Surface flux diagnostics

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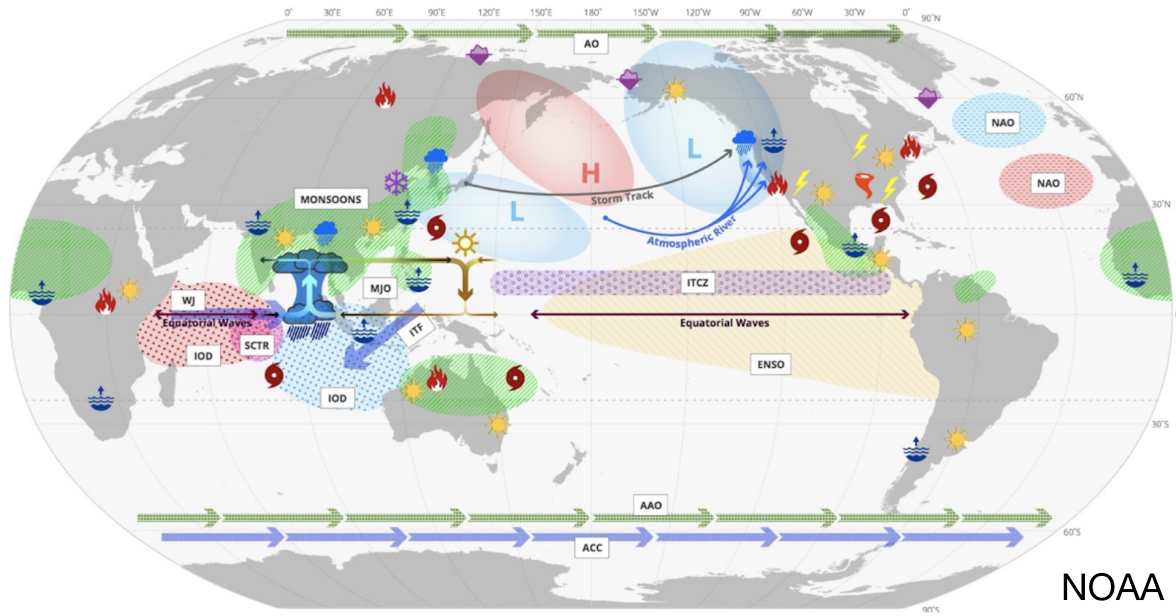
WGNE informal surface coupling discussion, 9 June 2021 (virtual)

