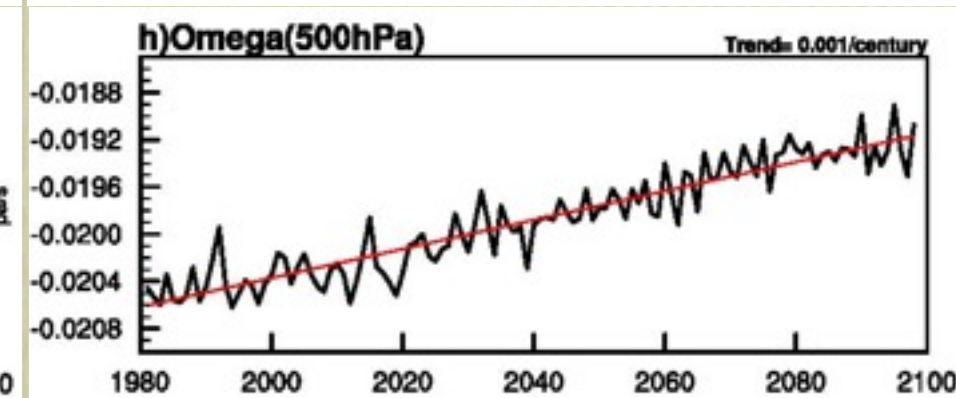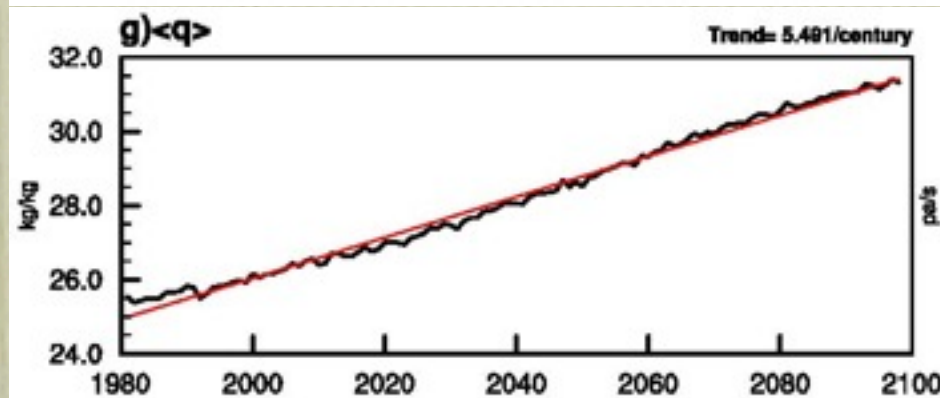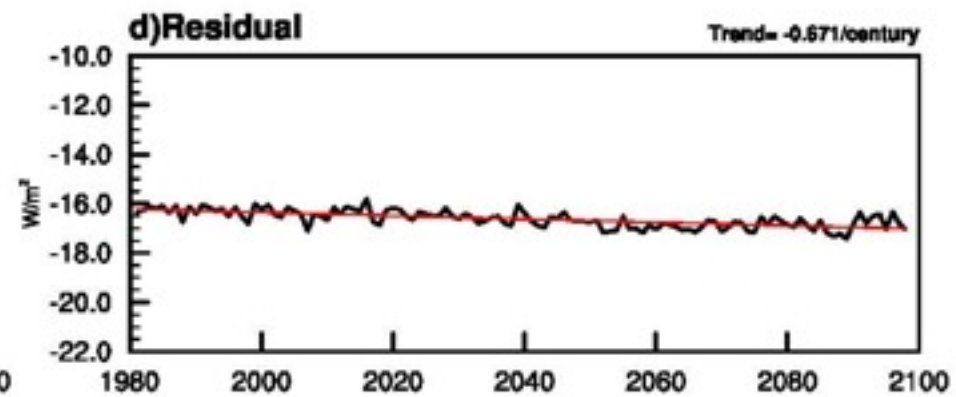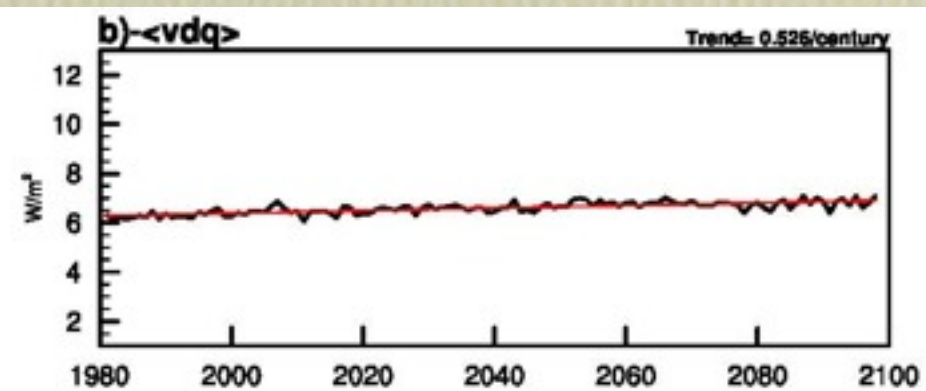-$\langle v \cdot \nabla q \rangle$

Residual

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Evap

thermo

$\langle q\rangle$
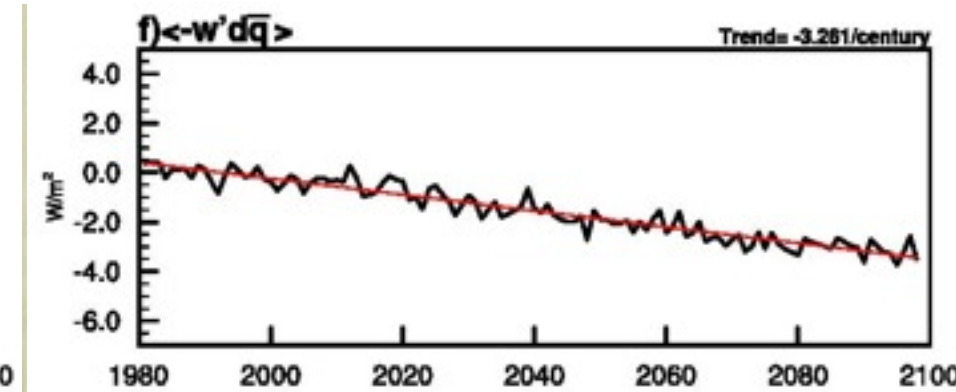
$-\langle v\cdot\nabla q\rangle$

Residual

dynamic
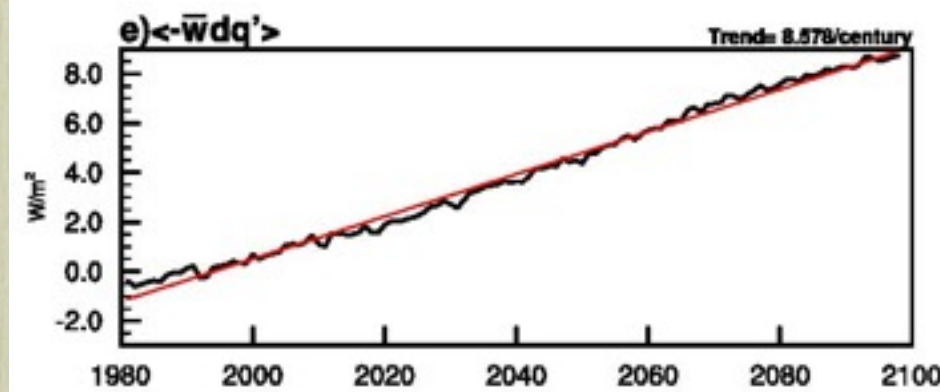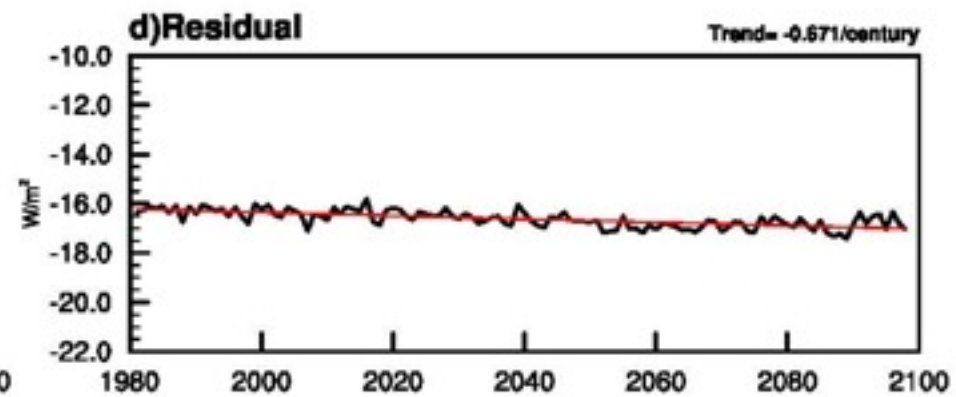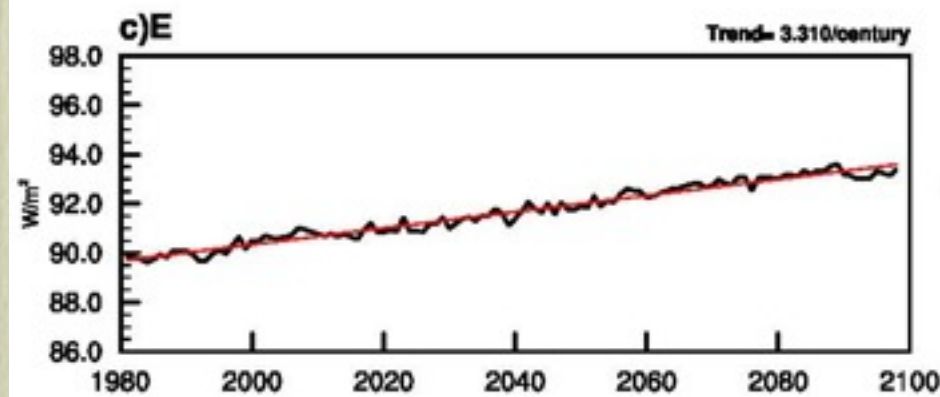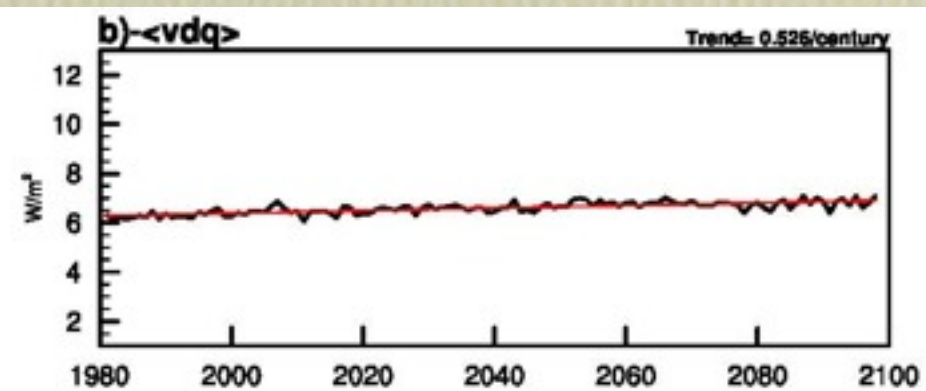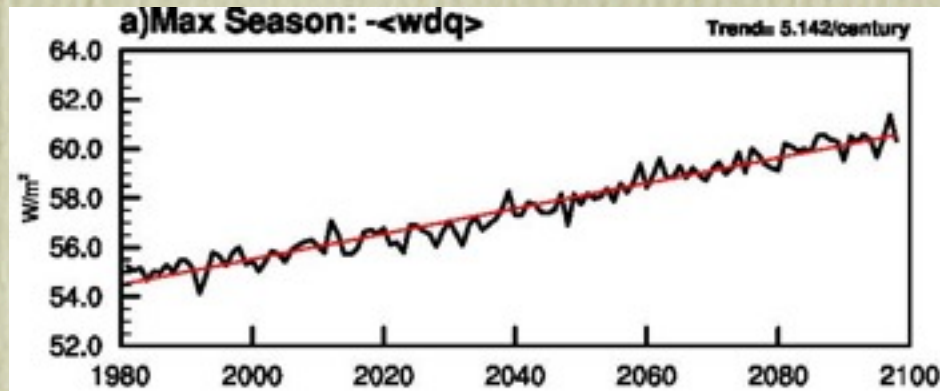
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$\langle q \rangle$

