Why does ocean coupling improve the MJO?

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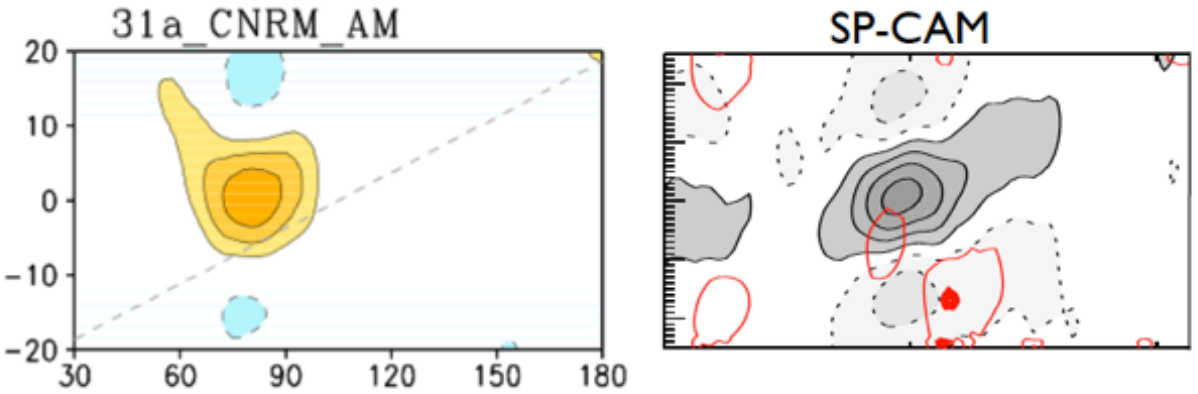
how can we understand the role of air-sea interaction on the simulation of the ISO?



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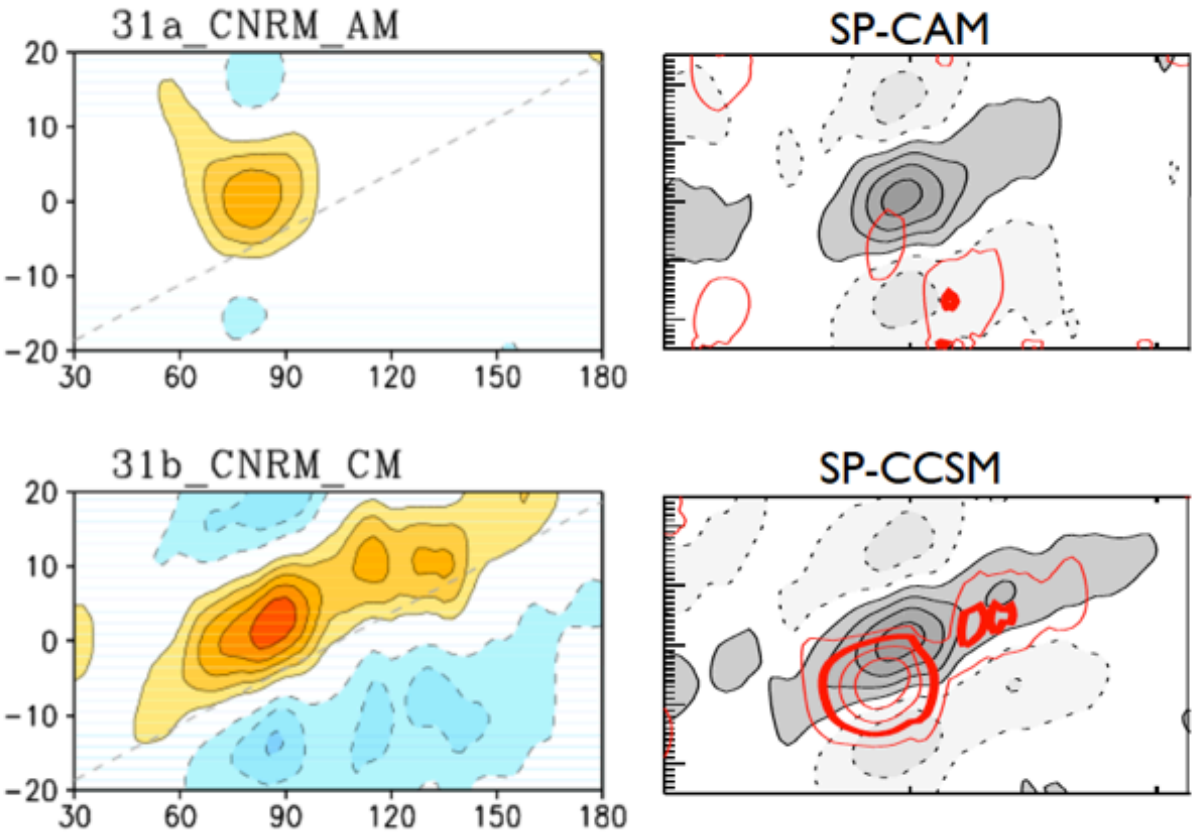
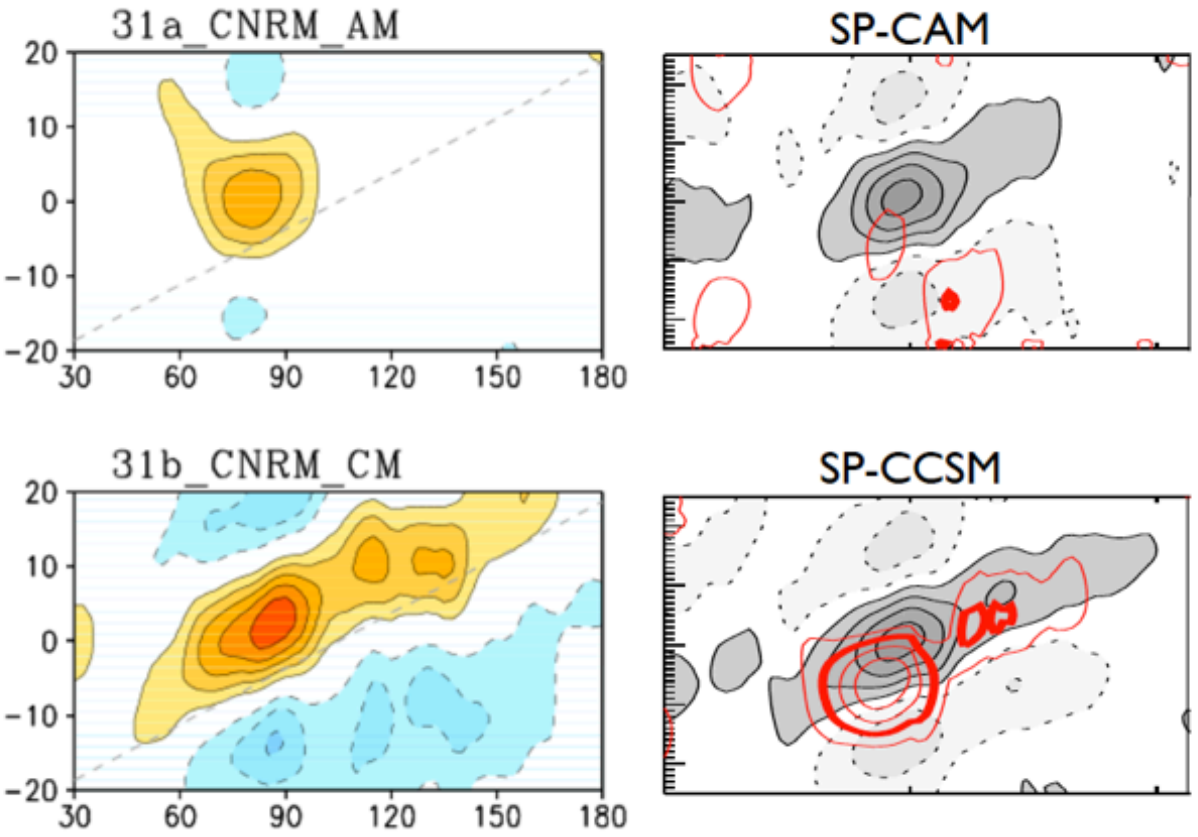


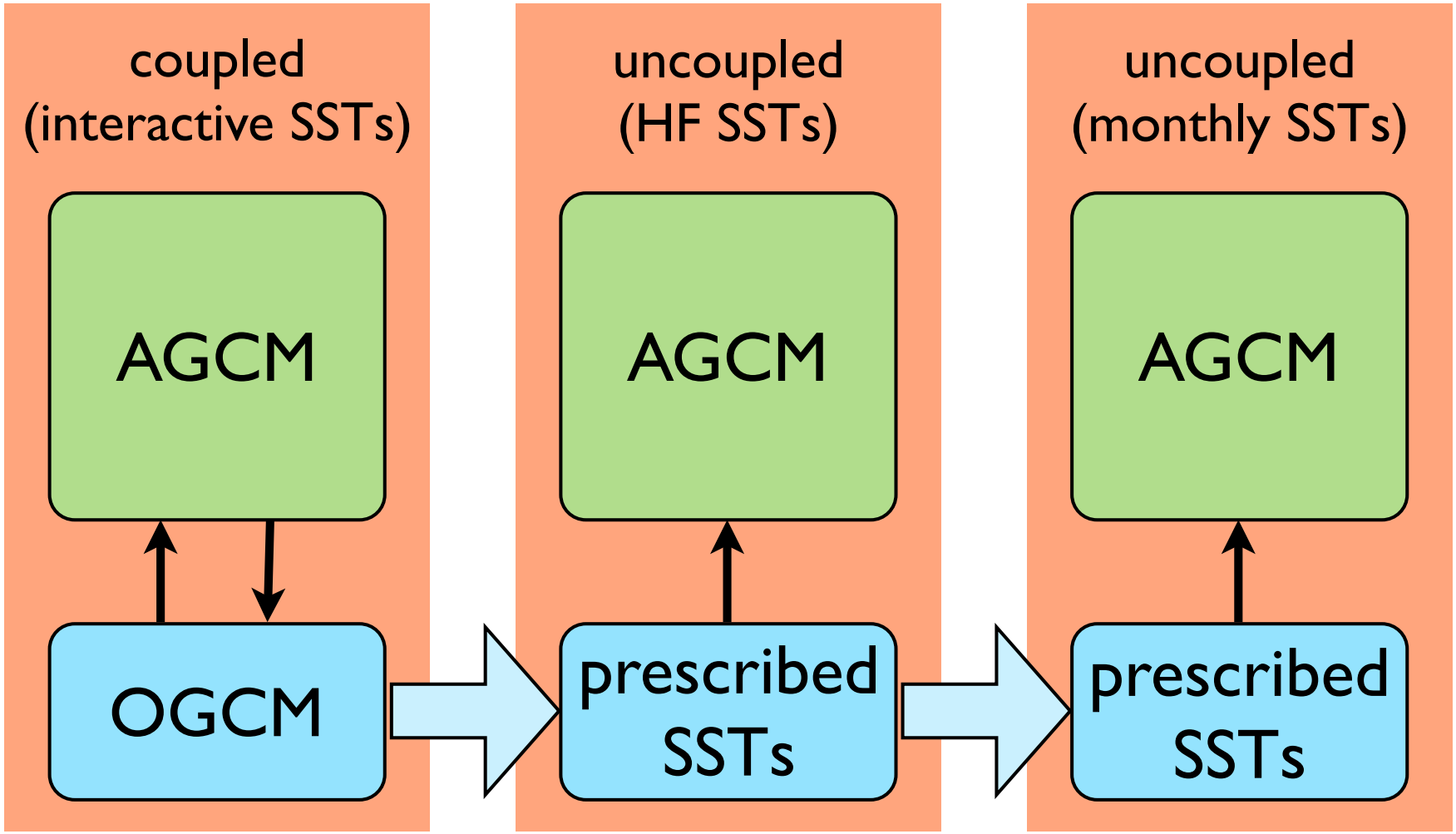
how can we understand the role of air-sea interaction on the simulation of the ISO?



CNRM analysis
by Xianan Jiang

model physics differences cloud the issue

experimental design



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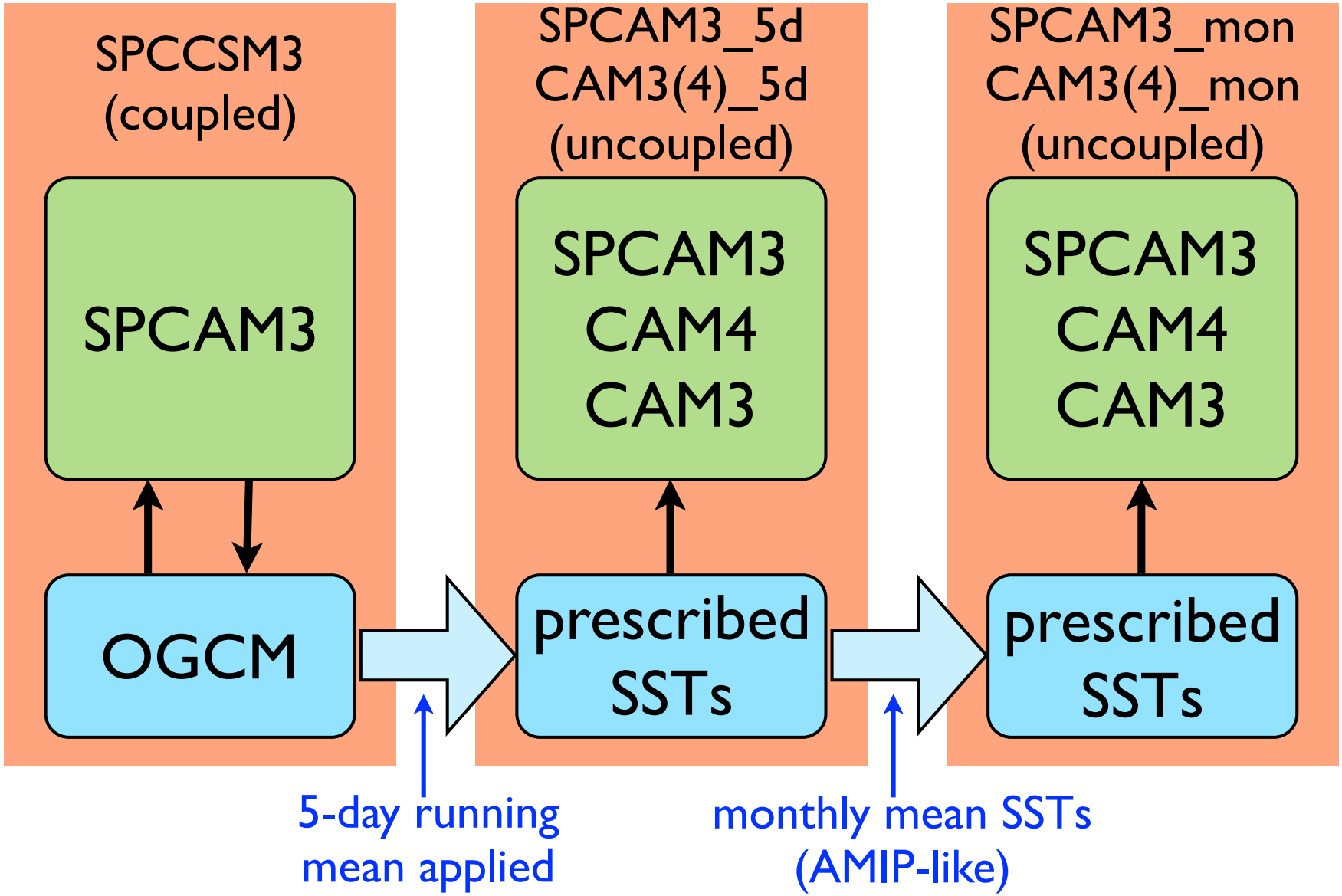
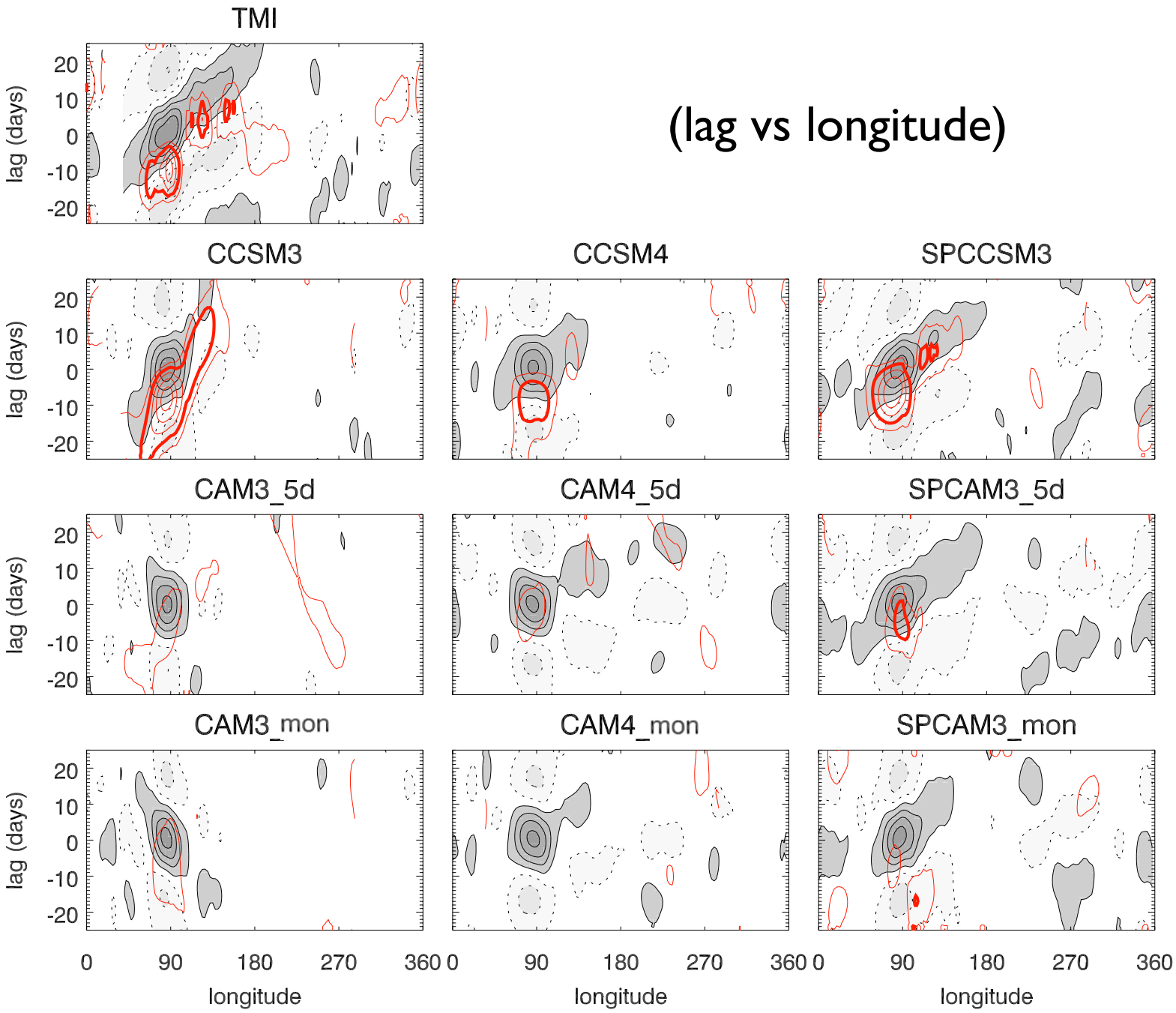


rainfall and SST anomaly lag-correlation (all seasons)