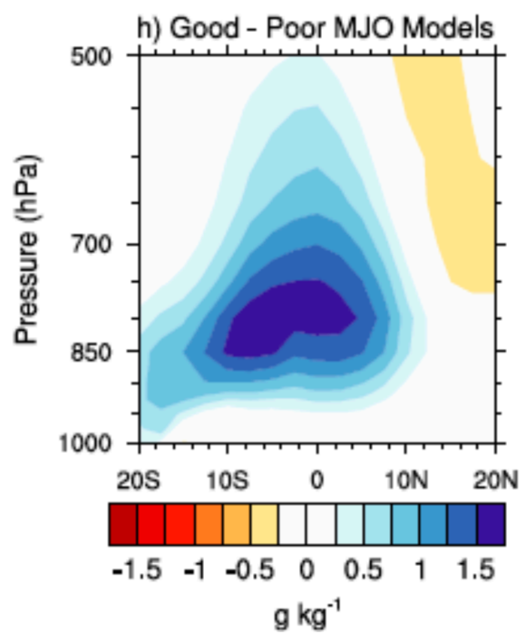
Some motivation

- The MJO affects weather and prediction skill globally



NOAA

- MJO eastward propagation depends critically on tropical mean state moisture



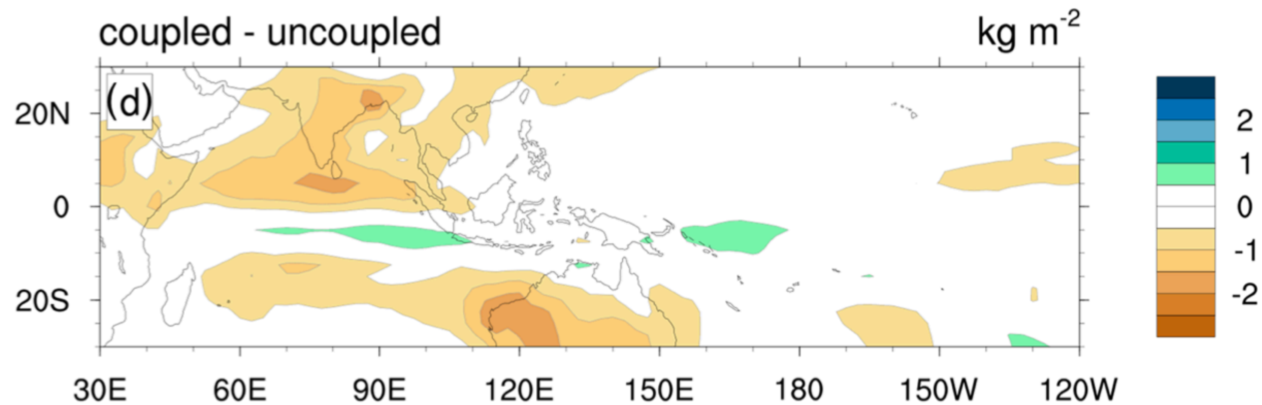
$$\frac{\partial q}{\partial t} \approx -V' \cdot \nabla \overline{q}$$

MJO propagation is governed by advection of **mean state moisture** by MJO wind anomalies

Gonzalez and Jiang (2017)

Some motivation

- Mean state moisture is sensitive to high-frequency (~daily) feedbacks between convection and surface fluxes.



DeMott et al. (2019)

- Surface flux drift may affect background moisture drift and MJO prediction

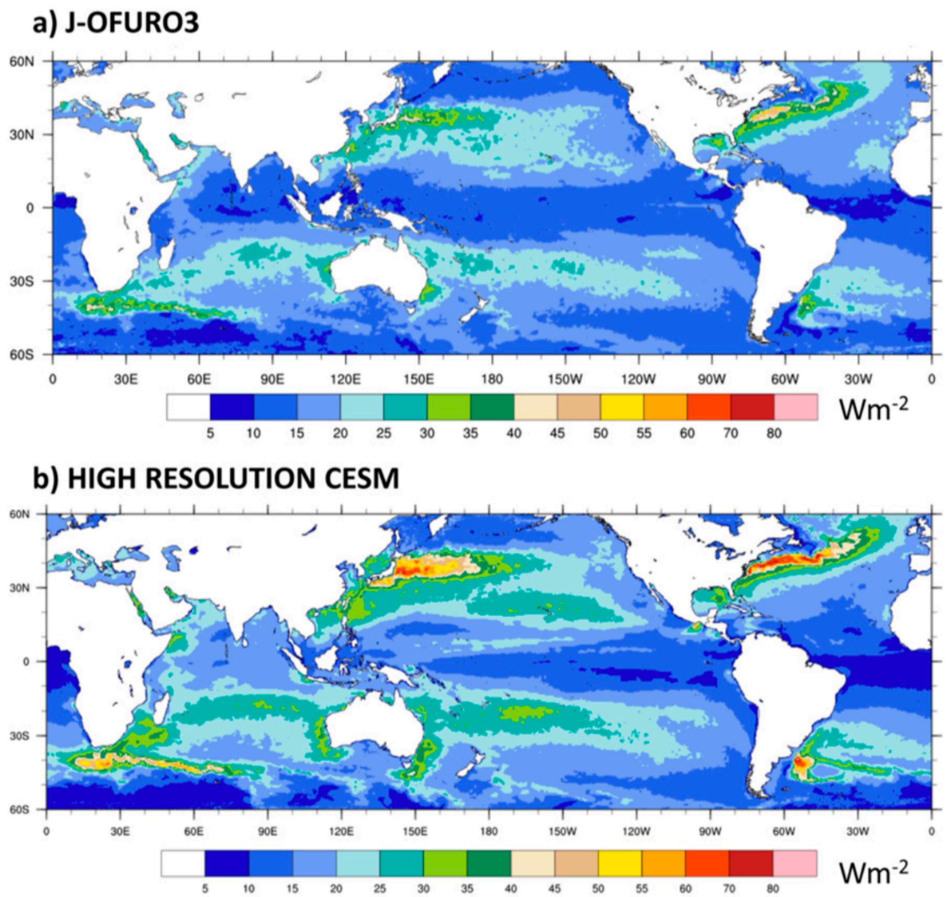
flux → convection → CWV → $-V' \cdot \nabla \overline{q}$ → MJO