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Residual

dynamic
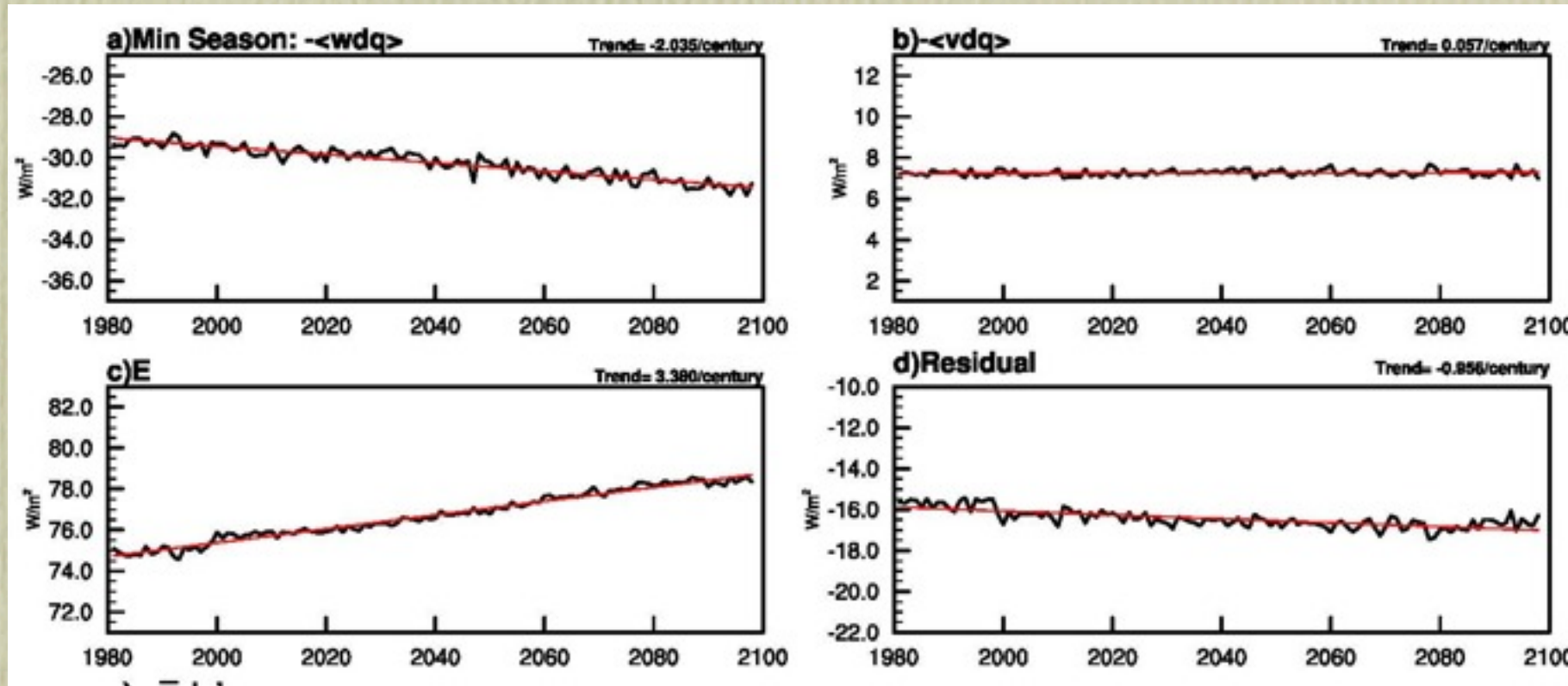
$\omega(500\text{hPa})$

water vapor budget in dry (min.) season

$-\langle \omega \partial q \rangle$

Evap

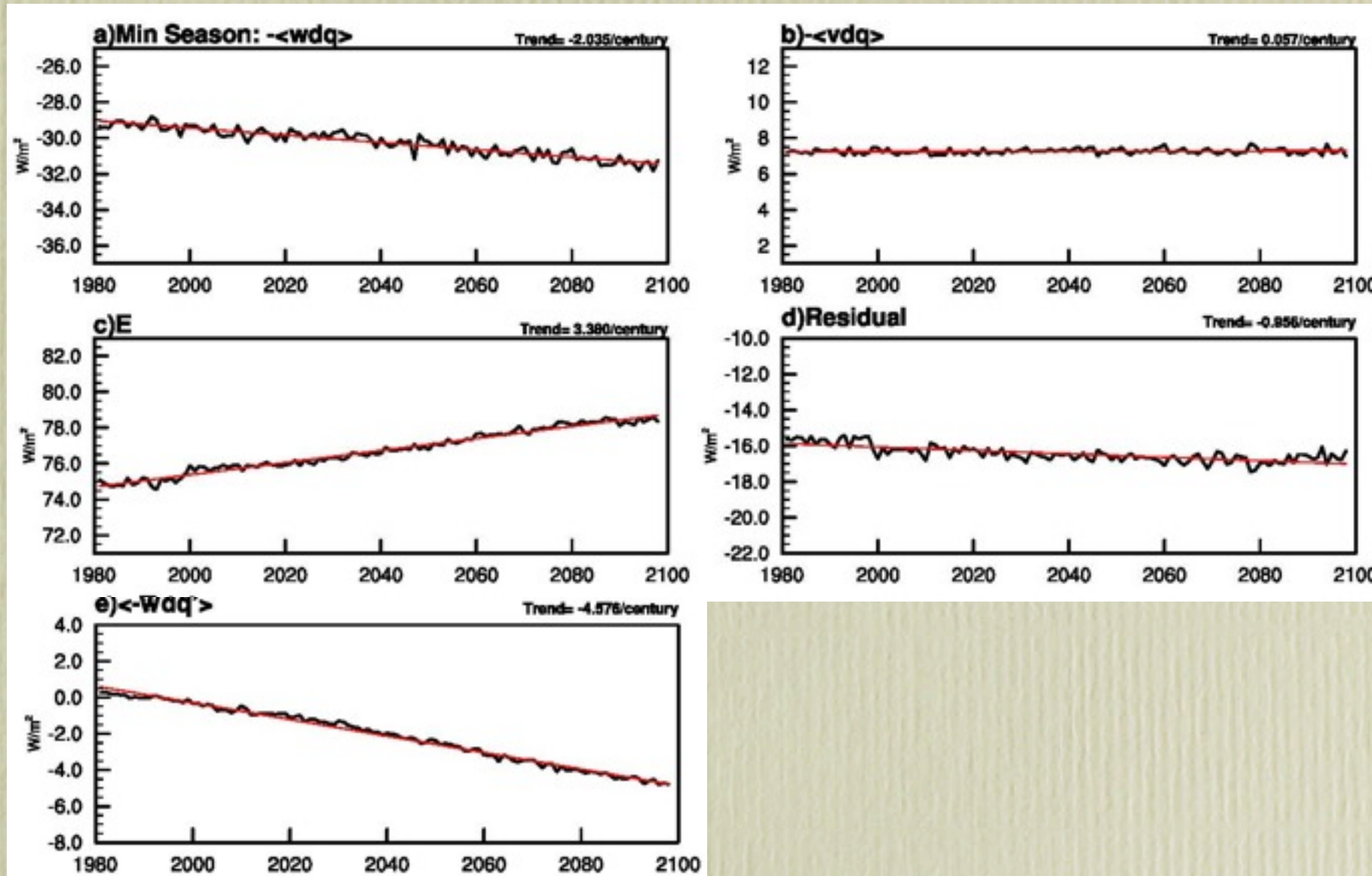$-\langle v \cdot \nabla q \rangle$

Residual

water vapor budget in dry (min.) season

$-\langle \omega \partial q \rangle$

Evap

thermo

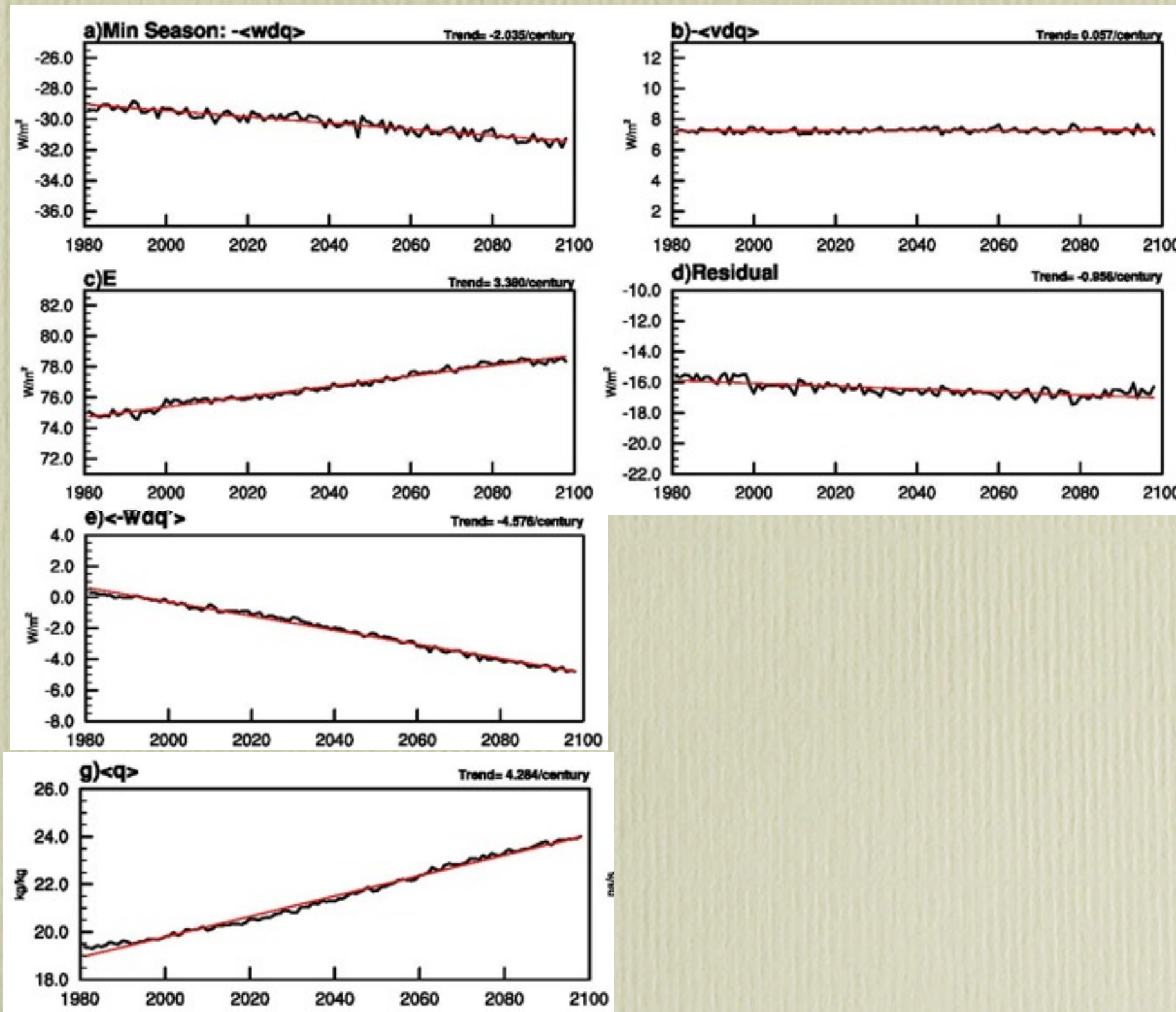$-\langle v \cdot \nabla q \rangle$

Residual
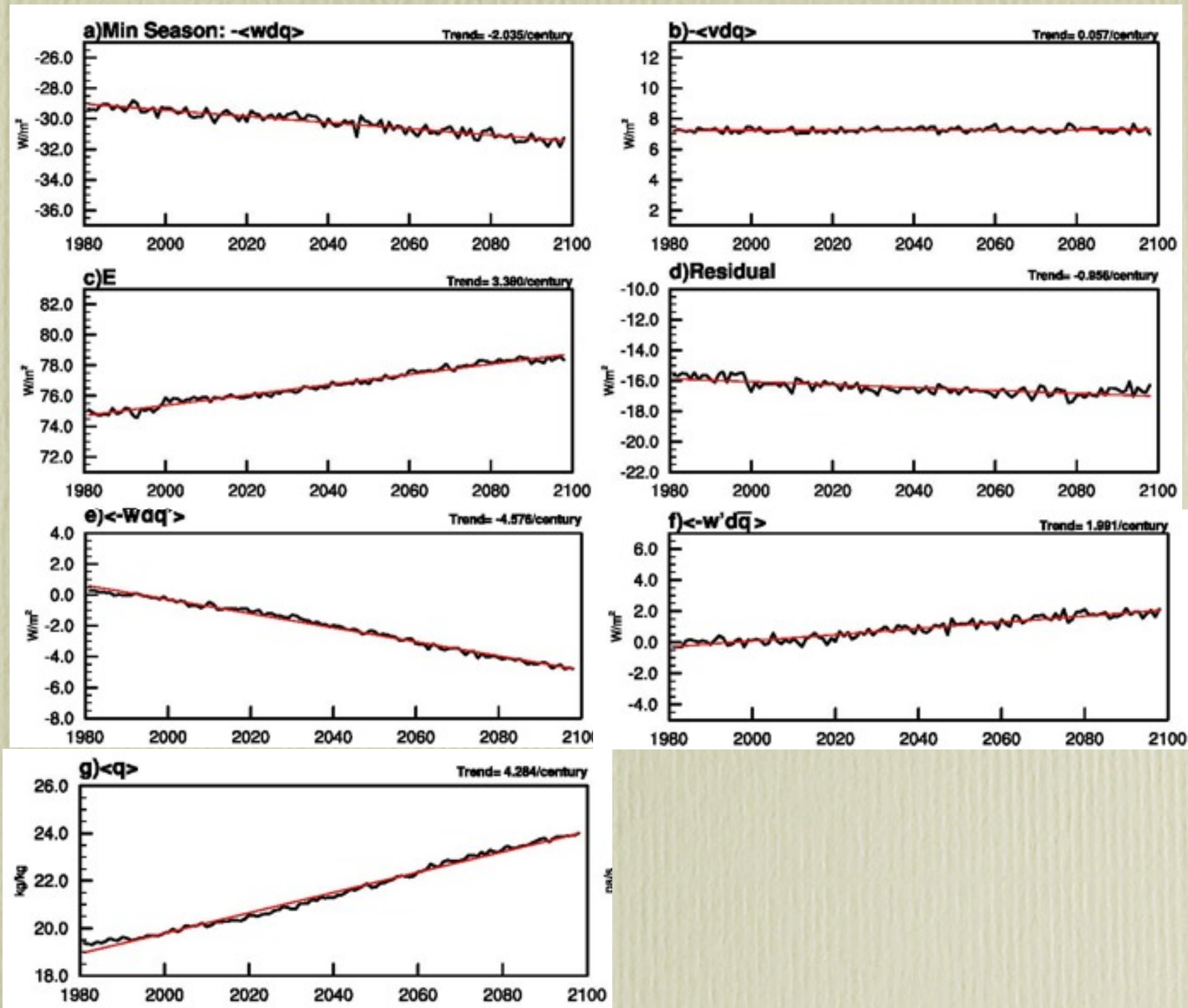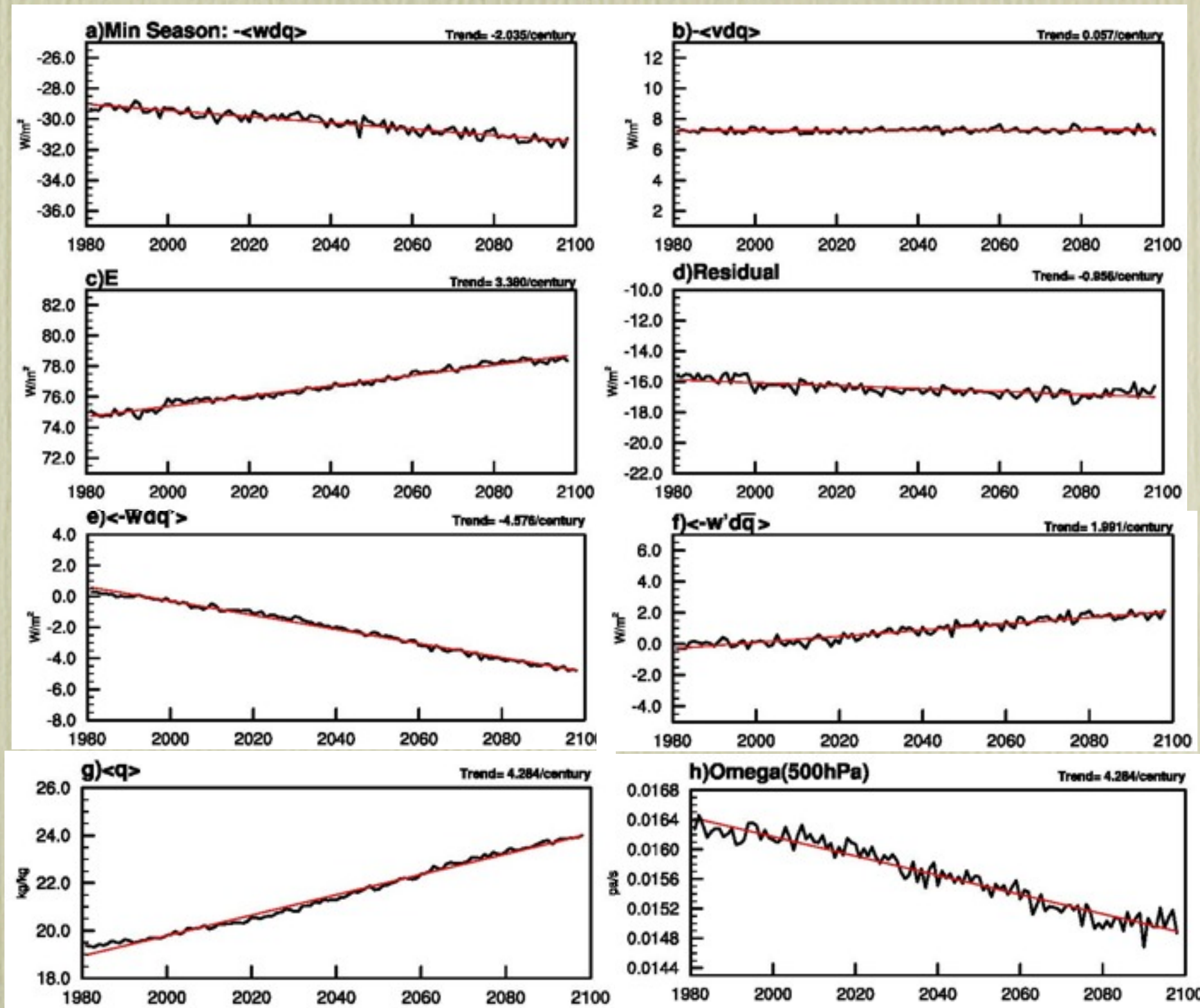
water vapor budget in dry (min.) season