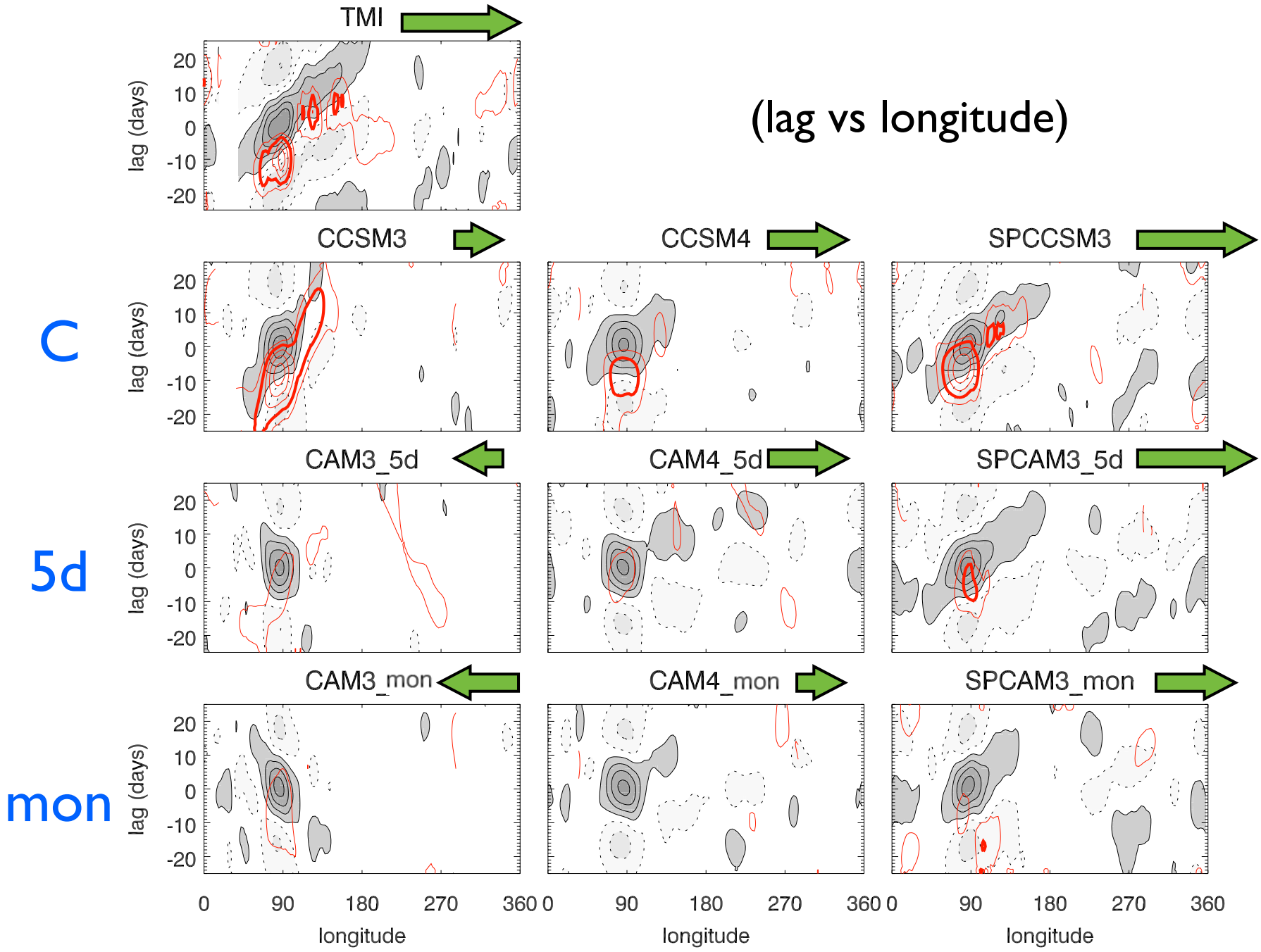
(lag vs longitude)

C

5d

mon

rainfall and SST anomaly lag-correlation (all seasons)



the atmosphere senses SST anomalies
via surface fluxes.

$$lh \sim \Delta q^* |V|$$

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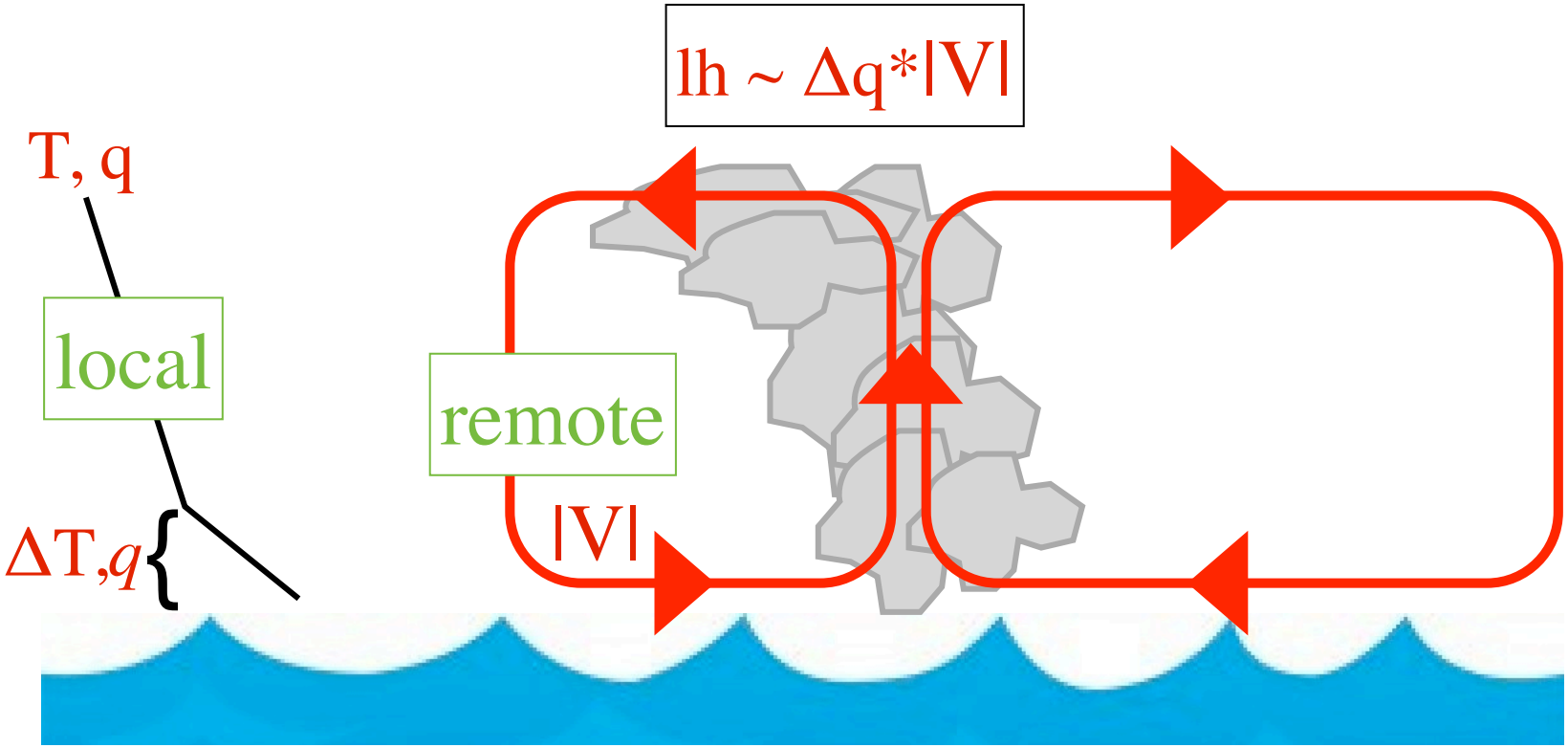
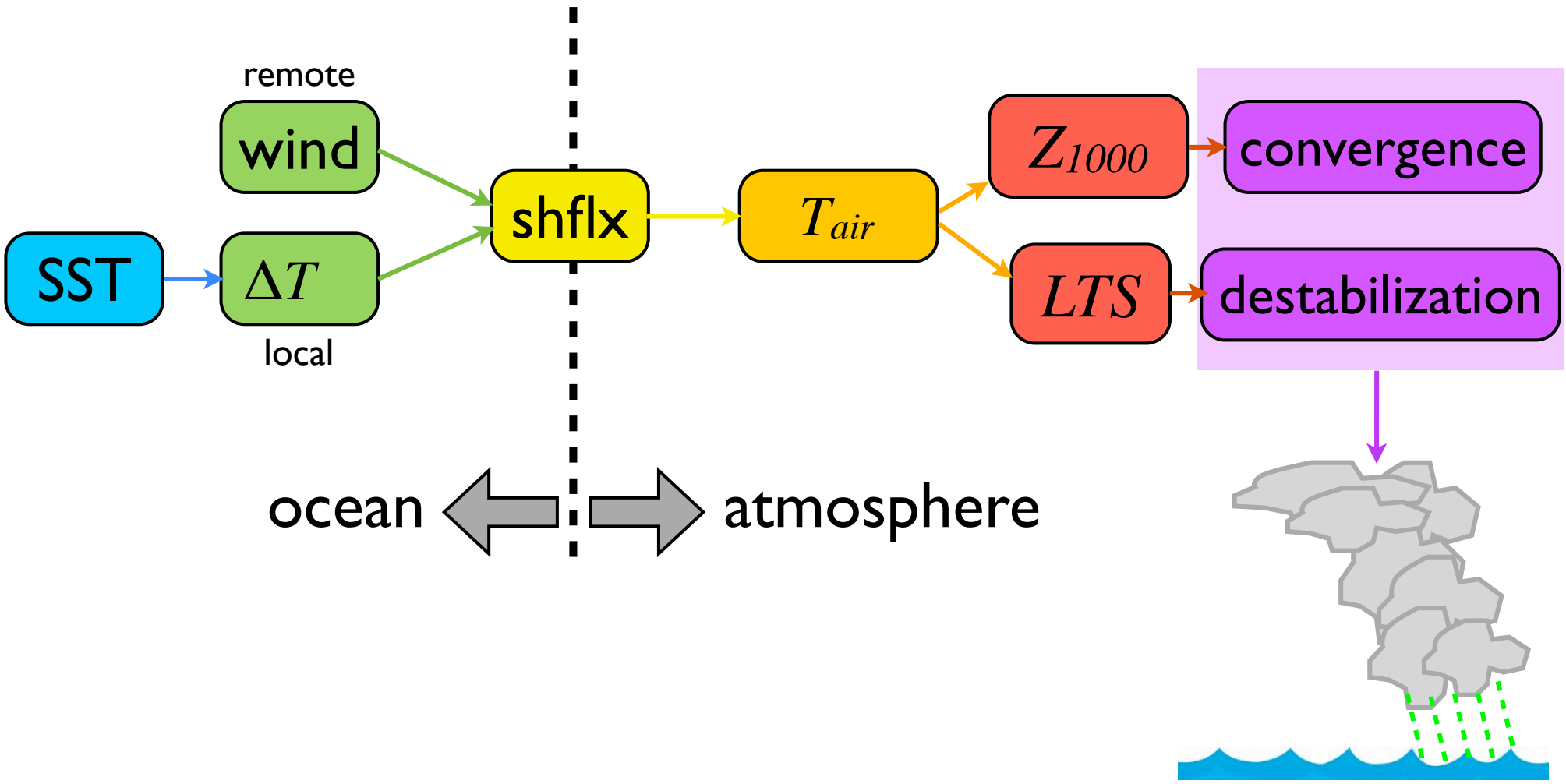


tropical air-sea interaction



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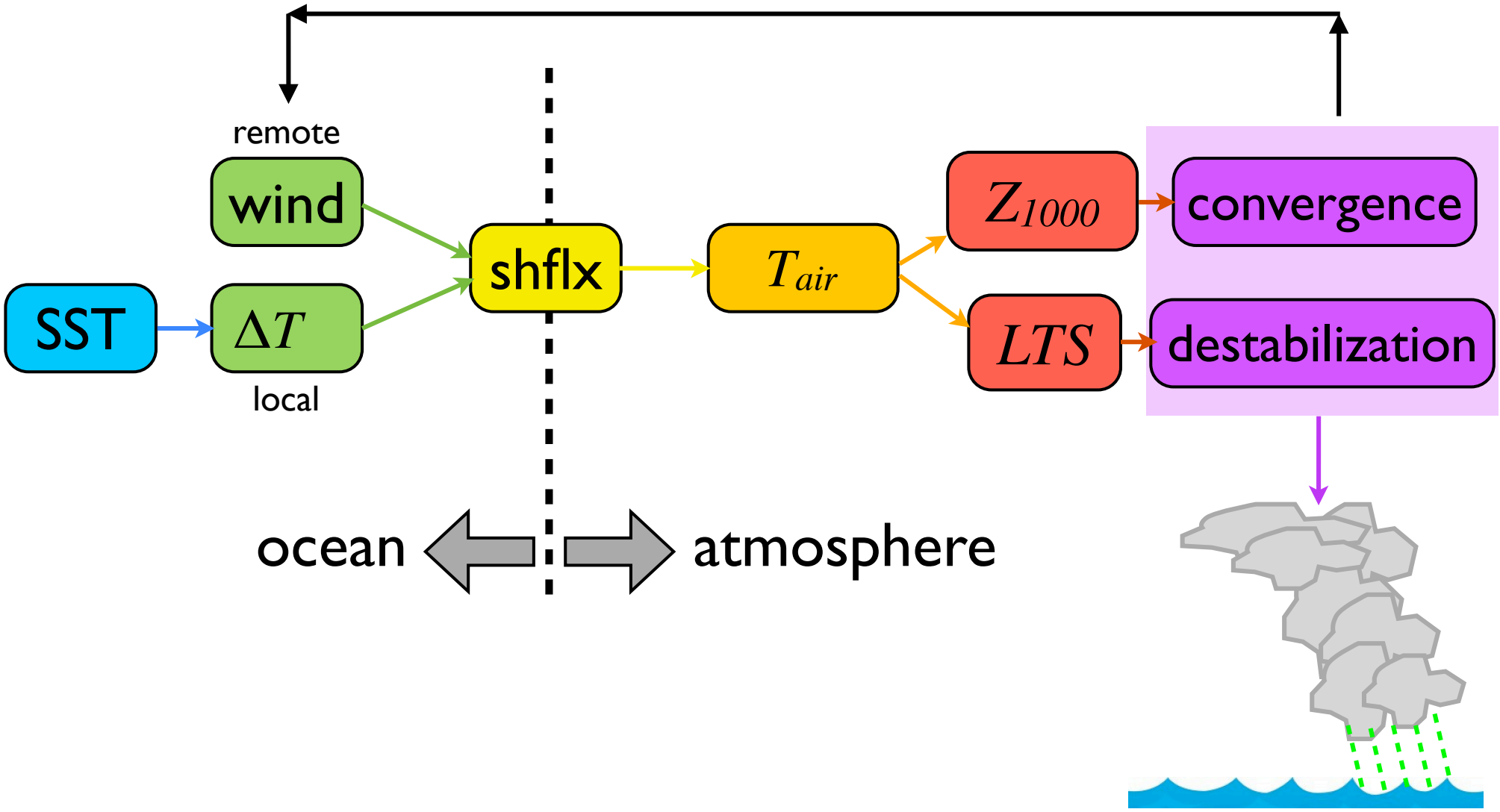