WGNE Surface Flux Intercomparison

- July 2018 and January 2019; 0, 6, 12, . . . , 120 hours

	Contact person	Data format	Comments
CMA	Jian Sun	NetCDF	No 'LS_SNOW', 'CO_SNOW', 'TH_NET_CS', 'U_MOM_FL', 'V_MOM_FL' EVAP, SH, LH opposite sign
CPTEC	Ariane Frassoni		Dataset to be provided
DWD	Günther Zängl	NetCDF	
ECCC	Ron McTaggart-Cowan	NetCDF	2 datasets provided (oper + new) U_MOM_FL, V_MOM_FL opposite sign
ECMWF	Souhail Boussetta	GRIB	
MF	François Bouyssel	GRIB	
NCEP	Weizhong Zheng	NetCDF	No 'LS_SNOW', 'CO_SNOW', 'SO_NET_CS', 'TH_NET_CS'
NRL	Carolyn Reynolds	NetCDF	No 'SO_NET_CS', 'TH_NET_CS' EVAP, SH, LH opposite sign
RU	Mikhail Tolstykh	NetCDF	No ‘EVAP’, 'SO_NET_CS', 'TH_NET_CS'
UKMO	Paul Earnshaw	NetCDF	No 'SO_NET', 'TH_NET', 'SO_NET_CS', 'TH_NET_CS', 'U_MOM_FL', 'V_MOM_FL' U10, V10 inverse

diagnostics: familiar approach



Advantages

- enables global assessment
- model vs observation differences easy to see

Disadvantages

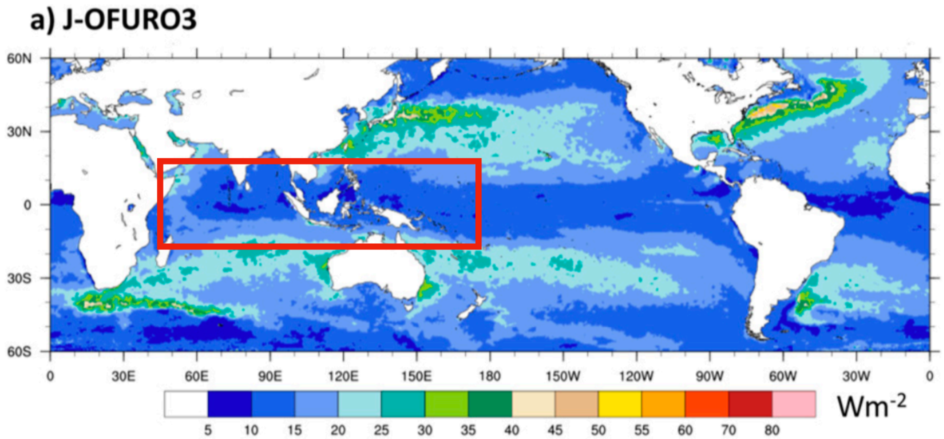
- model fluxes are parameterized and based on multiple inputs
- sources of error are not apparent

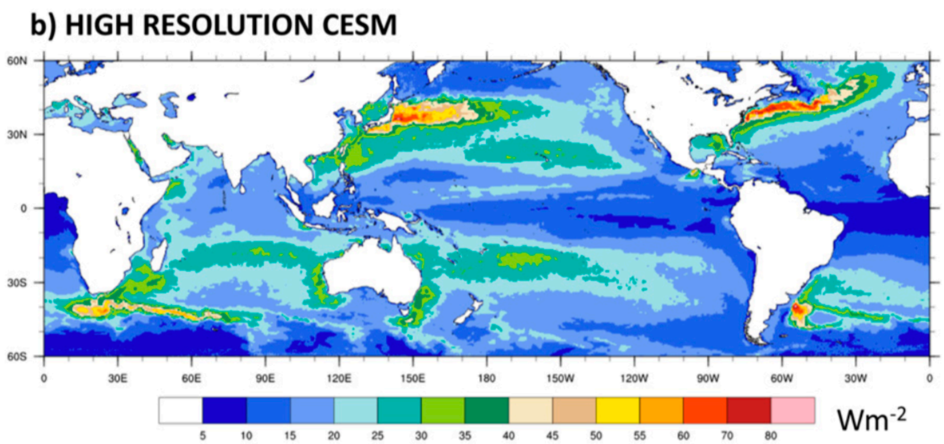
$$LH = \rho C_e L_v |V| (q^*_{SST} - q_a)$$