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Evap

thermo

$\langle q\rangle$

$-\langle v\cdot\nabla q\rangle$

Residual

water vapor budget in dry (min.) season

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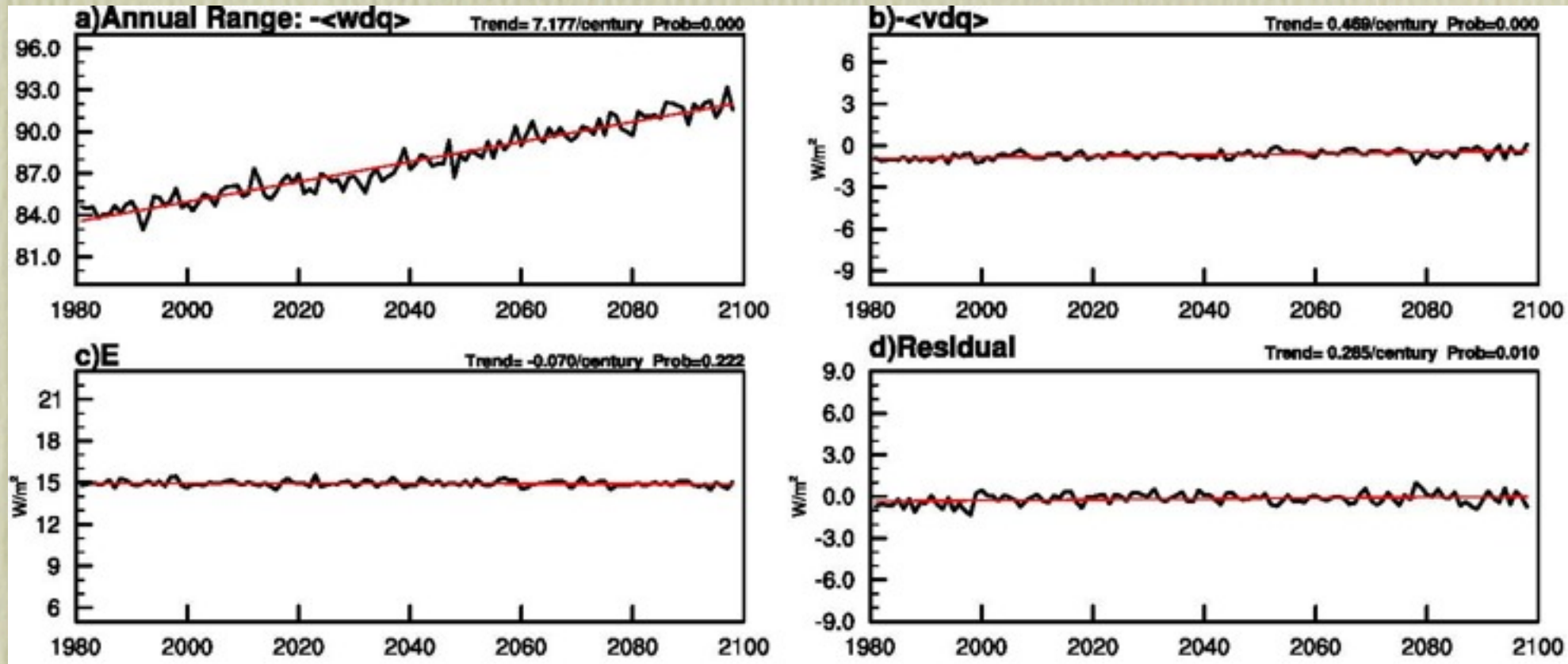

$-\langle v \cdot \nabla q \rangle$

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dynamic

$\omega(500\text{hPa})$

water vapor budget:
annual range of precipitation

$-\langle \omega \partial q \rangle$

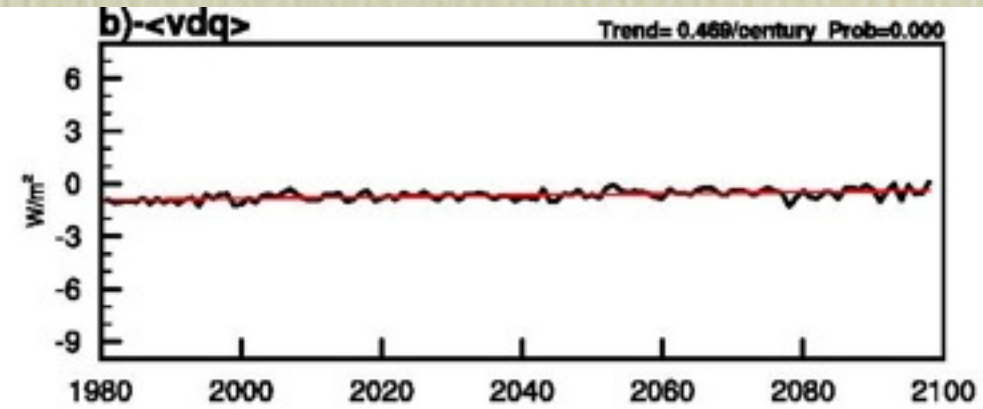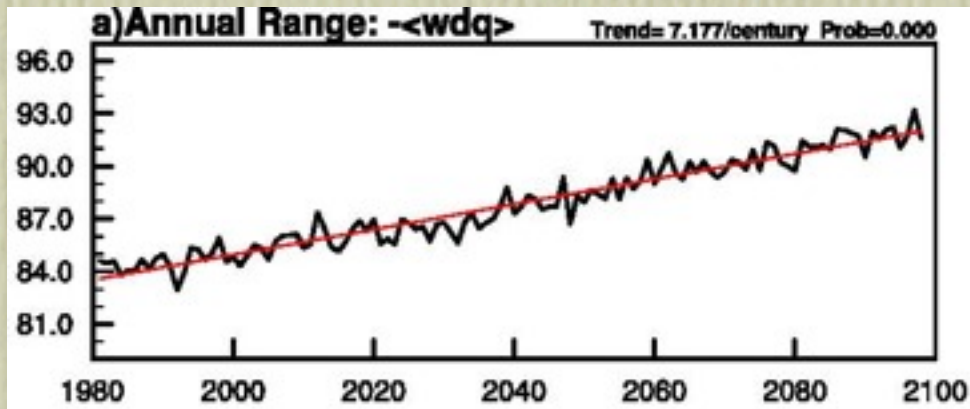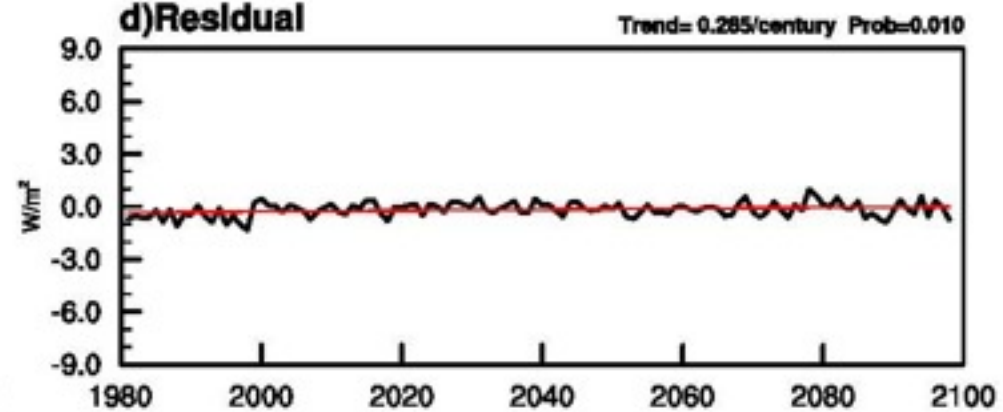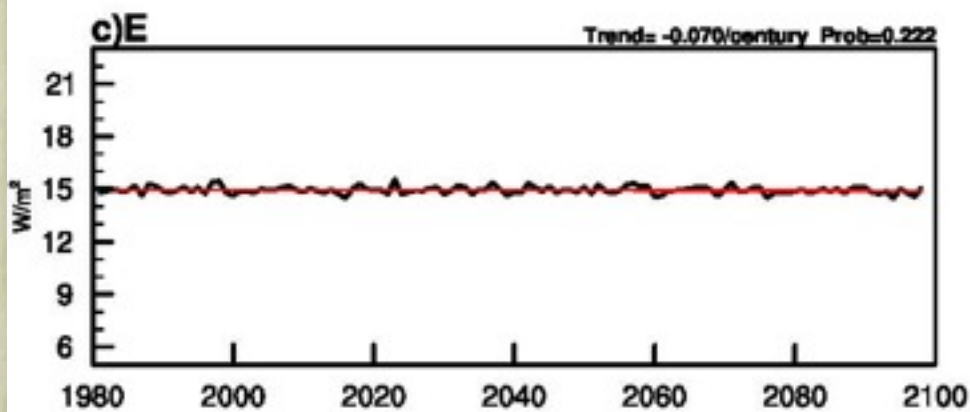$-\langle v \cdot \nabla q \rangle$