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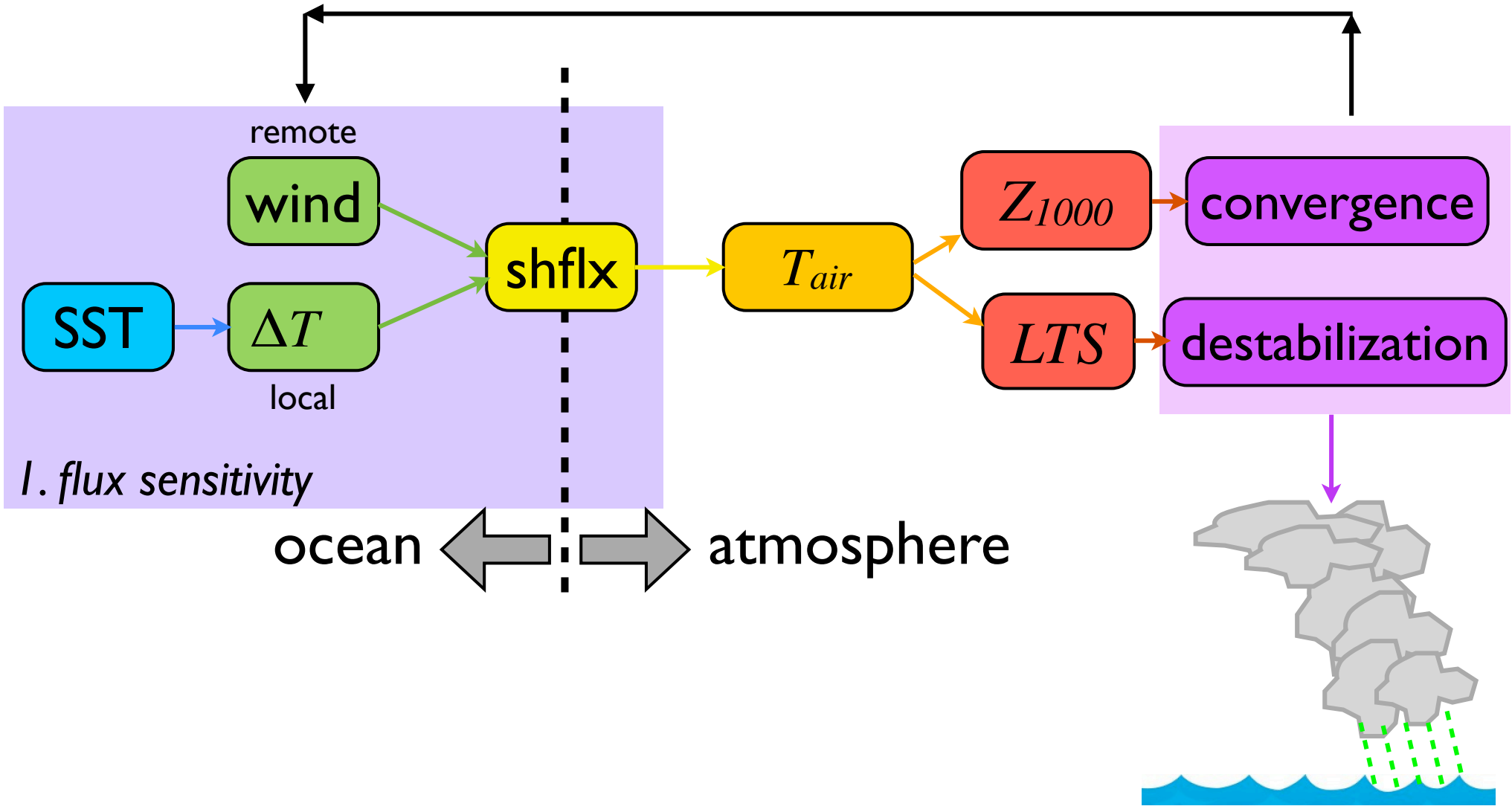

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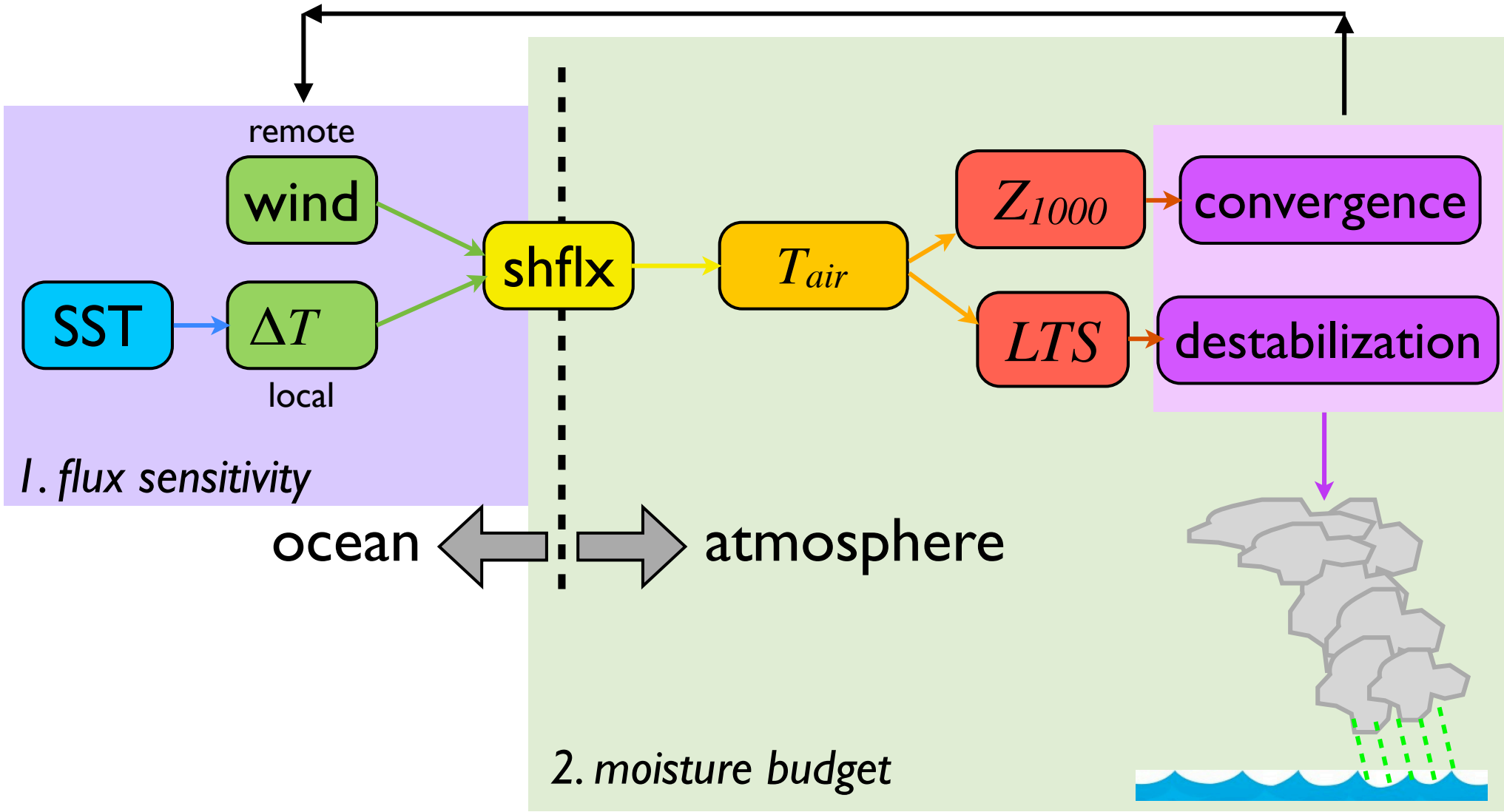
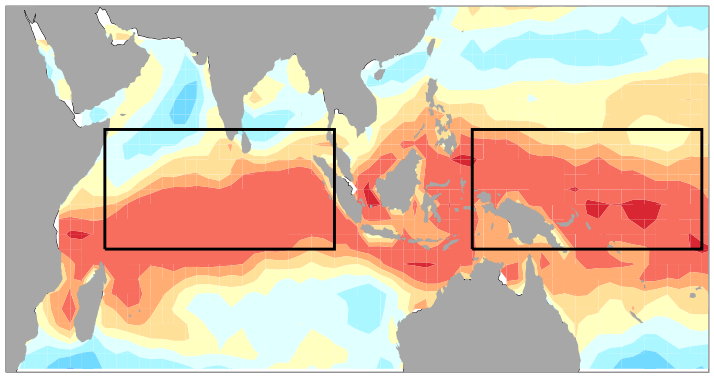


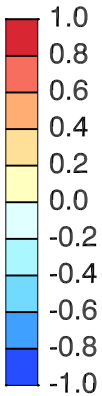
1. surface flux sensitivity

local vs remote control of surface fluxes

ERAI DJF

LH ratio difference: |V|' - (Δq')

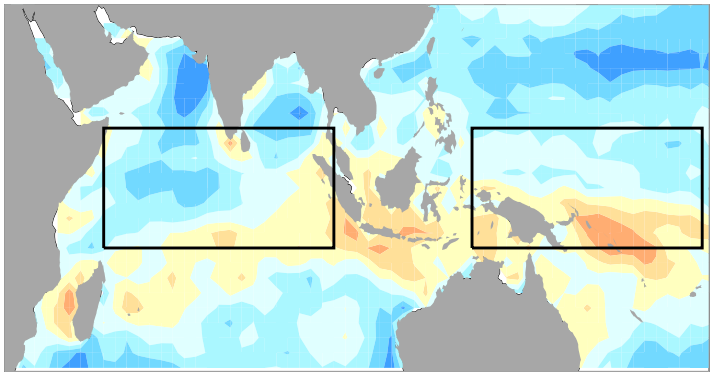


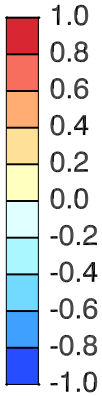


wind dominates

$\Delta T,q$ dominates

SH ratio difference: |V|' - (ΔT')





local vs remote control of surface fluxes

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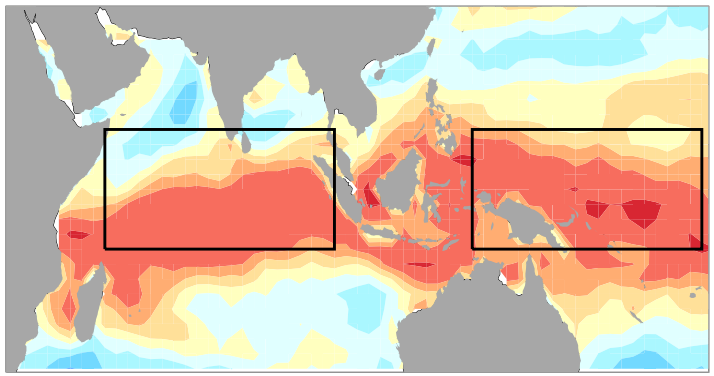

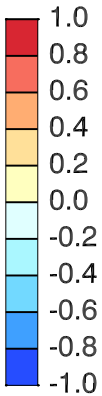

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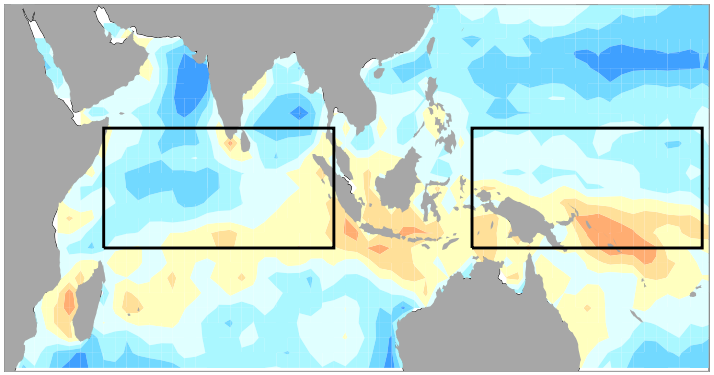
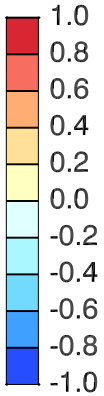
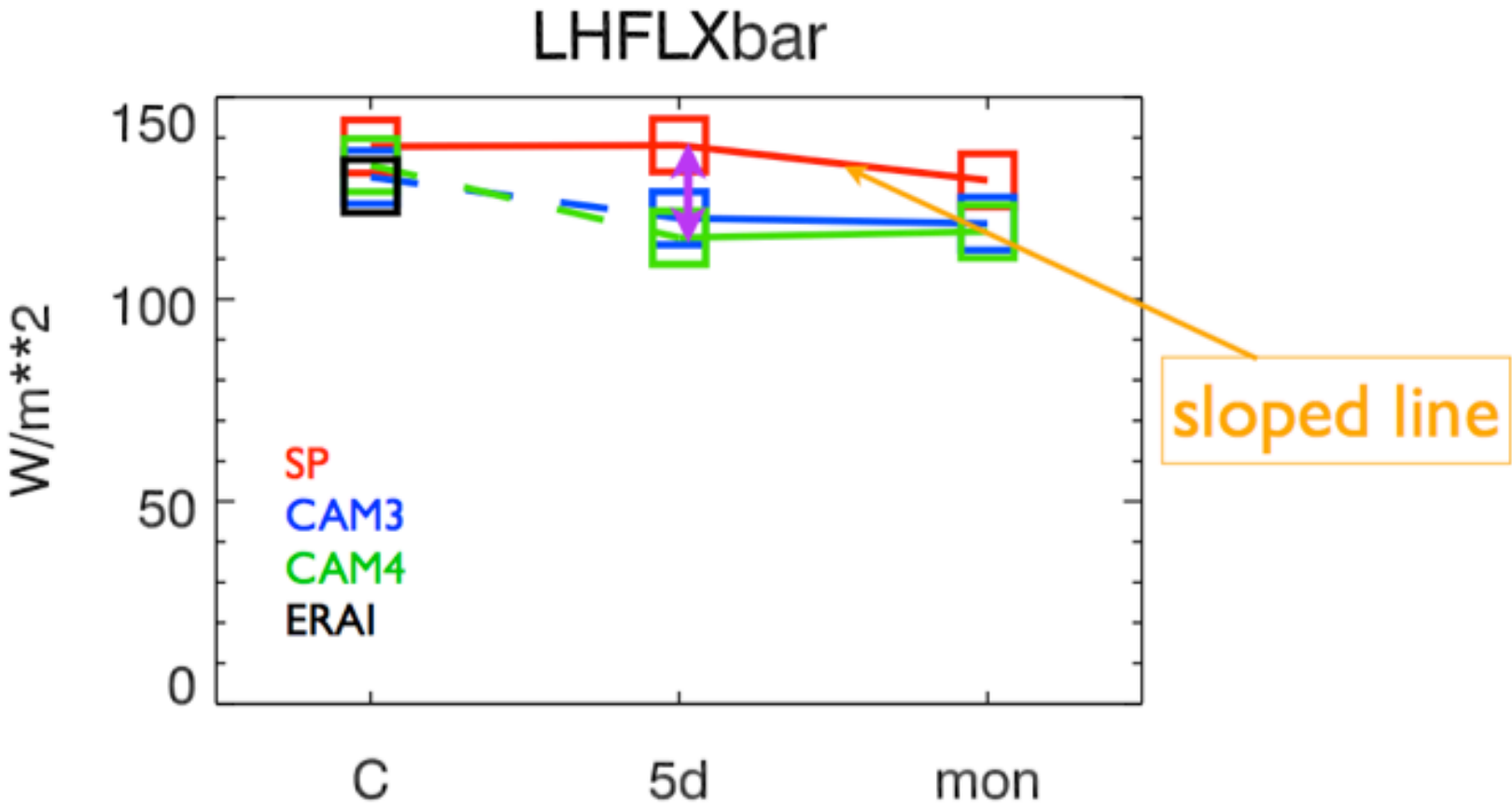




- how sensitive are local and remote effects to SST?
- for observations and models?