C_e → parameterization

$|V|$, q^*_{SST}, q_a → inputs

diagnostics: familiar approach





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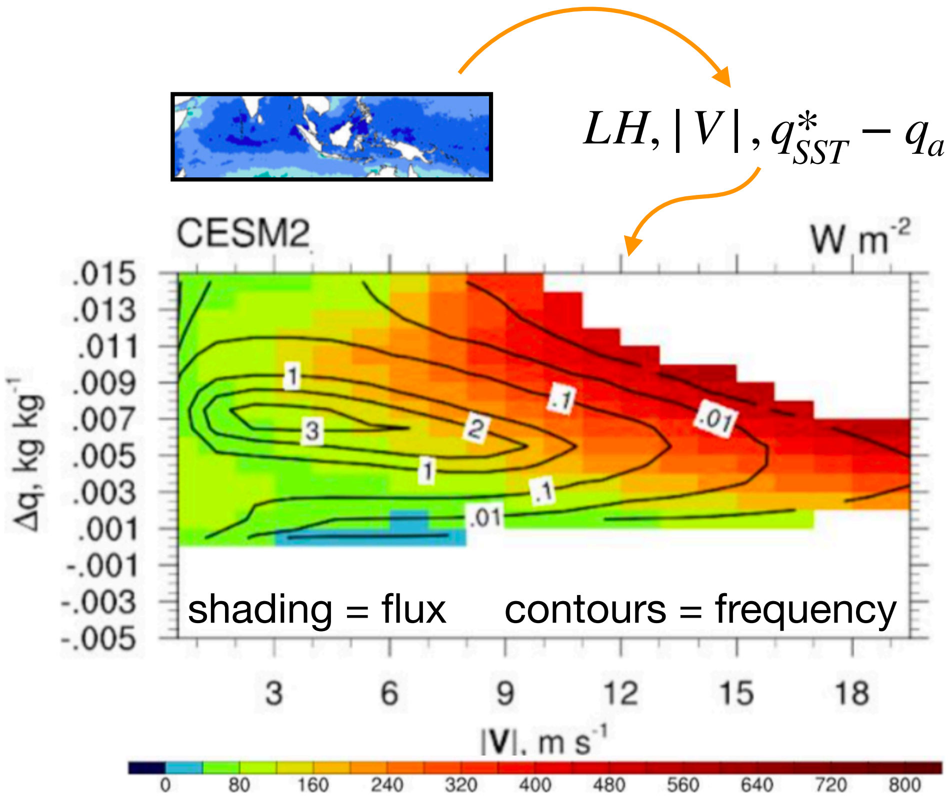
$$LH = \rho C_e L_v |V| (q^*_{SST} - q_a)$$

parameterization

inputs

diagnostics: conditional sampling approach



Advantages

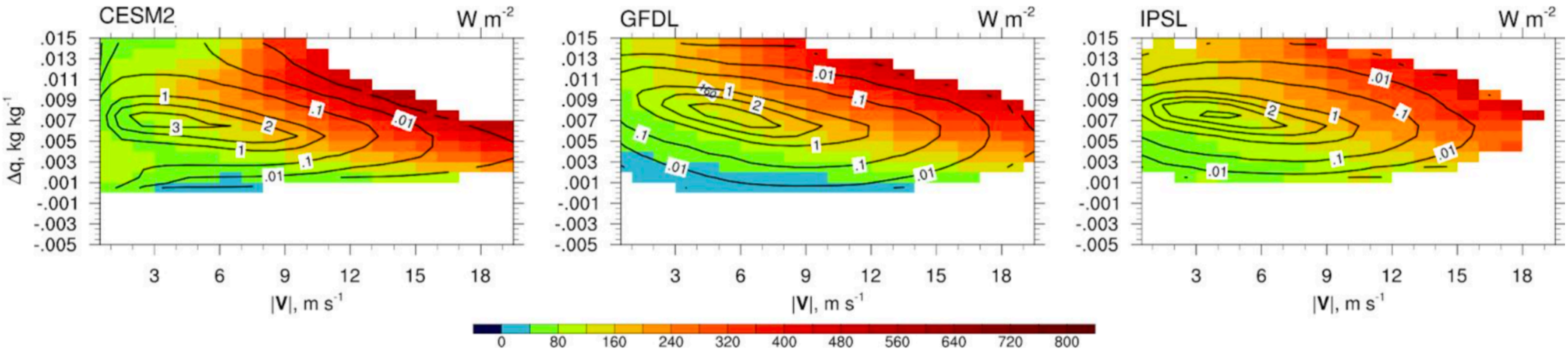
- separates inputs from parameterization
- can focus on regions with particular cloud type or large bias
- can be applied to model output and point measurements

$$LH = \rho C_e L_v \, |V| \, (q^*_{SST} - q_a)$$

parameterization (C_e)