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water vapor budget:
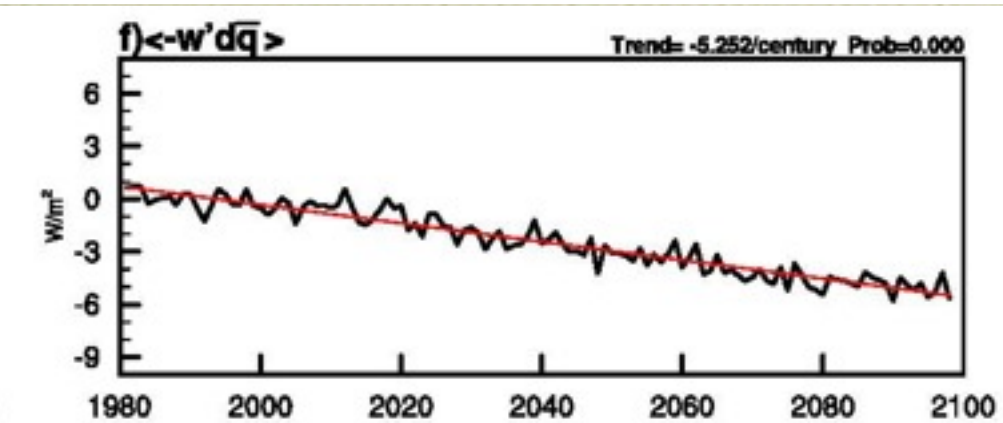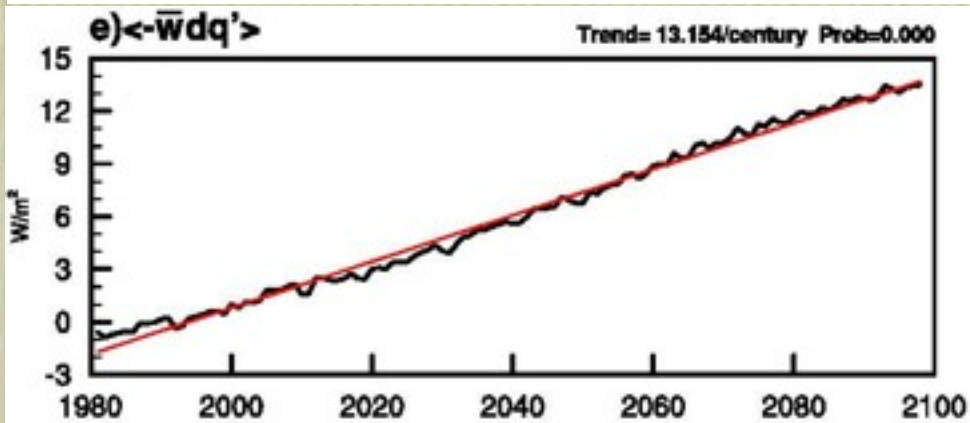# annual range of precipitation