we will focus on the average over the **Indian Ocean**

“box” diagrams



vertical offsets: arise from model physics

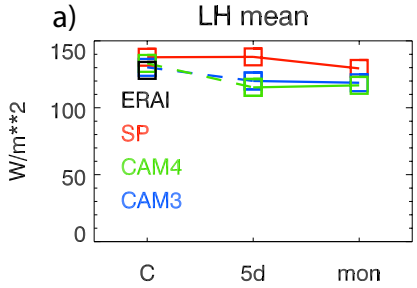
slopes of solid lines: arise from ocean treatment

slopes of dashed lines: may arise from both

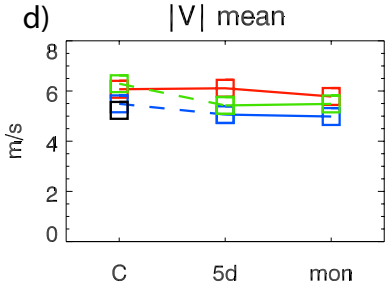
Indian Ocean latent heat flux relationships

mean

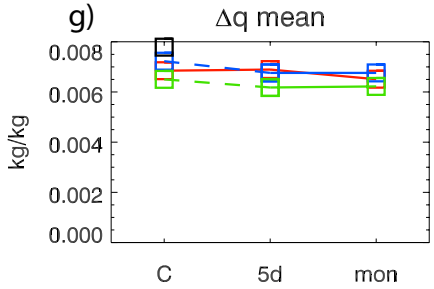
lh



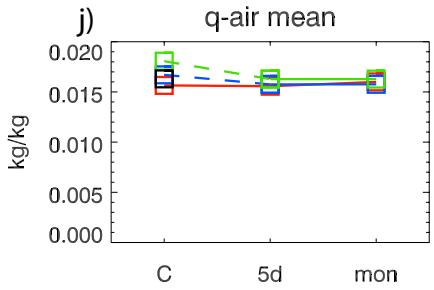
|V|



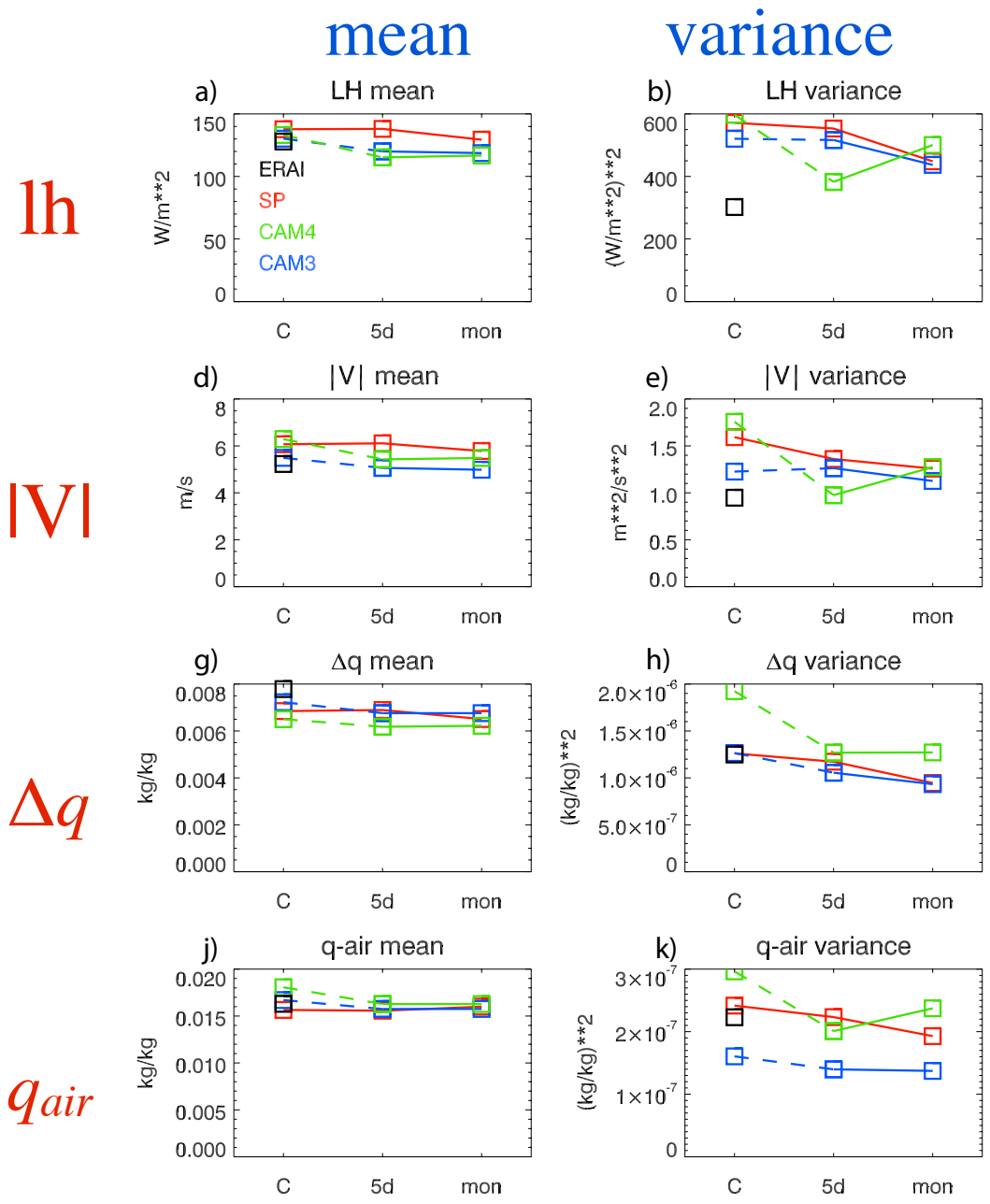
Δq



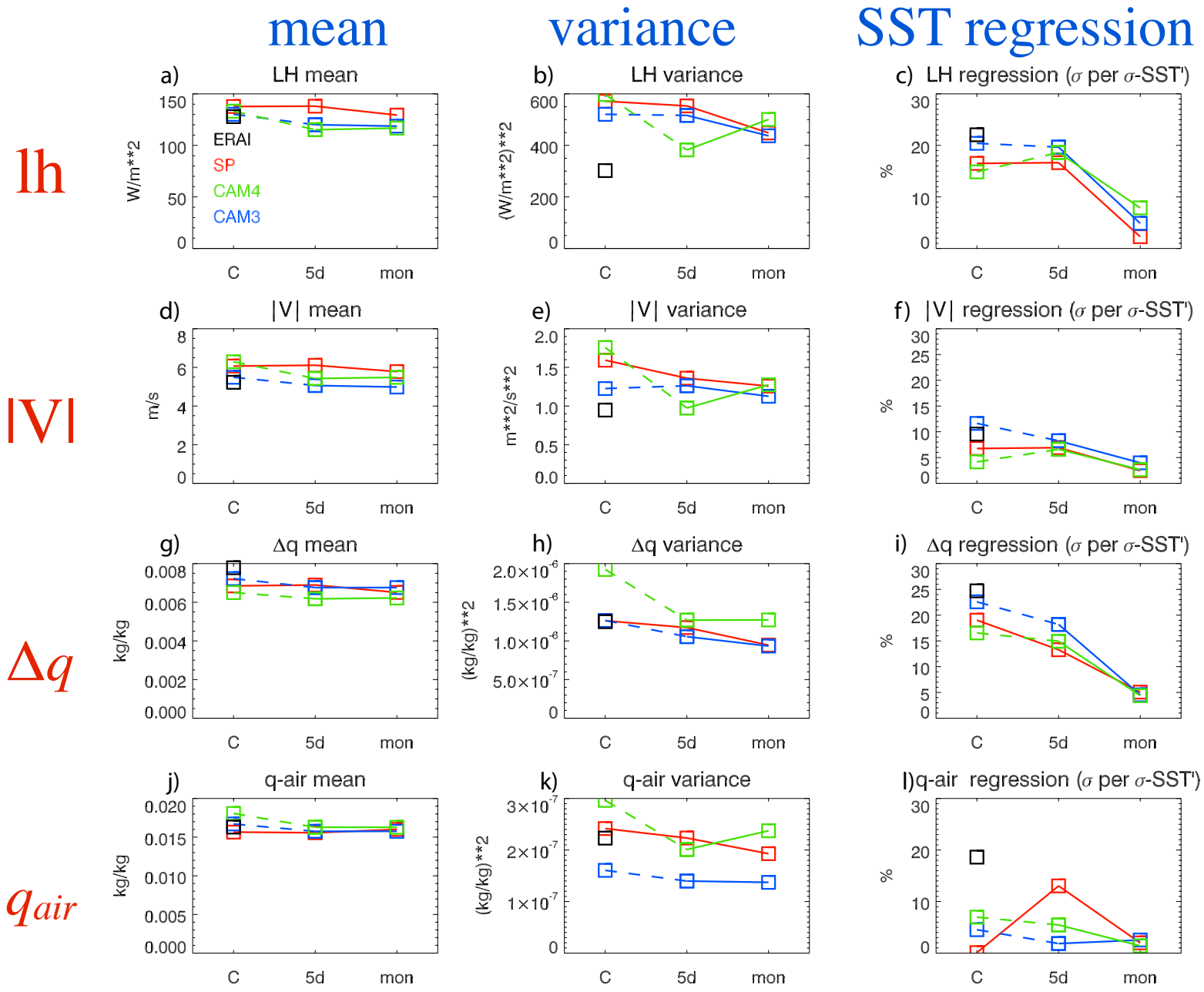
q_{air}



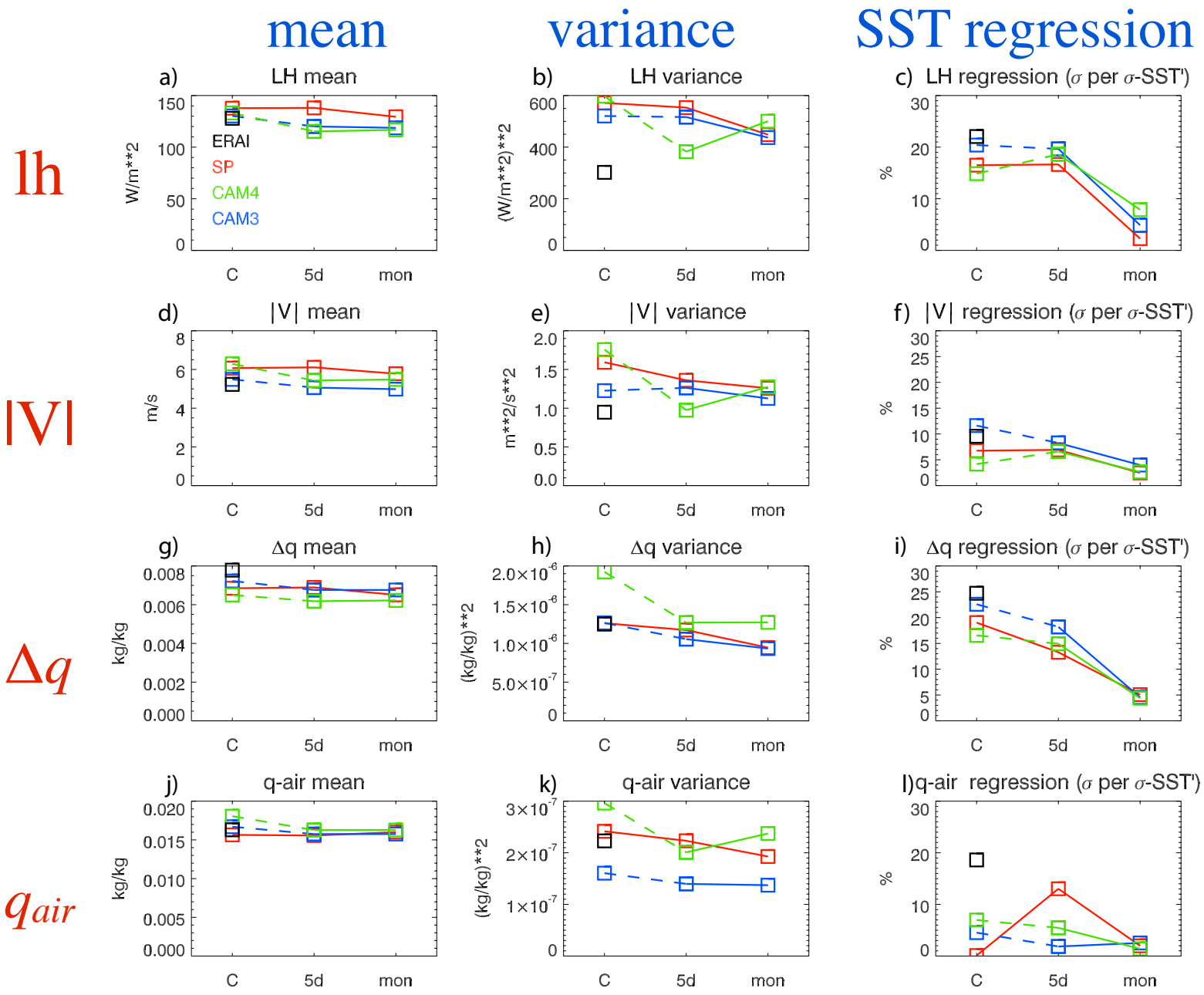
Indian Ocean latent heat flux relationships



Indian Ocean latent heat flux relationships



Indian Ocean latent heat flux relationships

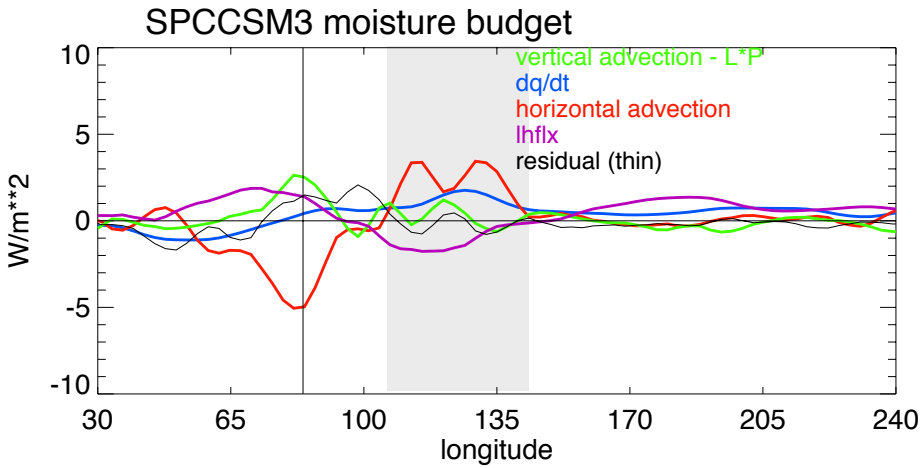


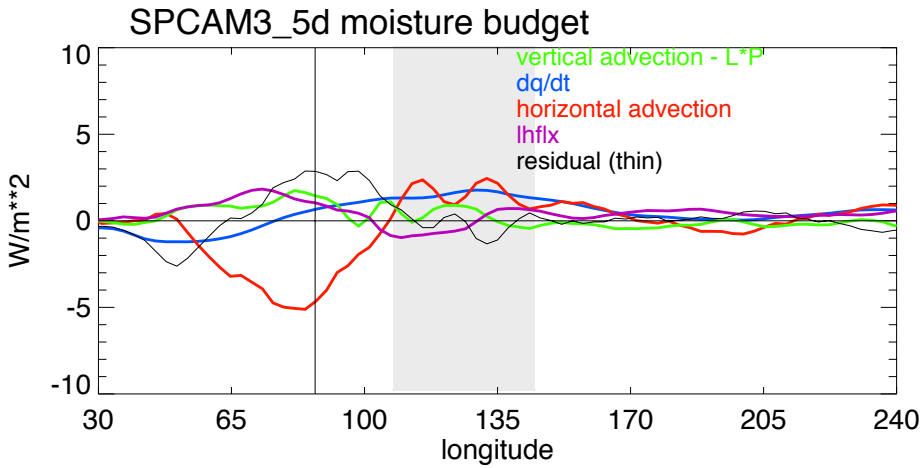
- "local" or "direct" SST control accounts for <30% of local dynamic range (<10% of total variance).
- latent heat flux variance is primarily driven by wind speed variance, which is a "remote" or "indirect" effect of coupling.

2. moisture budget

vertically integrated moisture budgets

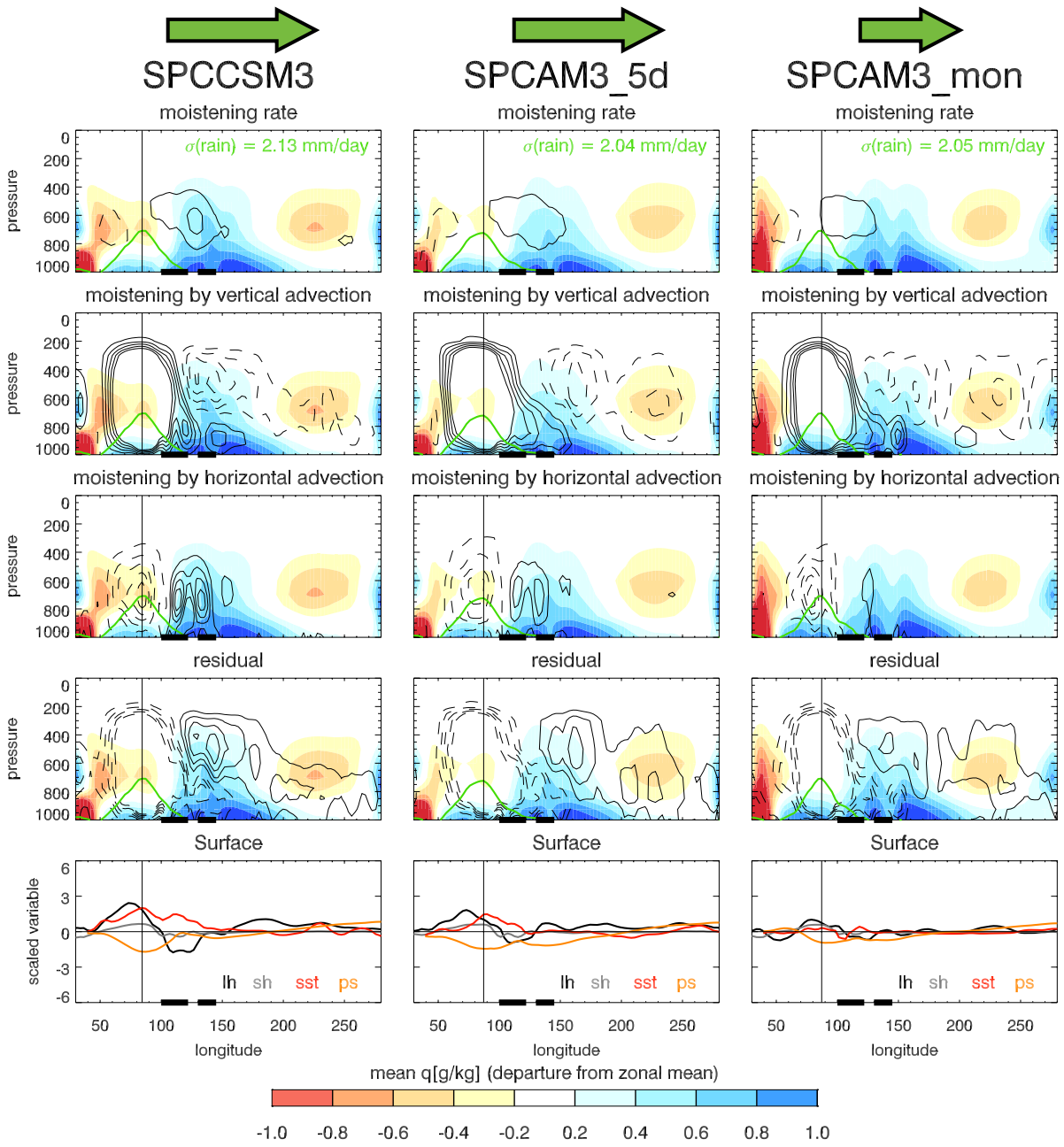
dq/dt = (vert. adv. - precip.) + horiz. adv. + lhflx+ res.