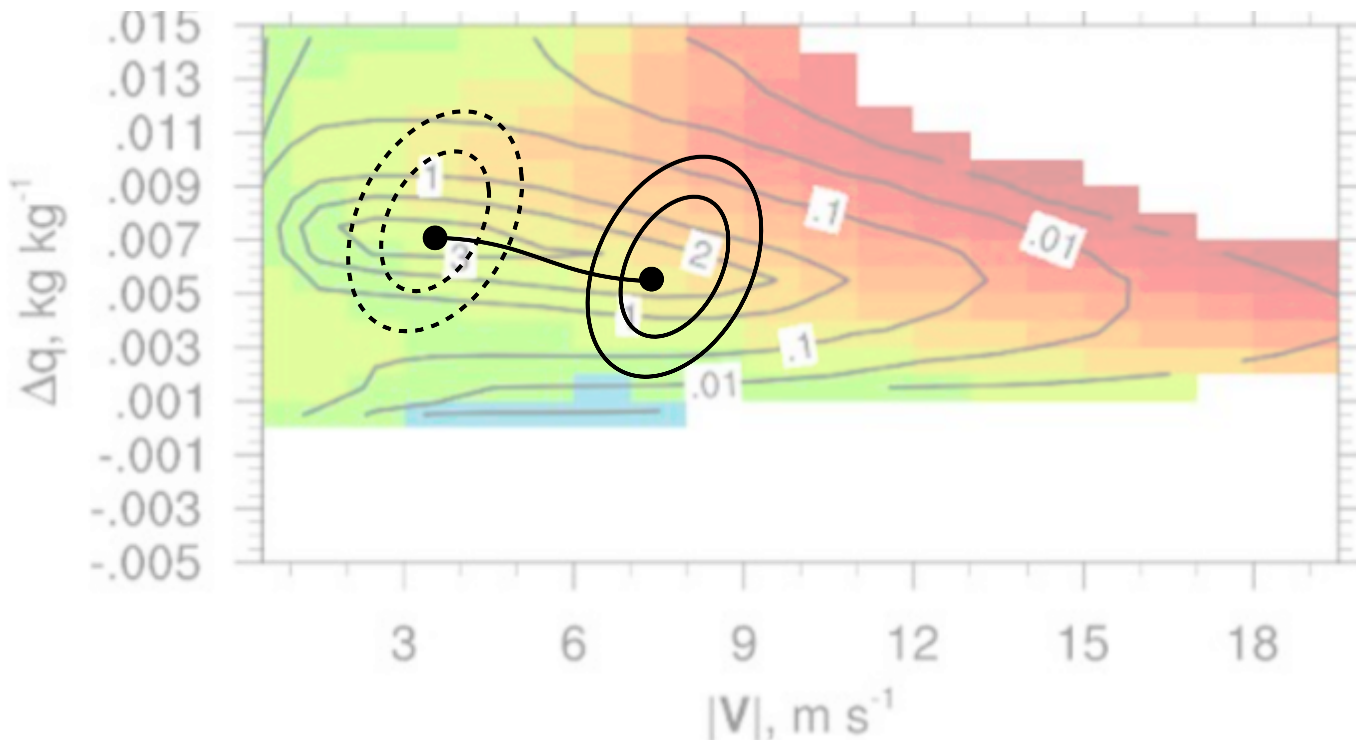
inputs ($|V|$, q^*_{SST}, q_a)