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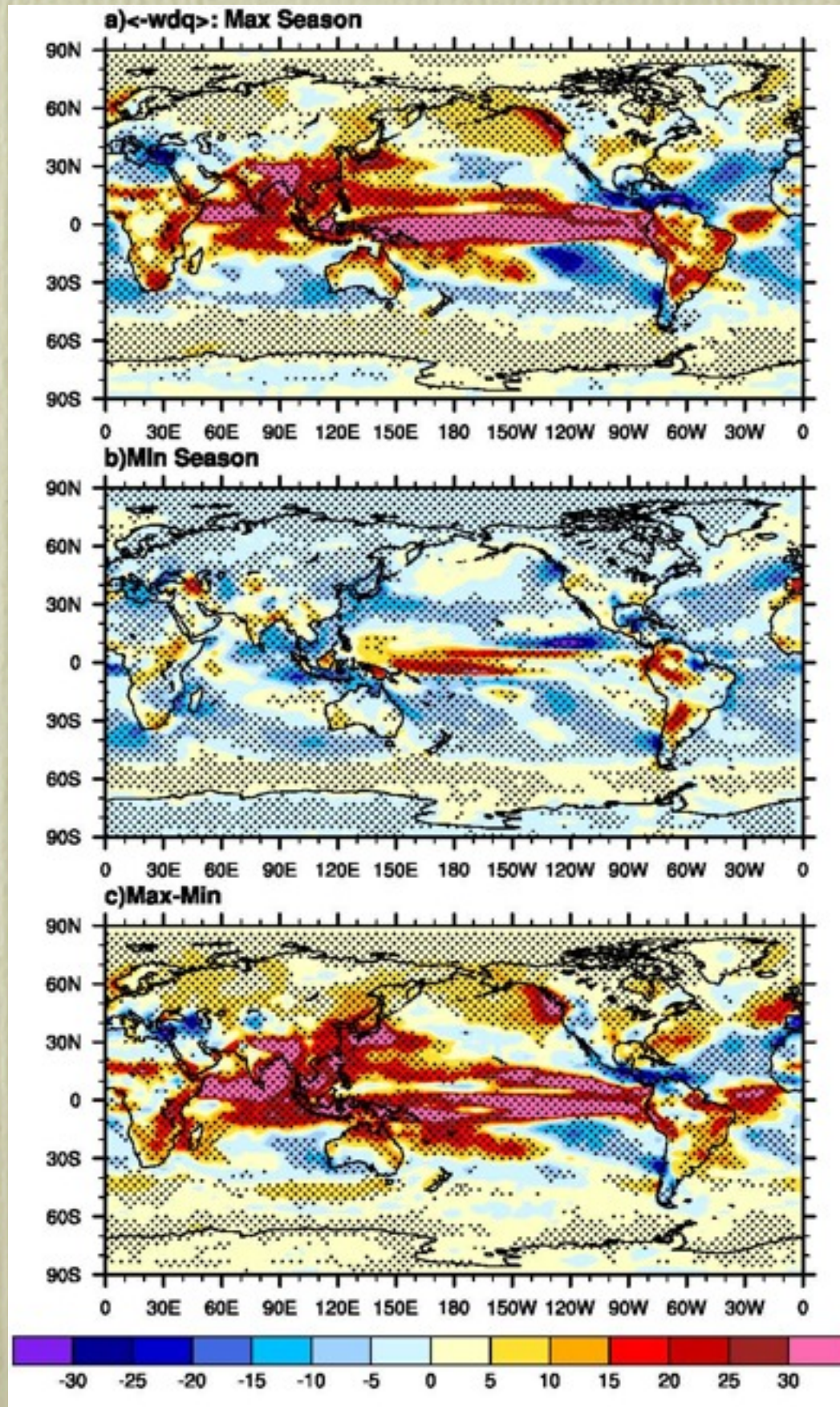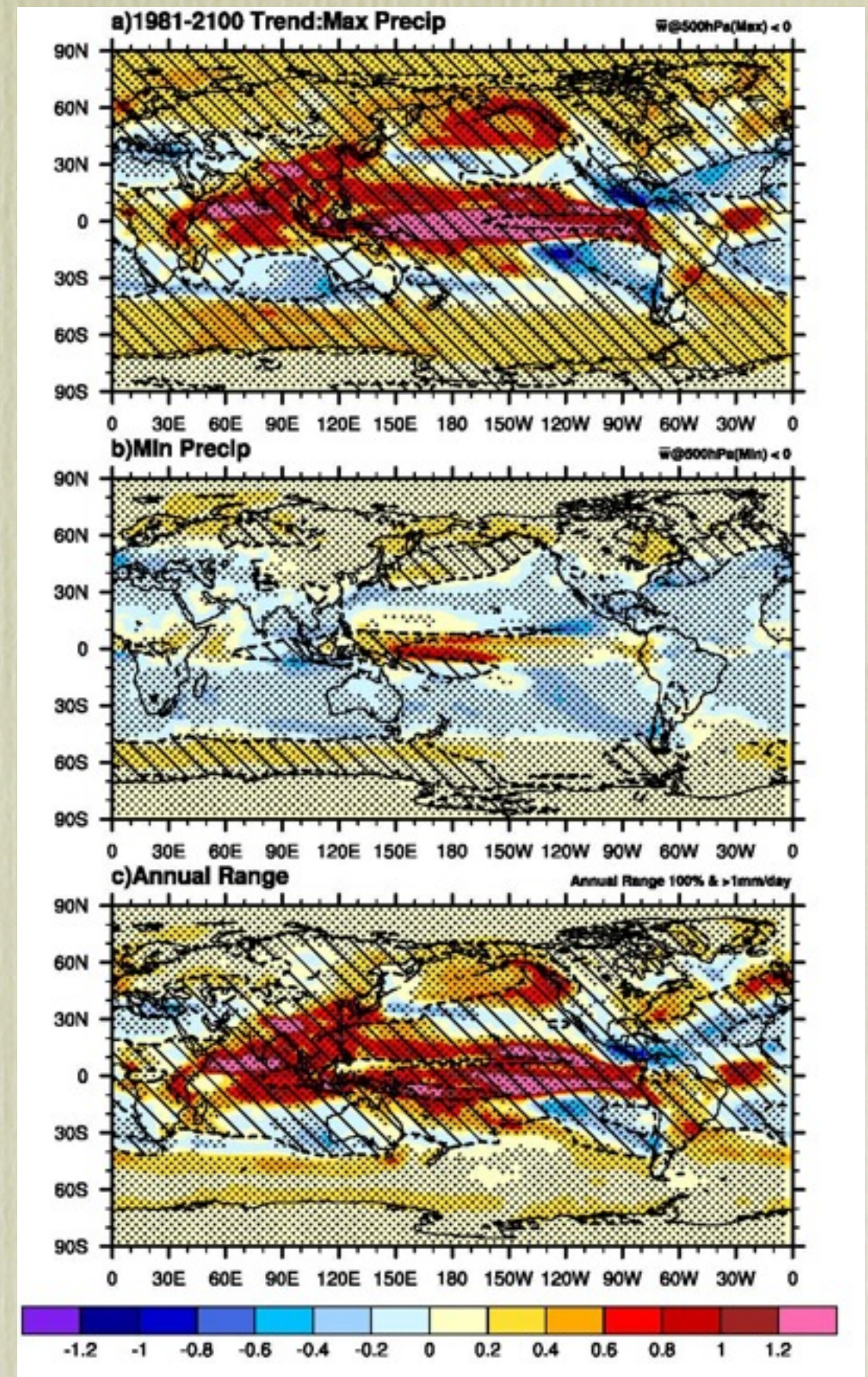