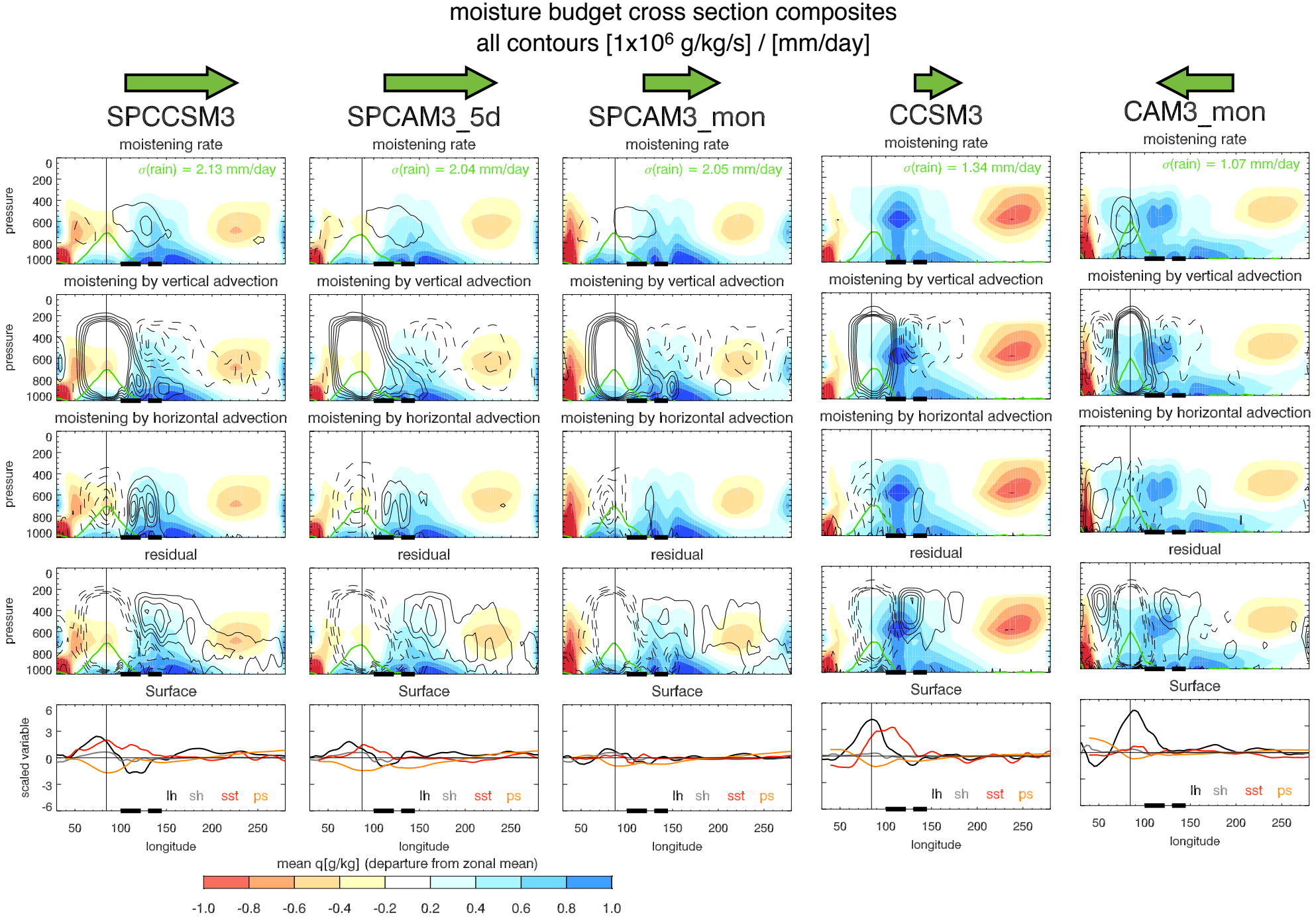




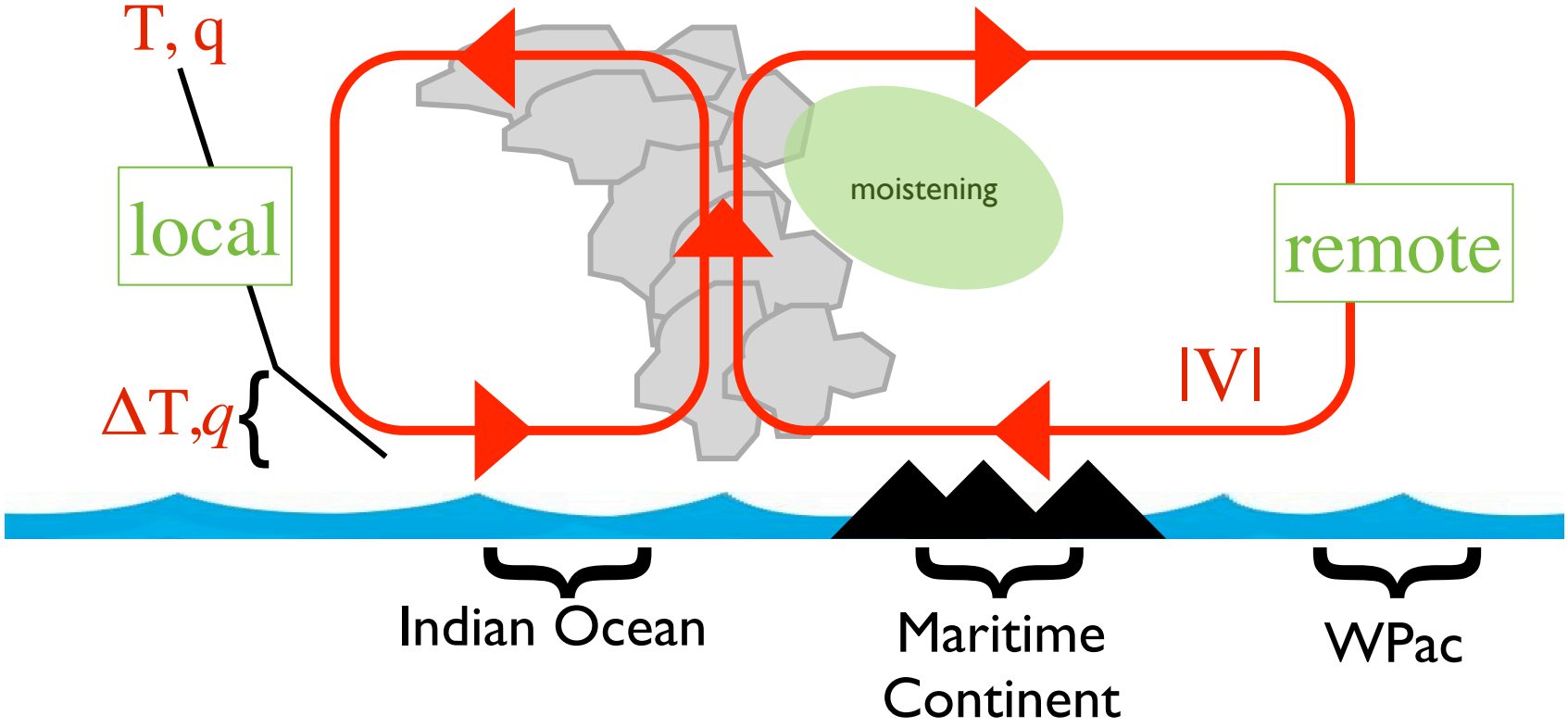
moisture budget cross section composites

all contours [1x10^6 g/kg/s] / [mm/day]

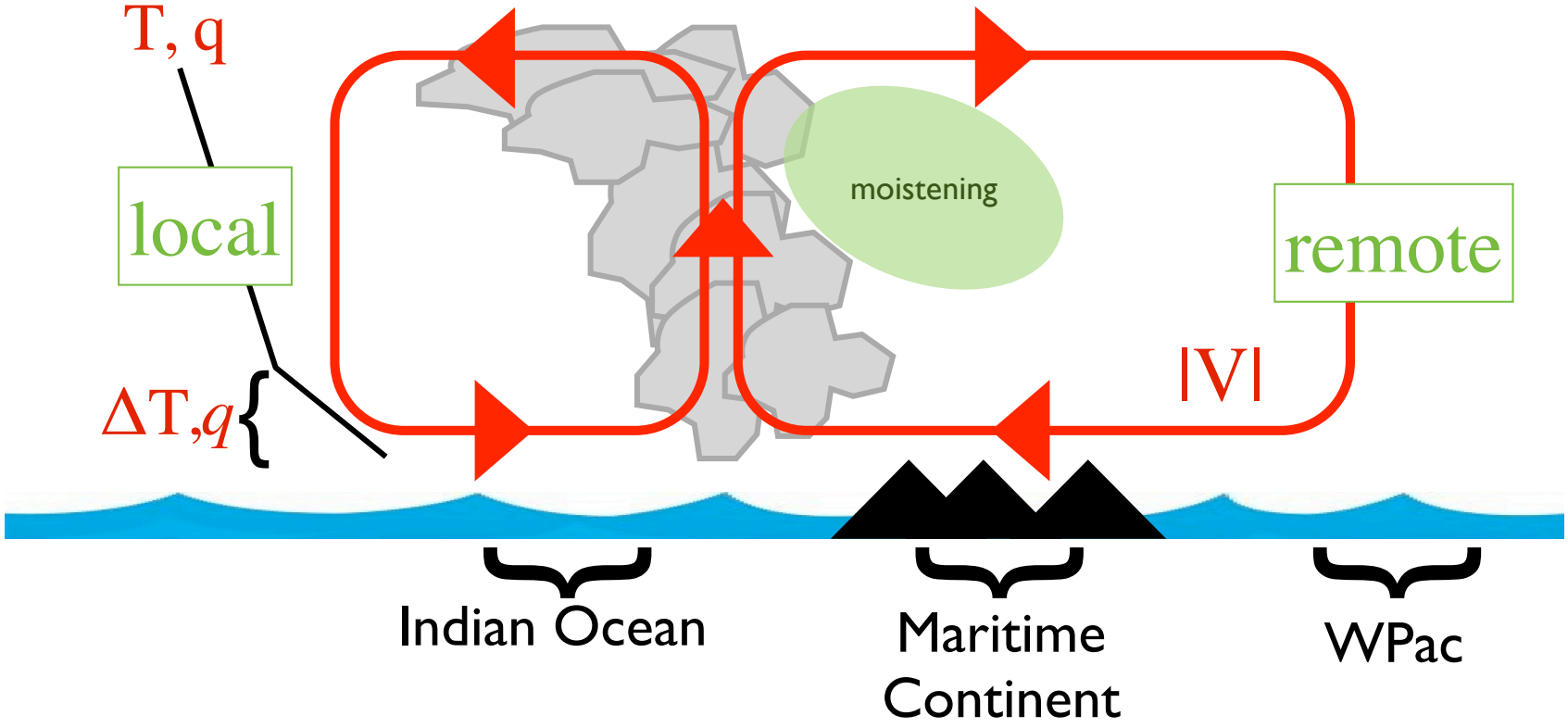



moisture budget cross section composites
all contours [1x10^6 g/kg/s] / [mm/day]
SPCCSM3
SPCAM3_5d
SPCAM3_mon
CCSM3
CAM3_mon
moistening rate
σ(rain) = 2.13 mm/day
σ(rain) = 2.04 mm/day
σ(rain) = 2.05 mm/day
σ(rain) = 1.34 mm/day
σ(rain) = 1.07 mm/day
moistening by vertical advection
moistening by horizontal advection
residual
Surface
pressure
scaled variable
lh sh sst ps
longitude
mean q[g/kg] (departure from zonal mean)
-1.0 -0.8 -0.6 -0.4 -0.2 0.2 0.4 0.6 0.8 1.0

interpretation



interpretation



- mid-level moistening determines propagation direction.
- horizontal advection by convectively-driven wind anomalies dominates moisture advection.
- local air-sea interaction during IO developing phase produces more robust convection capable of downstream moistening.
- model physics strongly influences the "processing" of surface fluxes.