example: GCM output



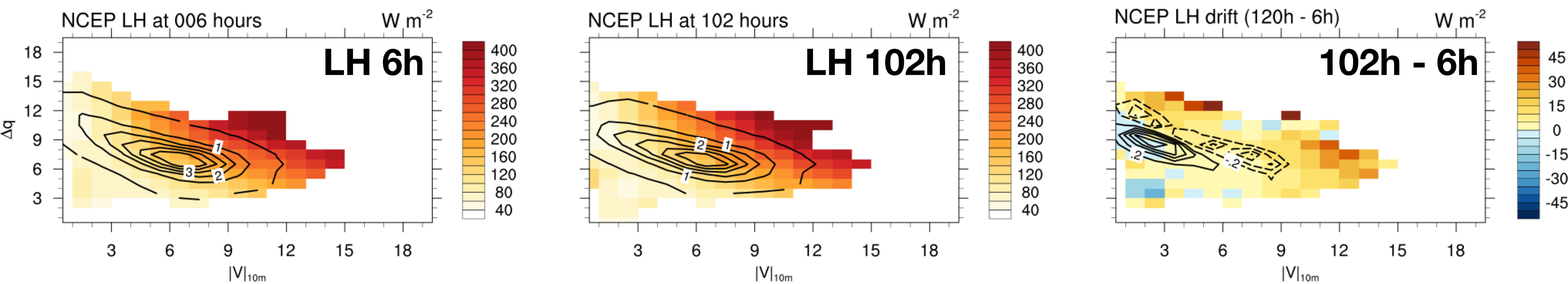
- differences in shading reflect parameterization differences
- differences in contours reflect differences in winds and Δq (inputs)

strategy for intercomparison data: flux drift analysis



- aggregate 006h and 102h variables for all common initializations (26 overlapping days)
- compute mean latent heat flux, q_{2m}, and q^*_{SST} ($\Delta q = q^*_{SST} - q_{2m}$) for 006h and 102h
- evaluate change in distribution of inputs, fluxes

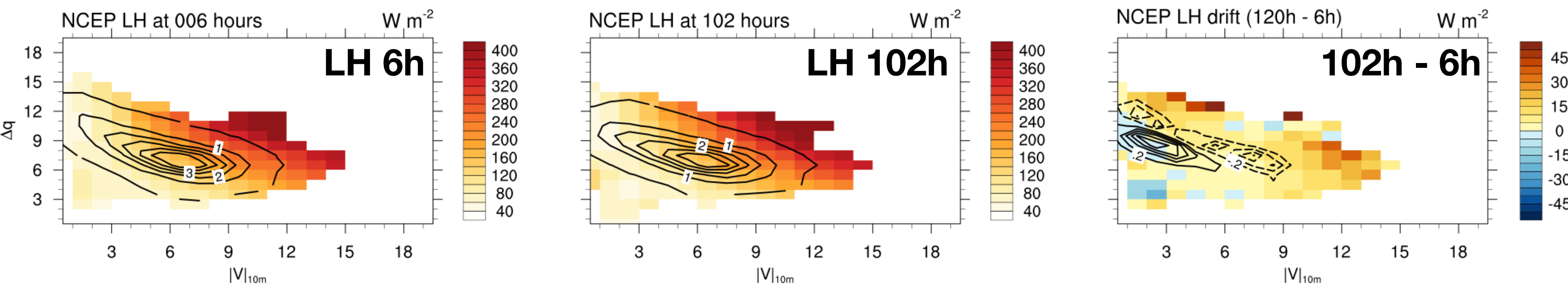
example: NCEP for 201901



Note: some panels are erroneously labeled “120h” instead of “102h”

- PDF shifts to weaker winds, weaker thermodynamics
- non-zero flux differences: why?