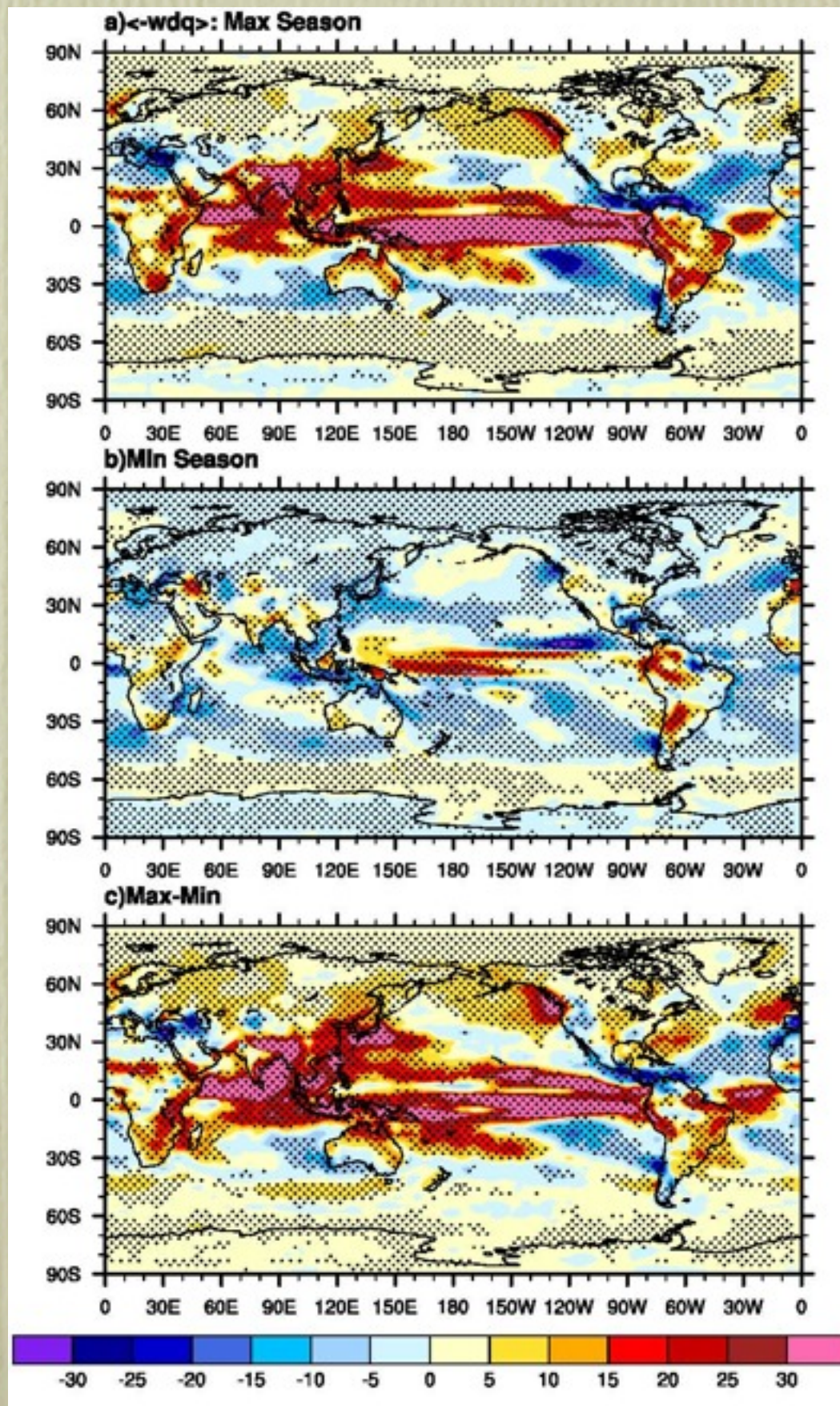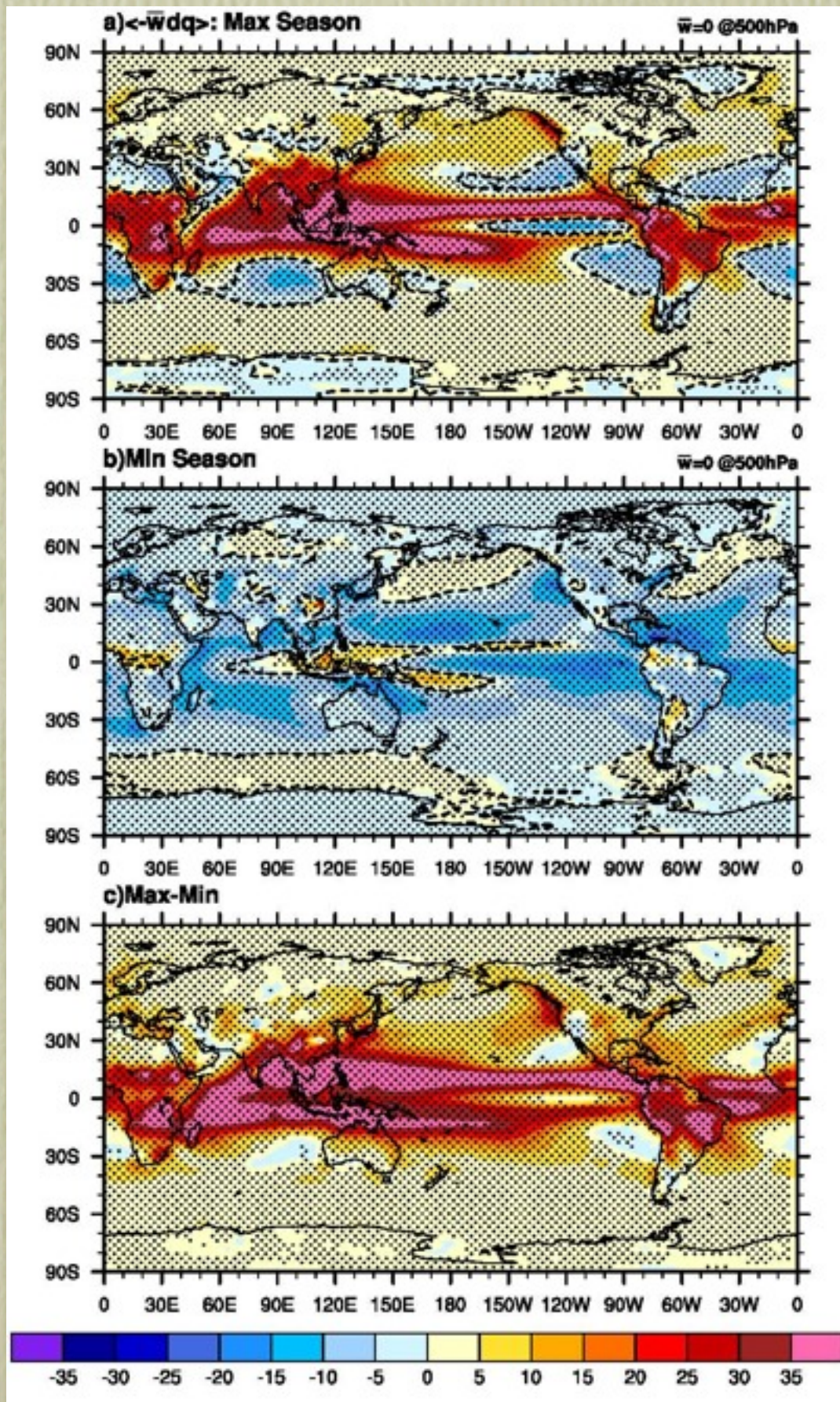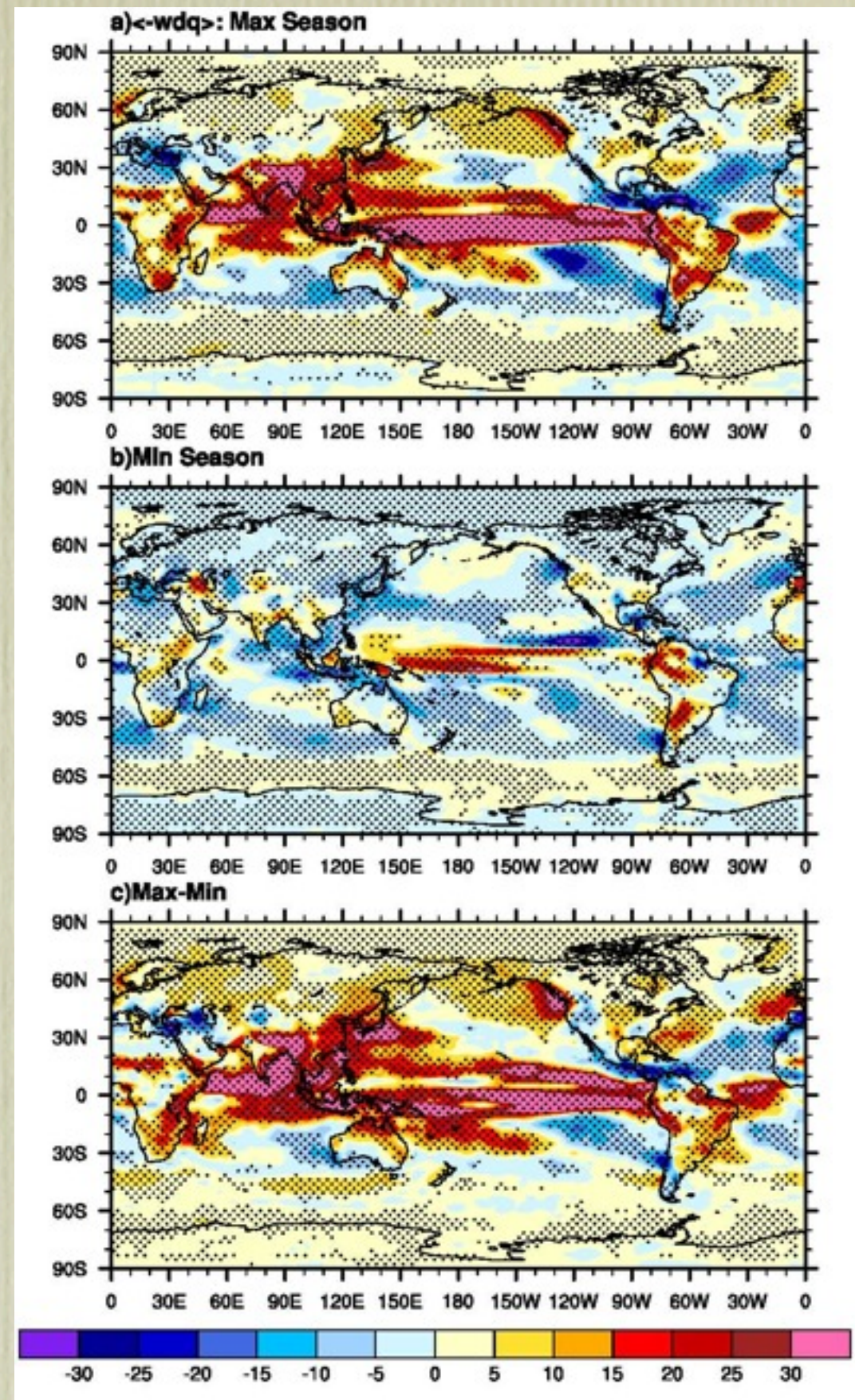
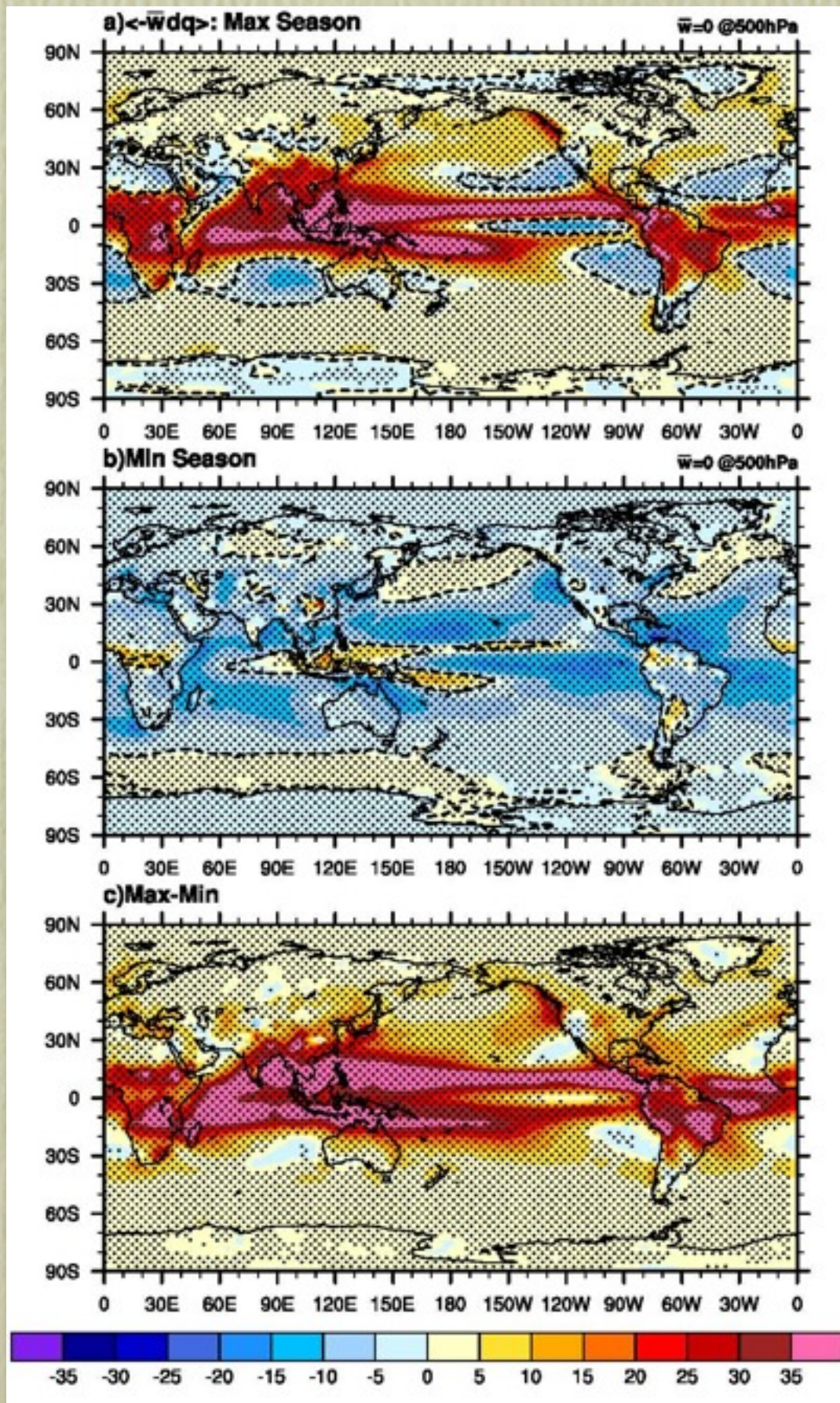thermo