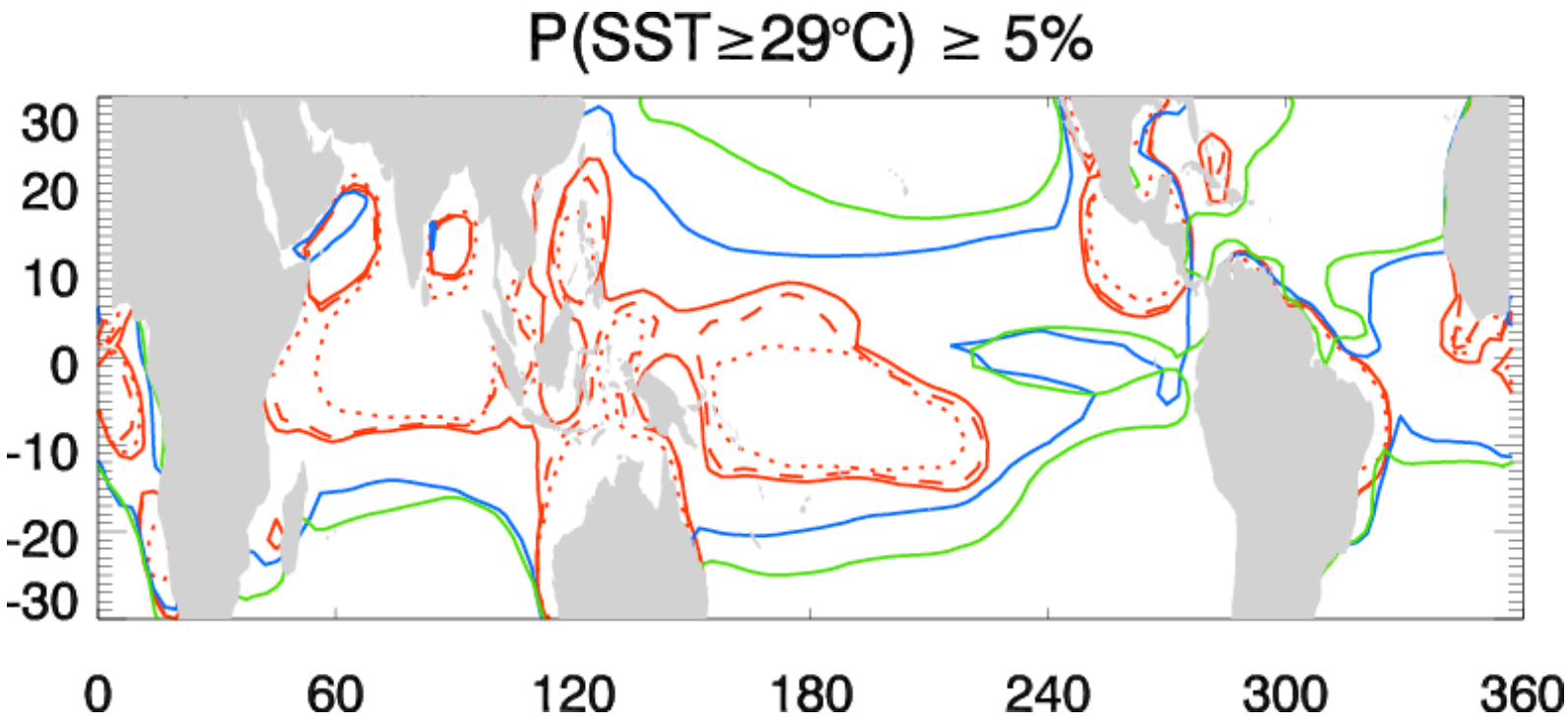
conclusions

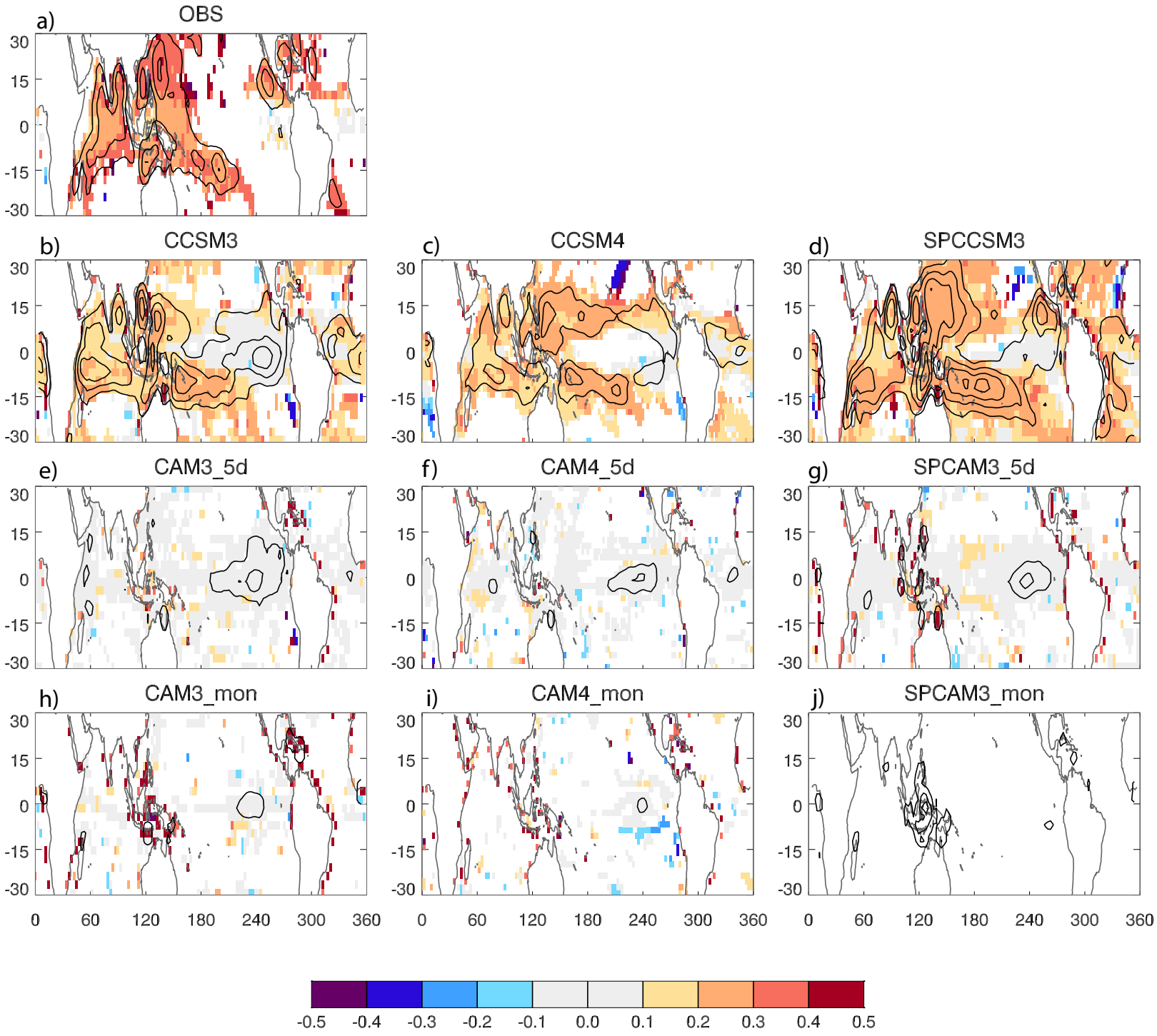
1. **local** effects in Indian Ocean can "intensify" ISO convection, enhancing **remote** effects over MC.

2. air-sea coupling can lead to more robust convection, which drives stronger downstream advective moistening.

3. details of model physics may strongly influence points 2 and 3.

extra slides

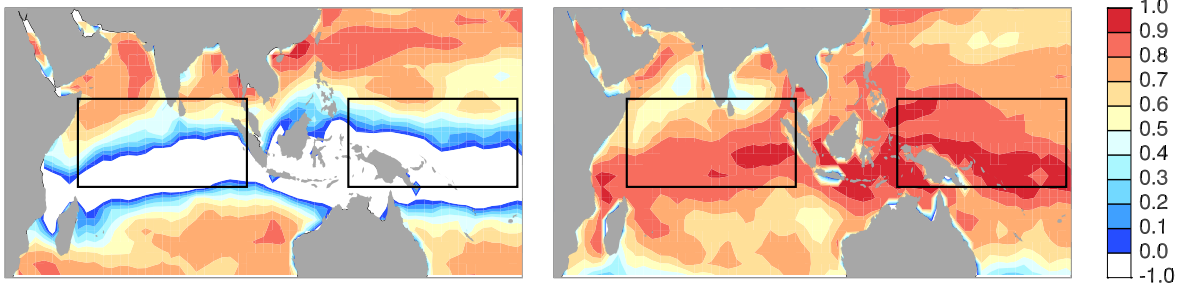

P(SST≥29°C) ≥ 5%
30
20
10
0
-10
-20
-30
0
60
120
180
240
300
360


a) OBS
b) CCSM3
c) CCSM4
d) SPCCSM3
e) CAM3_5d
f) CAM4_5d
g) SPCAM3_5d
h) CAM3_mon
i) CAM4_mon
j) SPCAM3_mon
30
15
0
-15
-30
0 60 120 180 240 300 360
-0.5 -0.4 -0.3 -0.2 -0.1 0.0 0.1 0.2 0.3 0.4 0.5

ERAI DJF

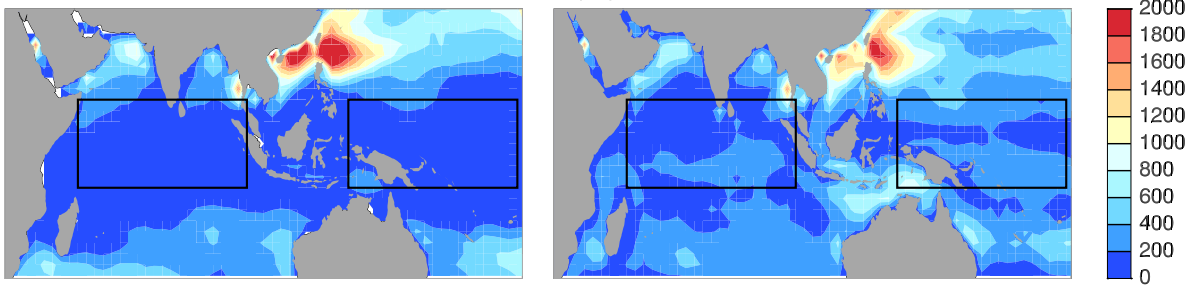
a) normalized LHFLX'-Δq' regression [σ/σ]

b) normalized LHFLX'-|V|' regression [σ/σ]



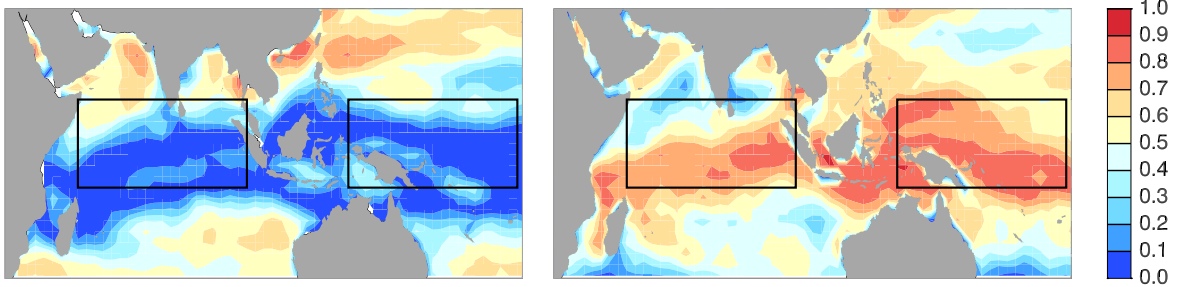
c)(Δq)'-predicted LHFLX variance [(W/m^2)^2]

d)|V|'-predicted LHFLX variance [(W/m^2)^2]

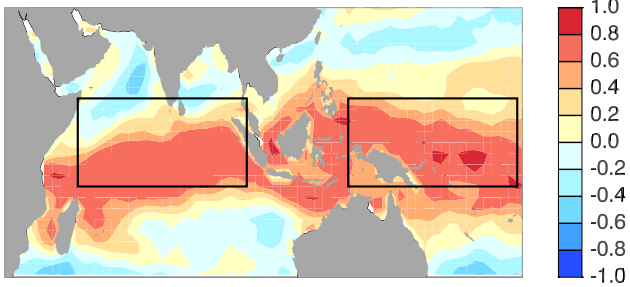


e) variance ratio: (Δq)'-predicted / total

f) variance ratio: |V|'-predicted / total



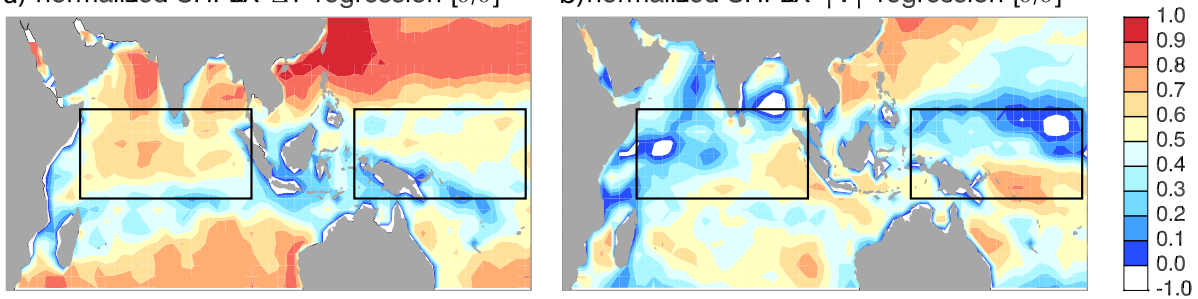
g) ratio difference: |V|' - (Δq')



ERAI DJF

a) normalized SHFLX'-ΔT' regression [σ/σ]

b)normalized SHFLX'-|V|' regression [σ/σ]



c)(ΔT)'-predicted SHFLX variance [$(W/m^2)^2$]

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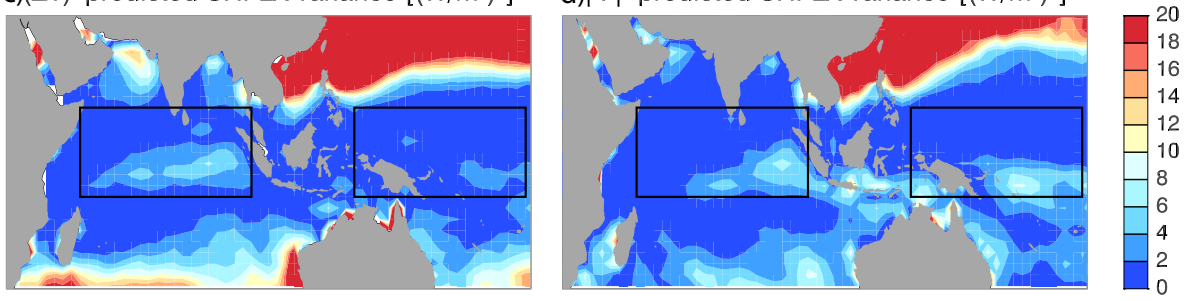
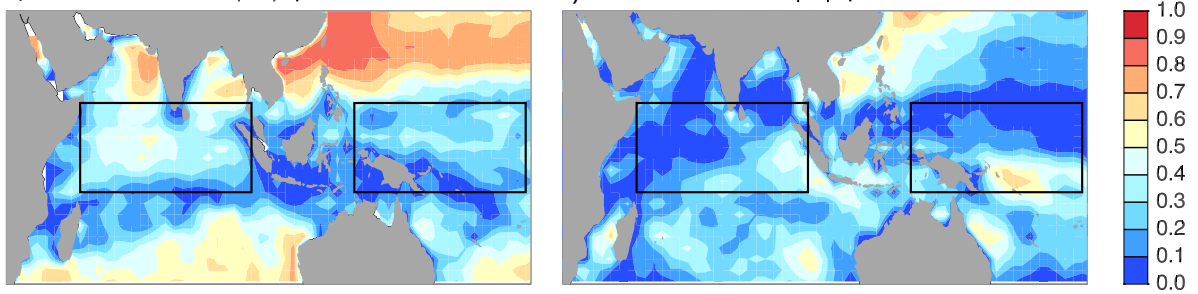
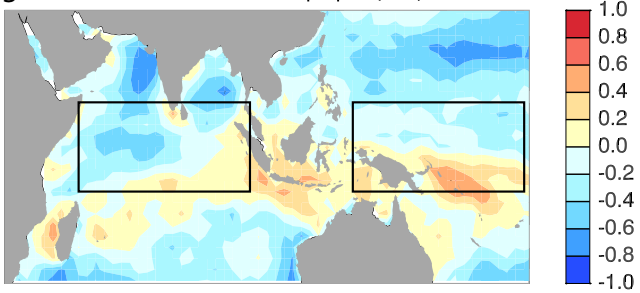


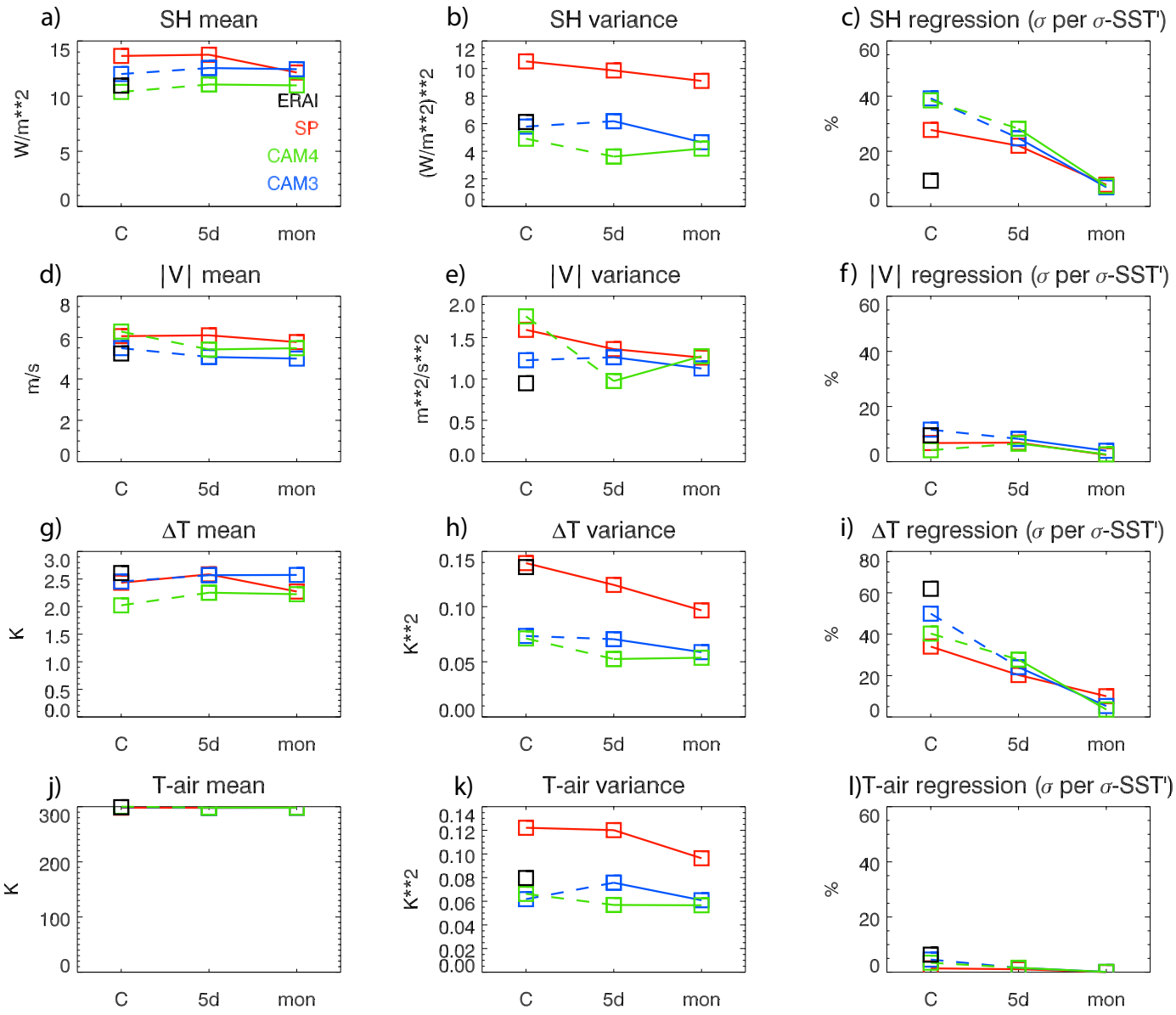
e) variance ratio: (ΔT)'-predicted / total