example: NCEP for 201901



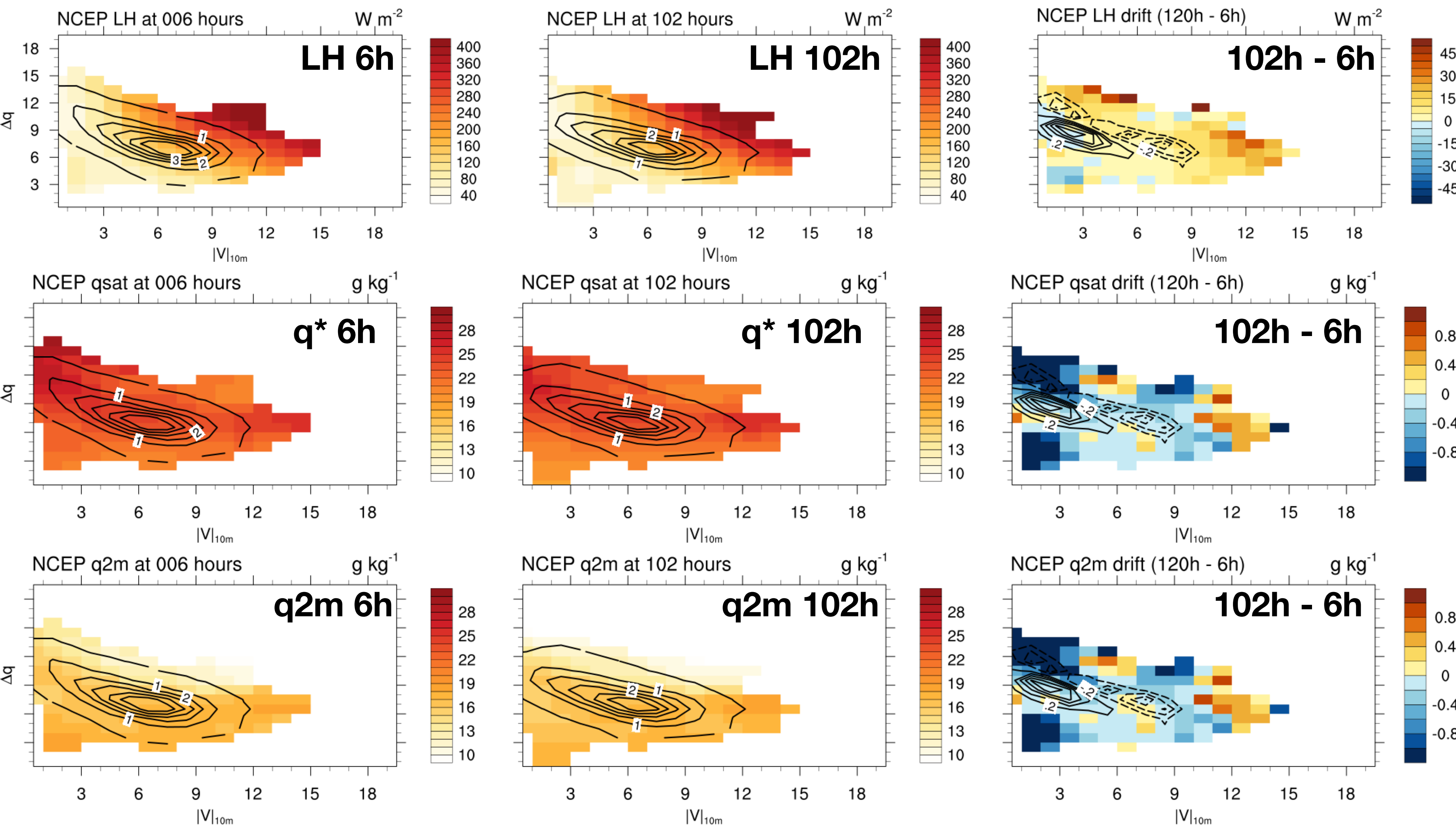
Note: some panels are erroneously labeled “120h” instead of “102h”

- PDF shifts to weaker winds, weaker thermodynamics
- non-zero flux differences: why?