dynamic

Vertical moisture advection
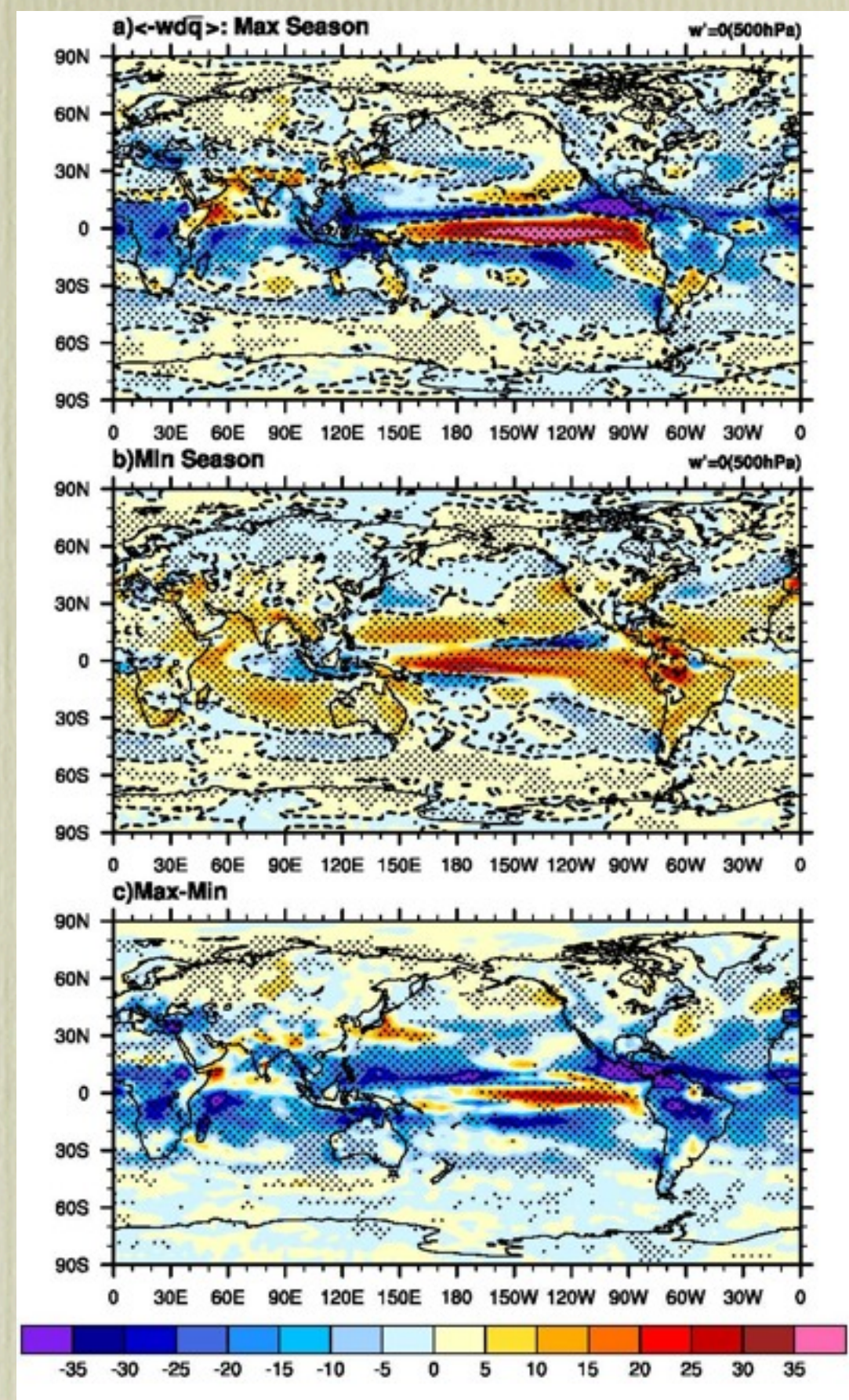
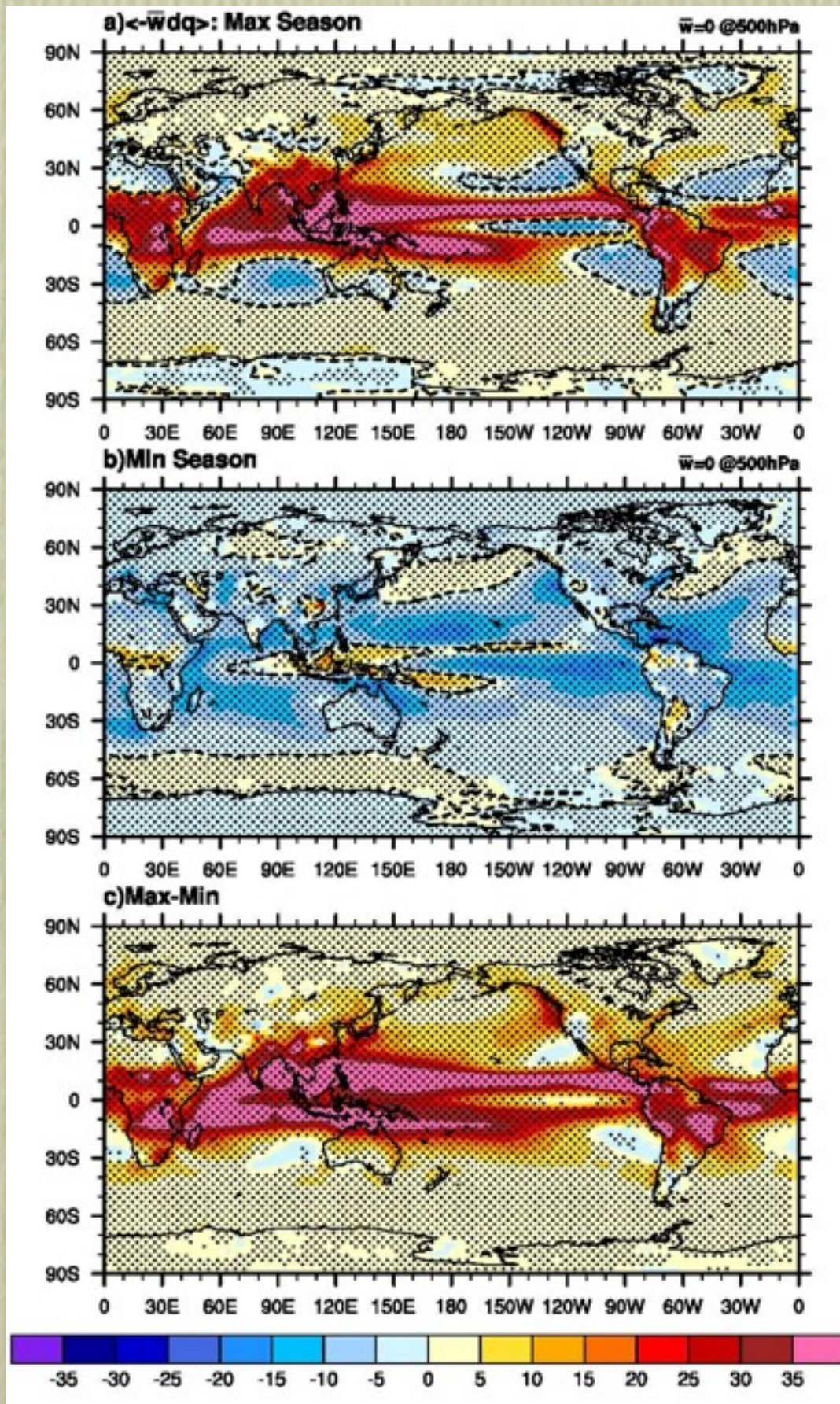# Vertical moisture advection