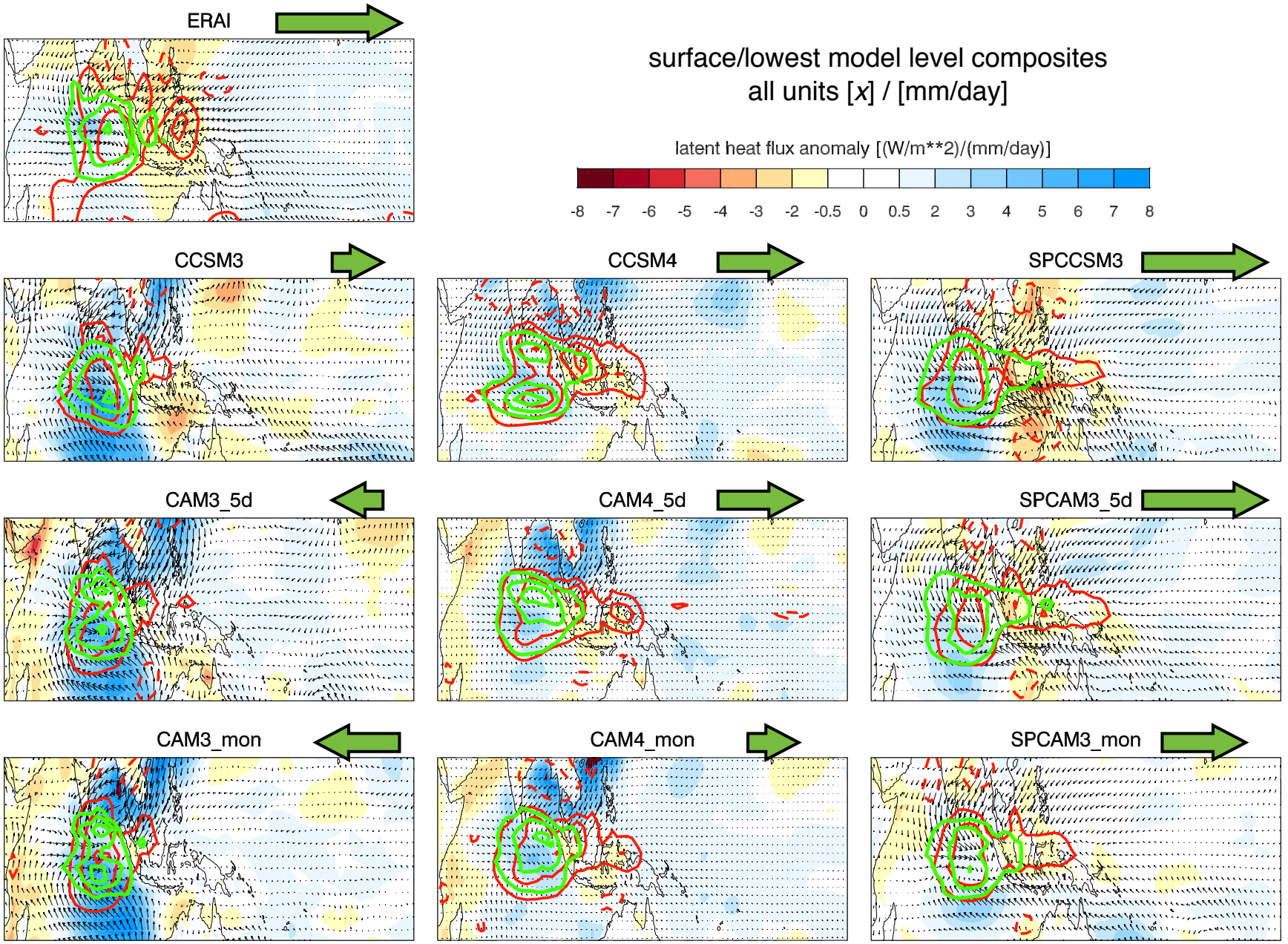
f) variance ratio: |V|'-predicted / total

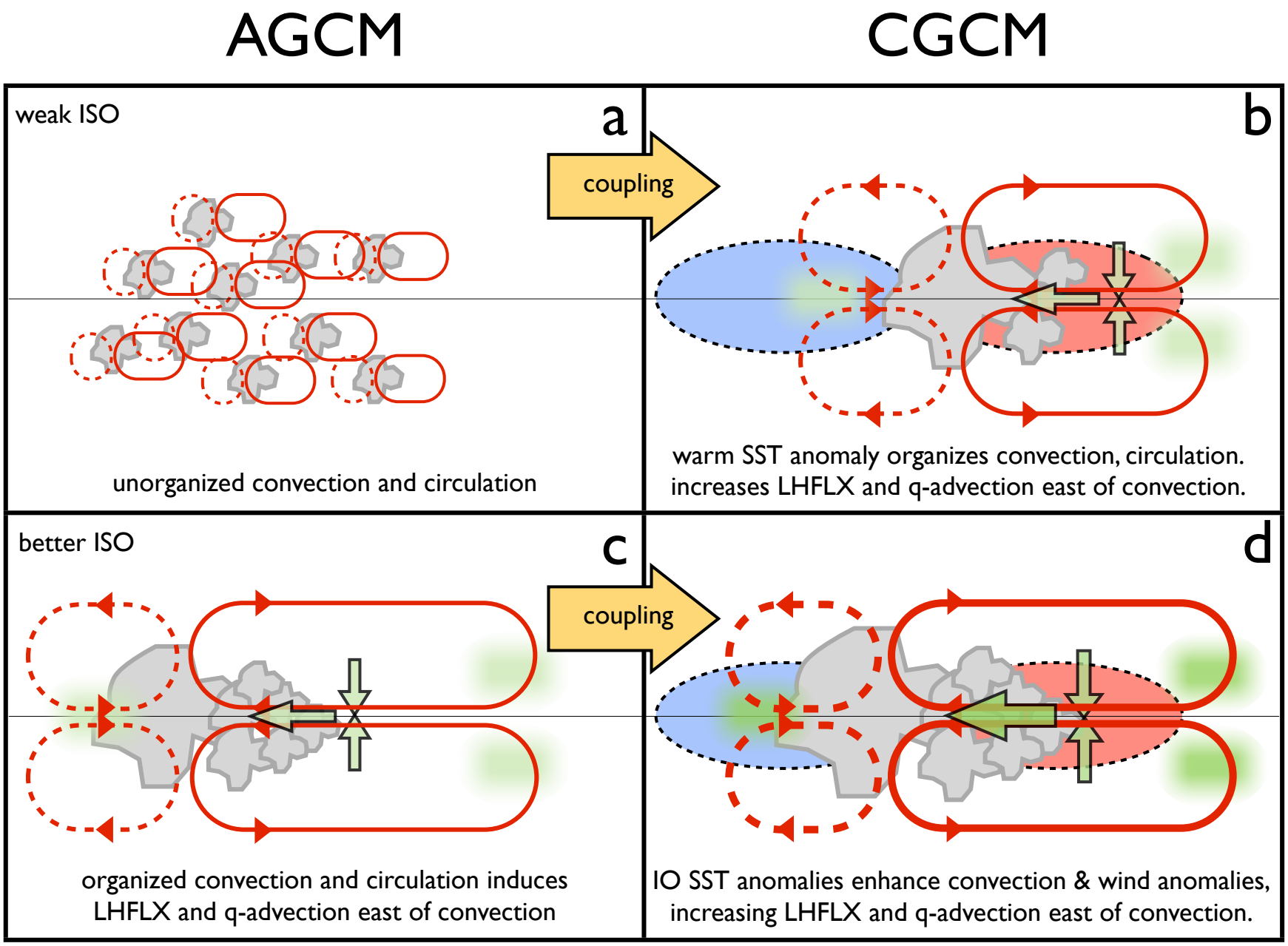


g) ratio difference: |V|' - (ΔT')



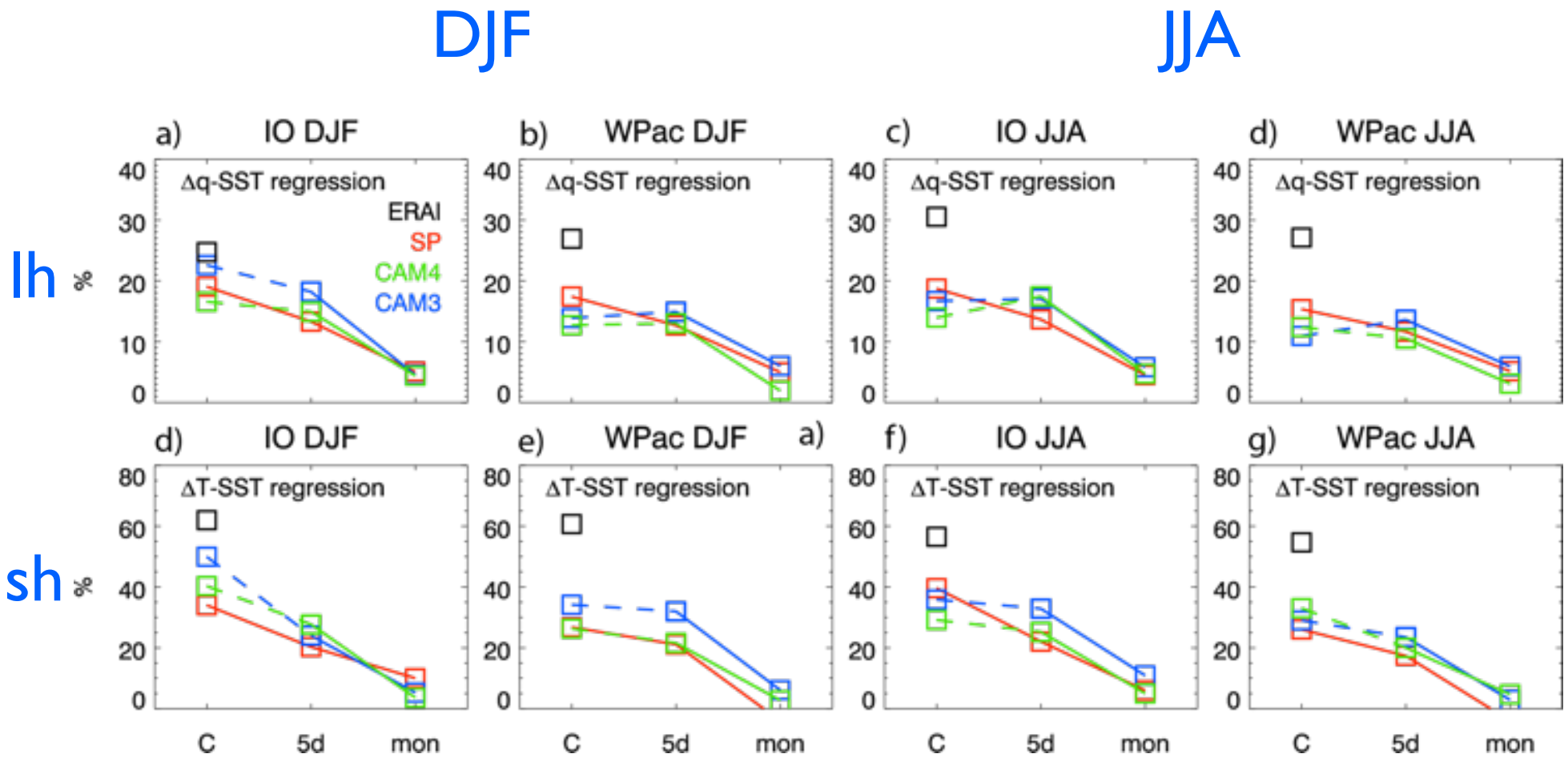

a) SH mean
W/m**2
ERAI
SP
CAM4
CAM3
b) SH variance
(W/m**2)**2
c) SH regression (σ per σ-SST')
%
d) |V| mean
m/s
e) |V| variance
m**2/s**2
f) |V| regression (σ per σ-SST')
%
g) ΔT mean
K
h) ΔT variance
K**2
i) ΔT regression (σ per σ-SST')
%
j) T-air mean
K
k) T-air variance
K**2
l)T-air regression (σ per σ-SST')
%
C
5d
mon


ERAI
surface/lowest model level composites
all units [x] / [mm/day]
latent heat flux anomaly [(W/m**2)/(mm/day)]
-8 -7 -6 -5 -4 -3 -2 -0.5 0 0.5 2 3 4 5 6 7 8
CCSM3
CCSM4
SPCCSM3
CAM3_5d
CAM4_5d
SPCAM3_5d
CAM3_mon
CAM4_mon
SPCAM3_mon
rainfall [0.5 (mm/day)/(mm/day)]
moisture convergence [1E-6 (g/kg/s)/(mm/day)]



plan view of equatorial convection

regional and seasonal local SST sensitivity

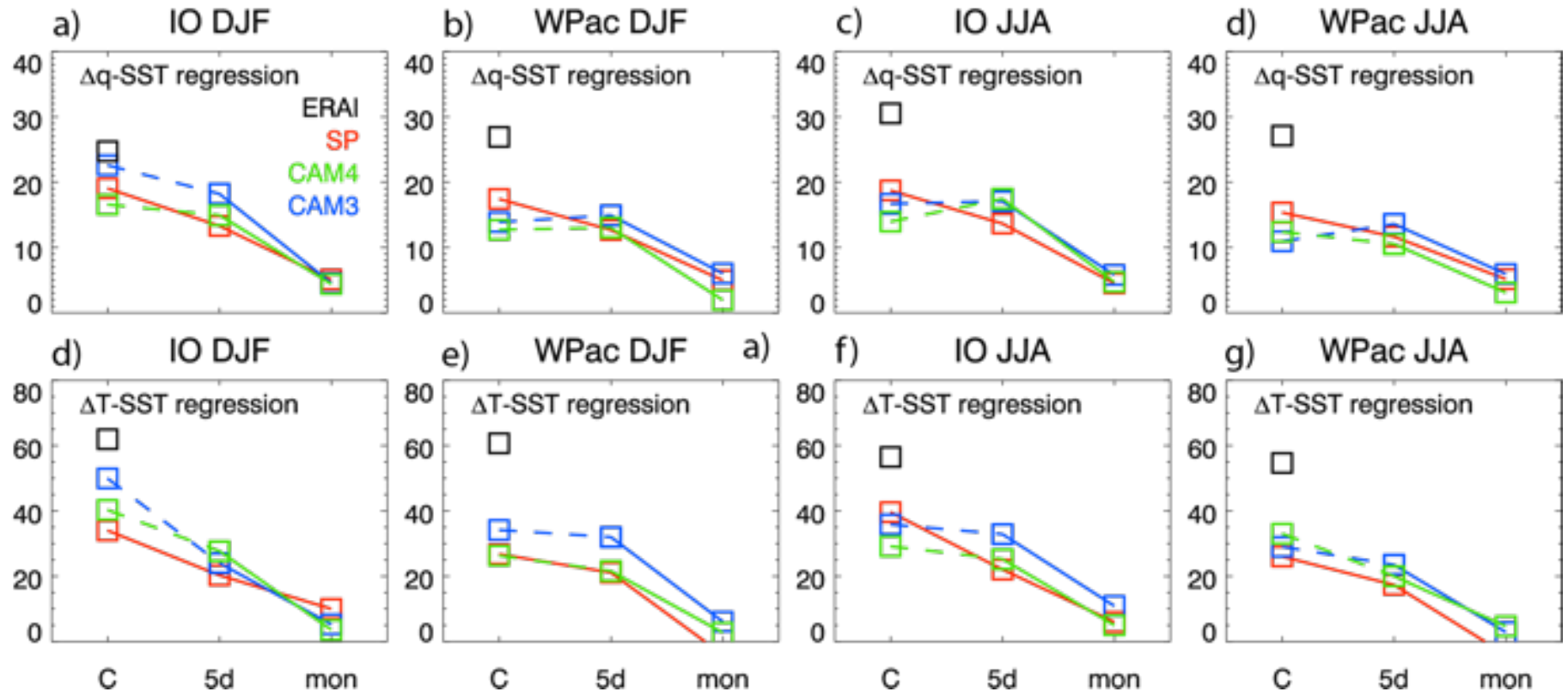


regional and seasonal local SST sensitivity

DJF JJA

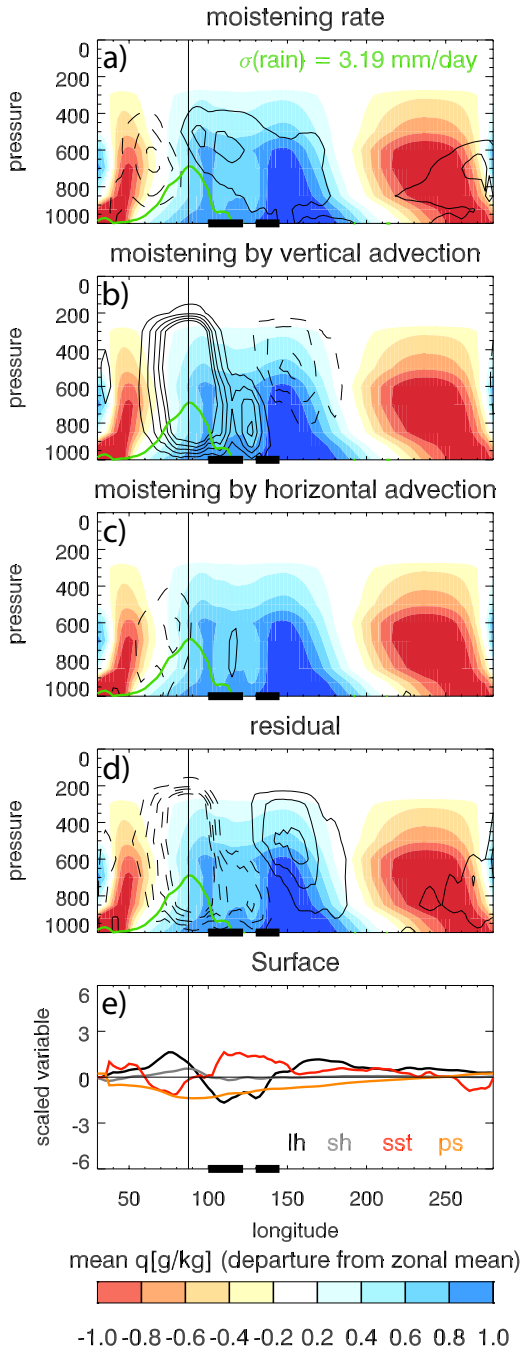
lh %

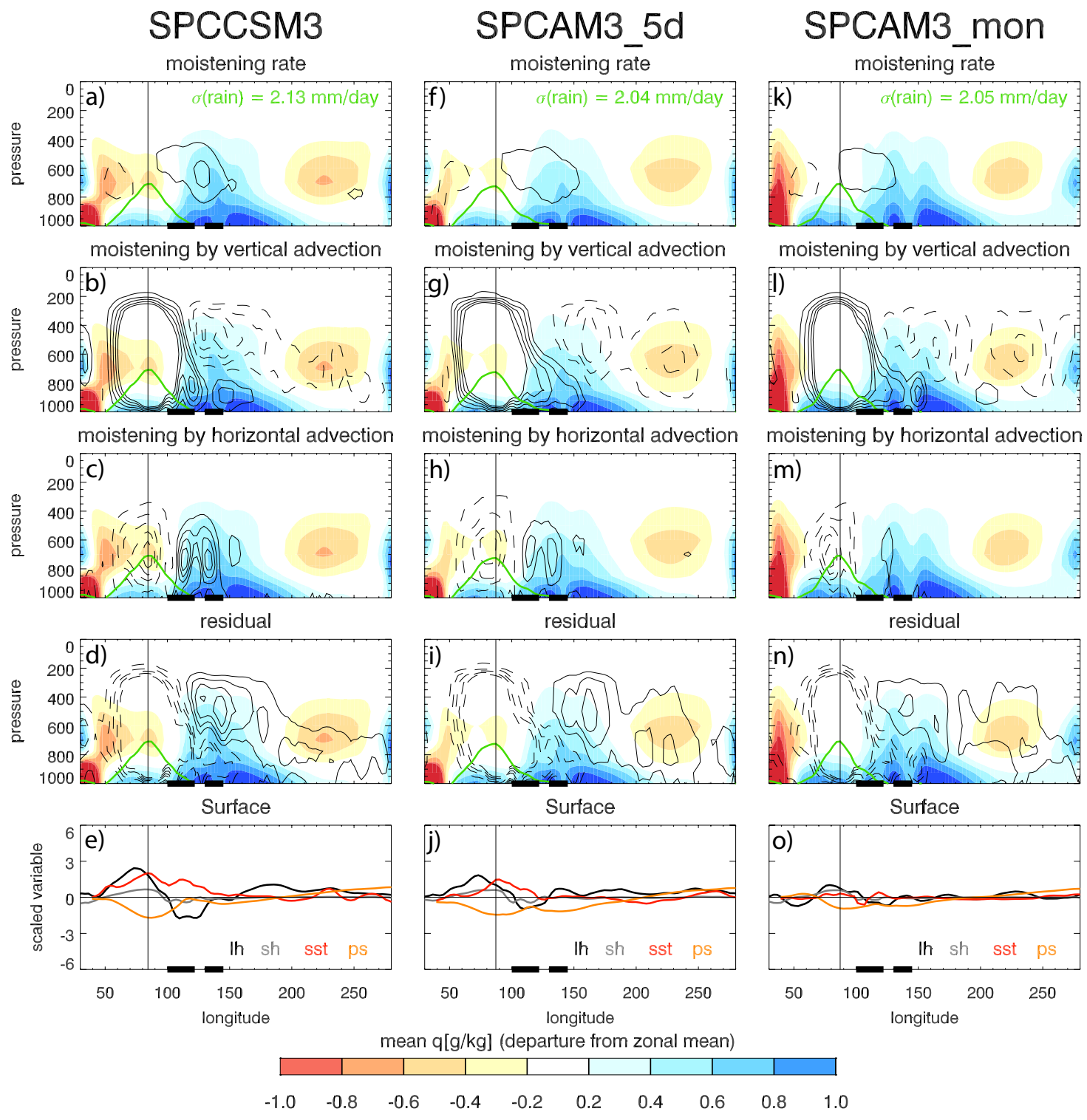
sh %

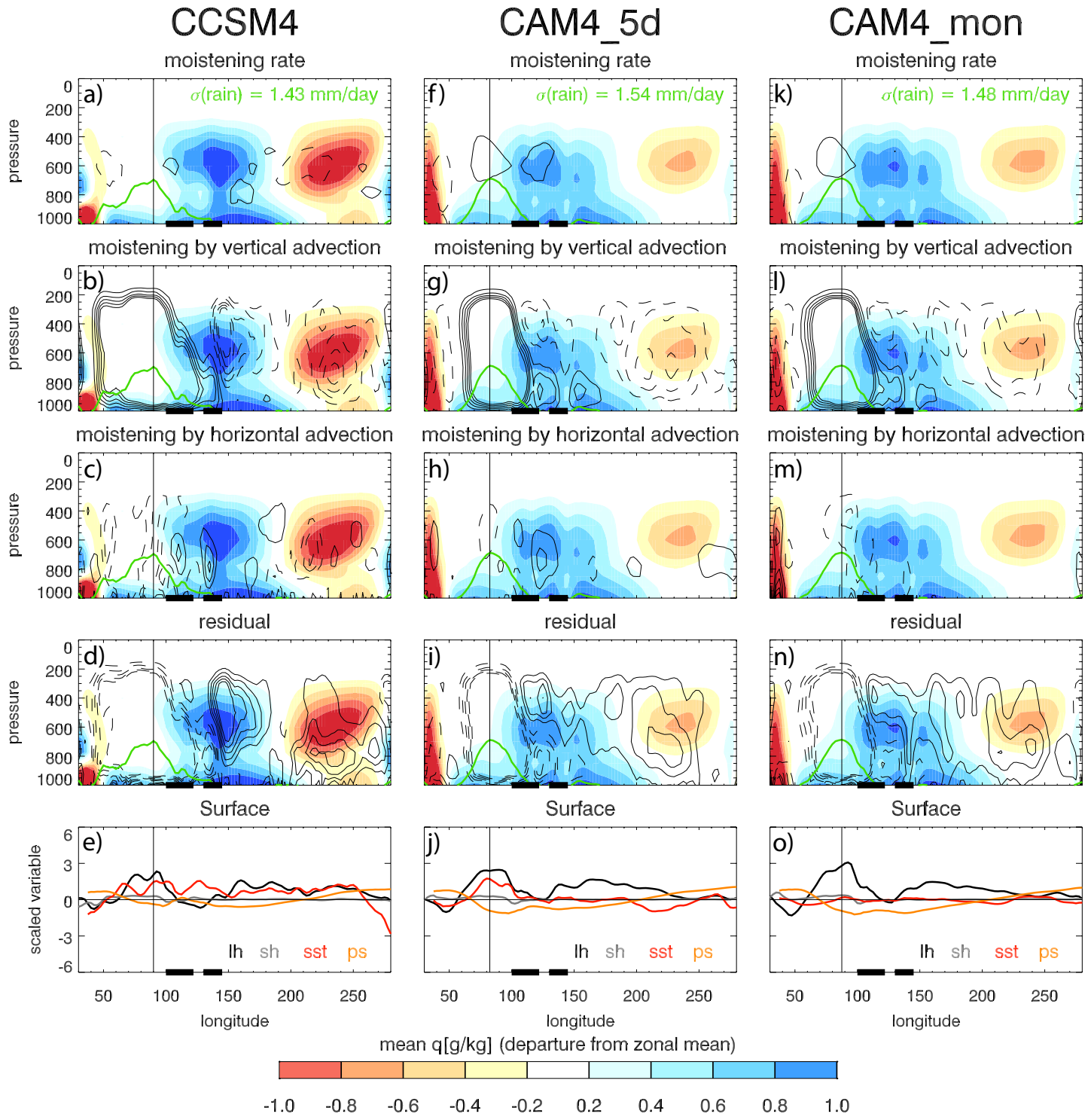


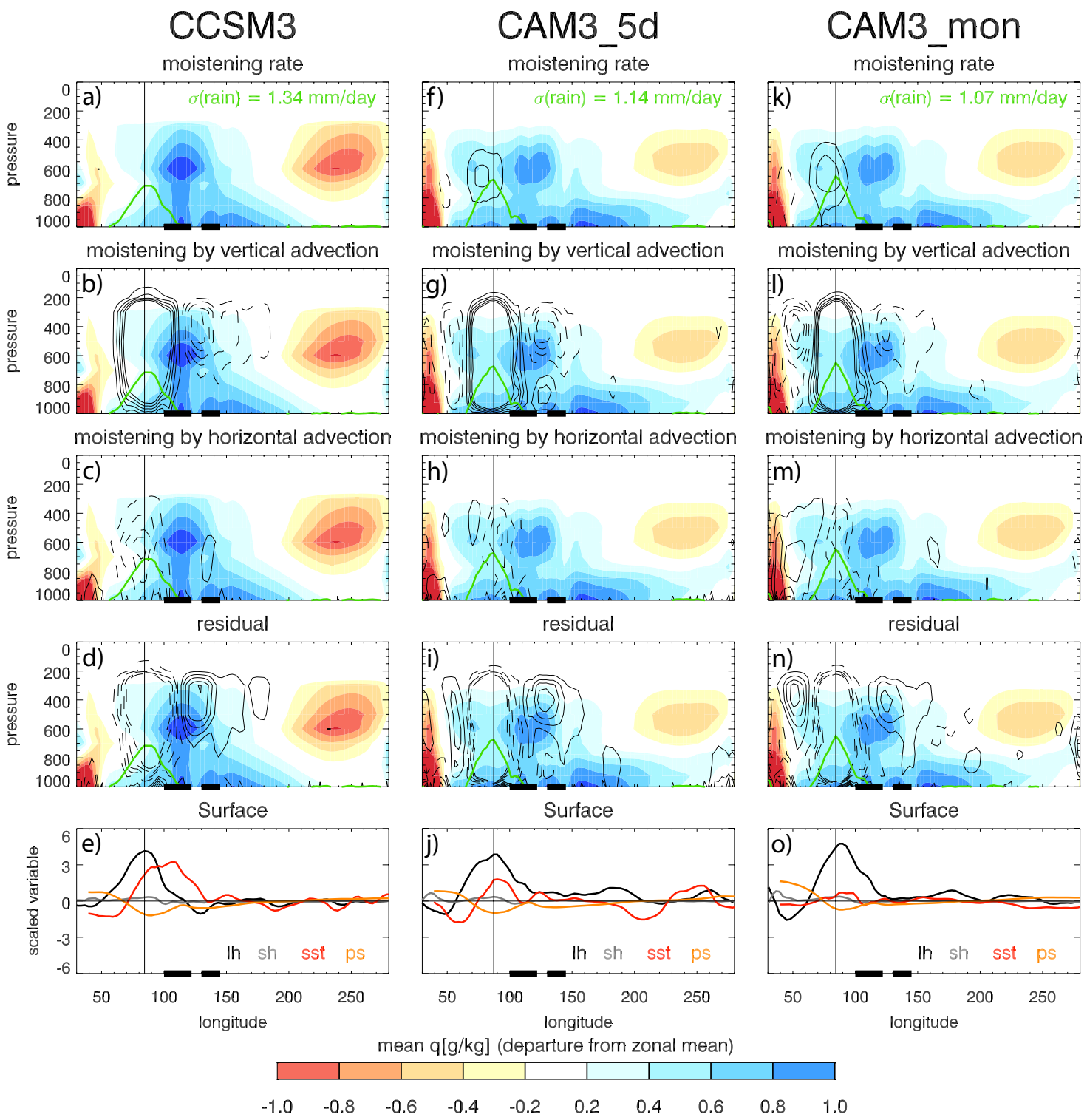
- shflx is more sensitive to SST than lhflx.
- greater sensitivity to SST in IO than WPac.
- SST sensitivity is greatest in DJF.
- IMPORTANT: these results are for 10N-10S only!

ERAI


moistening rate
a)
σ(rain) = 3.19 mm/day
pressure
0
200
400
600
800
1000
moistening by vertical advection
b)
moistening by horizontal advection
c)
residual
d)
Surface
e)
scaled variable
6
3
0
-3
-6
lh
sh
sst
ps
50
100
150
200
250
longitude
mean q[g/kg] (departure from zonal mean)
-1.0 -0.8 -0.6 -0.4 -0.2 0.2 0.4 0.6 0.8 1.0


SPCCSM3
SPCAM3_5d
SPCAM3_mon
moistening rate
moistening by vertical advection
moistening by horizontal advection
residual
Surface
a)
b)
c)
d)
e)
f)
g)
h)
i)
j)
k)
l)
m)
n)
o)
σ(rain) = 2.13 mm/day
σ(rain) = 2.04 mm/day
σ(rain) = 2.05 mm/day
pressure
0
200
400
600
800
1000
scaled variable
6
3
0
-3
-6
lh
sh
sst
ps
50
100
150
200
250
longitude
mean q[g/kg] (departure from zonal mean)
-1.0
-0.8
-0.6
-0.4
-0.2
0.2
0.4
0.6
0.8
1.0

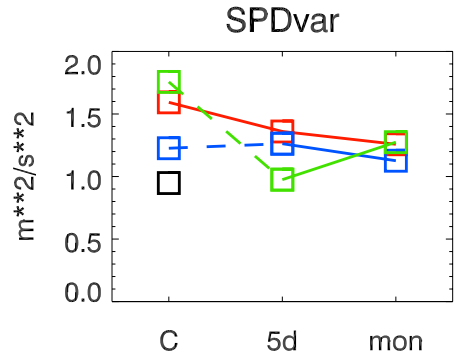

CCSM4
CAM4_5d
CAM4_mon
moistening rate
a)
σ(rain) = 1.43 mm/day
f)
σ(rain) = 1.54 mm/day
k)
σ(rain) = 1.48 mm/day
moistening by vertical advection
b)
g)
l)
moistening by horizontal advection
c)
h)
m)
residual
d)
i)
n)
Surface
e)
j)
o)
pressure
0
200
400
600
800
1000
scaled variable
6
3
0
-3
-6
lh
sh
sst
ps
50
100
150
200
250
longitude
mean q[g/kg] (departure from zonal mean)
-1.0
-0.8
-0.6
-0.4
-0.2
0.2
0.4
0.6
0.8
1.0

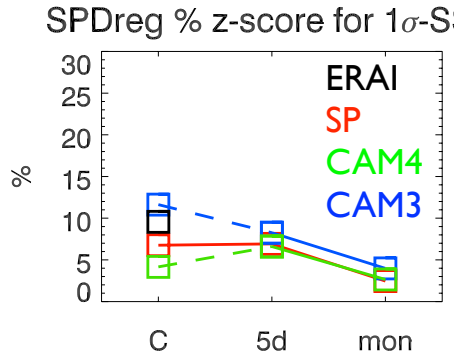

CCSM3
CAM3_5d
CAM3_mon
moistening rate
moistening by vertical advection
moistening by horizontal advection
residual
Surface
a)
b)
c)
d)
e)
f)
g)
h)
i)
j)
k)
l)
m)
n)
o)
σ(rain) = 1.34 mm/day
σ(rain) = 1.14 mm/day
σ(rain) = 1.07 mm/day
pressure
0
200
400
600
800
1000
scaled variable
6
3
0
-3
-6
lh
sh
sst
ps
50
100
150
200
250
longitude
mean q[g/kg] (departure from zonal mean)
-1.0
-0.8
-0.6
-0.4
-0.2
0.2
0.4
0.6
0.8
1.0

variance

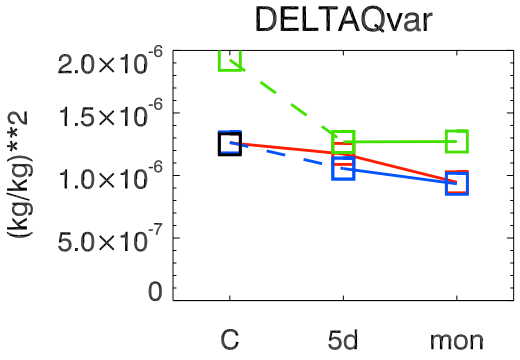
SST regression

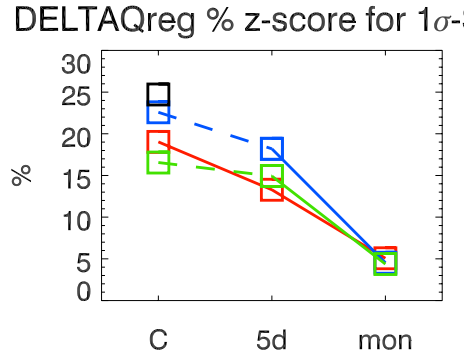
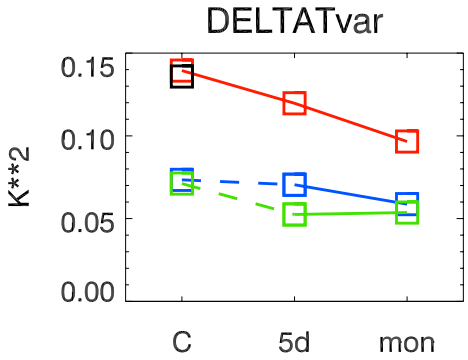
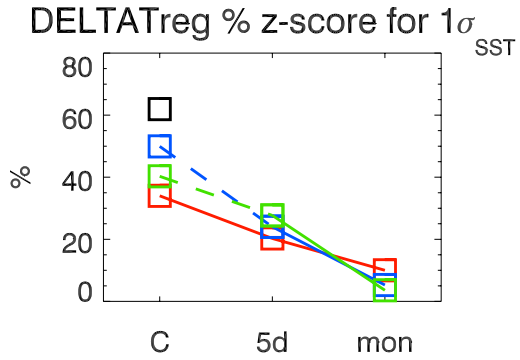
|V|





Δq





ΔT