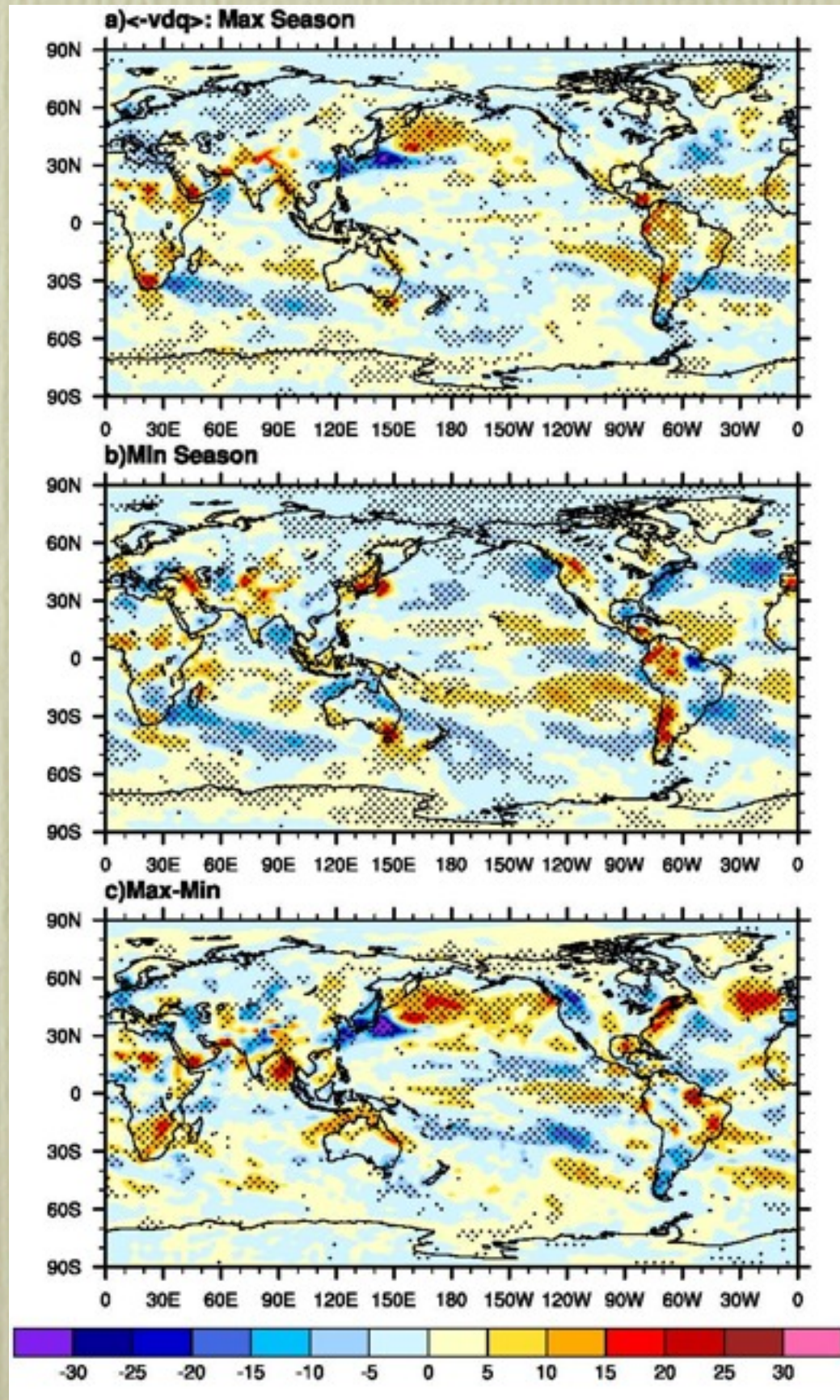# Thermodynamic

Thermodynamic

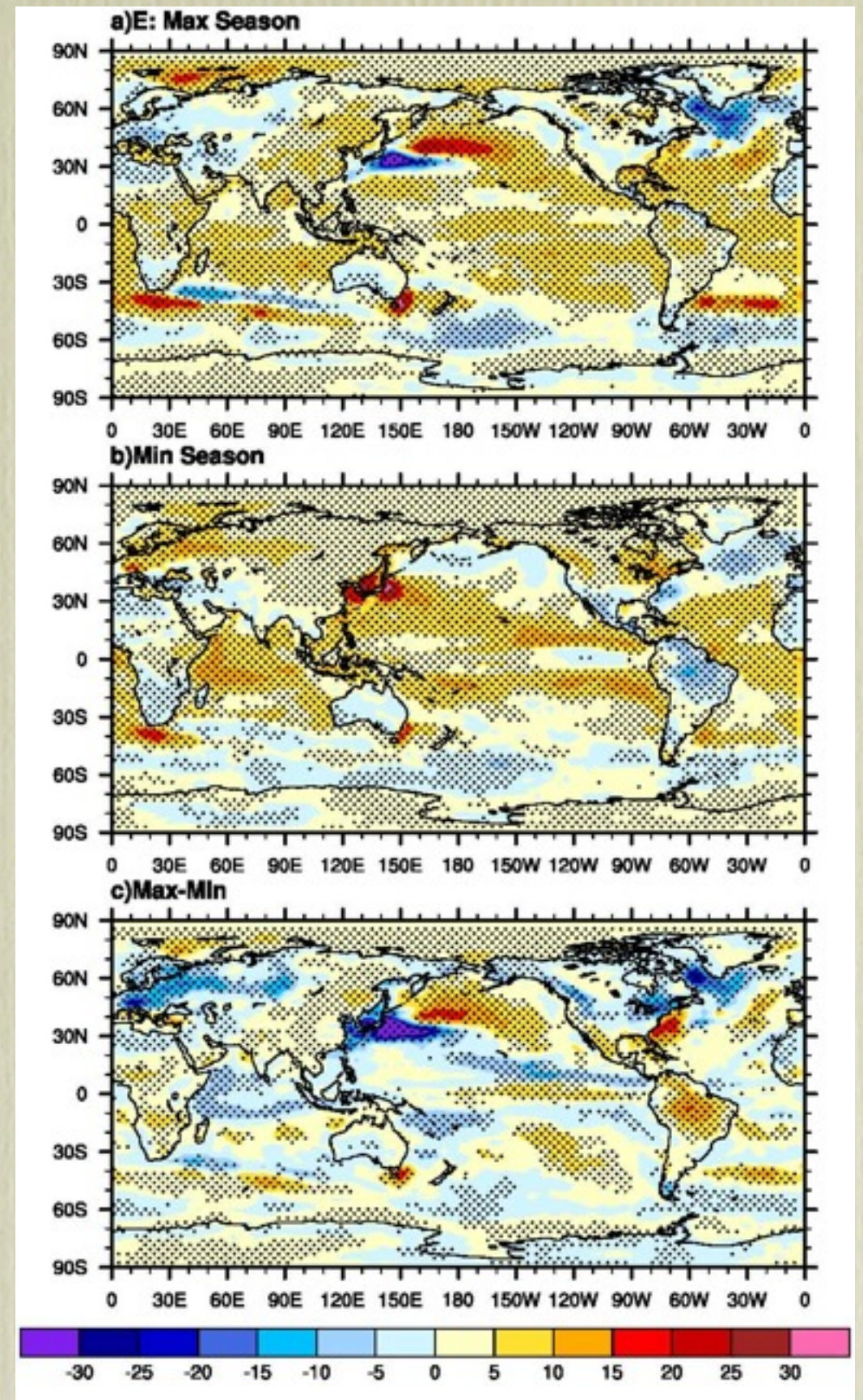# Thermodynamic

Dynamic

Horizontal moisture advection

Evaporation

Conclusions

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- Widening in the annual range of precipitation

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↪ wet season gets wetter and dry season gets slightly drier

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➙ wet season gets wetter and dry season gets slightly drier

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- Dynamic component opposes

Thank you