$$LH = \rho C_e L_v |V| (q^*_{SST} - q_a)$$

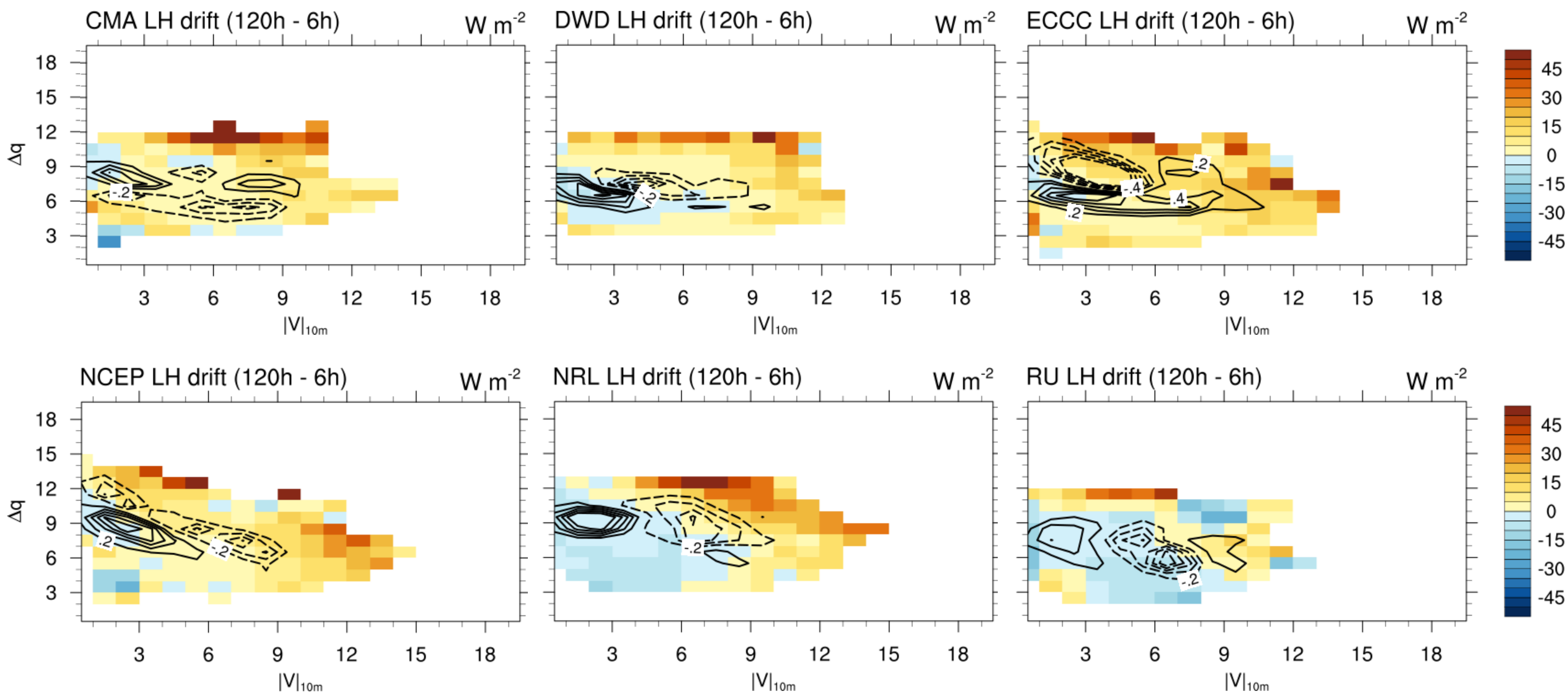
- Ce varies with:
  - ~~wind speed~~ (not applicable here, since we’ve constrained |V|)
  - stability
  - wind speed relative surface currents
  - wave state (surface roughness)

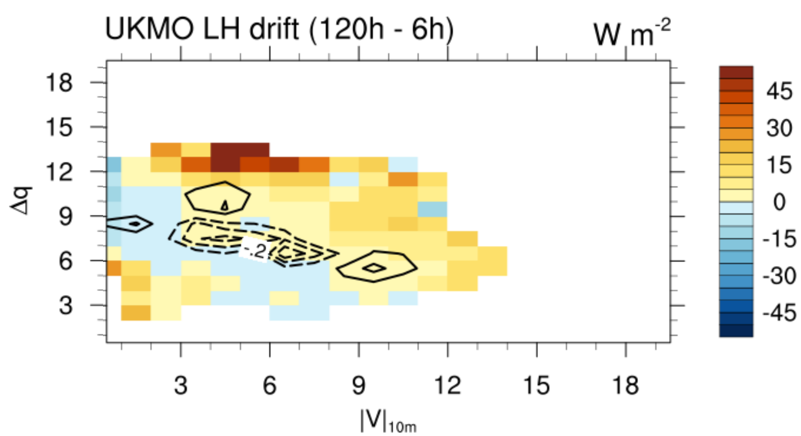
NCEP: LH, q*, q2m



NCEP LH at 006 hours
W m-2
LH 6h
NCEP LH at 102 hours
W m-2
LH 102h
NCEP LH drift (120h - 6h)
W m-2
102h - 6h
NCEP qsat at 006 hours
g kg-1
q* 6h
NCEP qsat at 102 hours
g kg-1
q* 102h
NCEP qsat drift (120h - 6h)
g kg-1
102h - 6h
NCEP q2m at 006 hours
g kg-1
q2m 6h
NCEP q2m at 102 hours
g kg-1
q2m 102h
NCEP q2m drift (120h - 6h)
g kg-1
102h - 6h
Δq
|V|10m

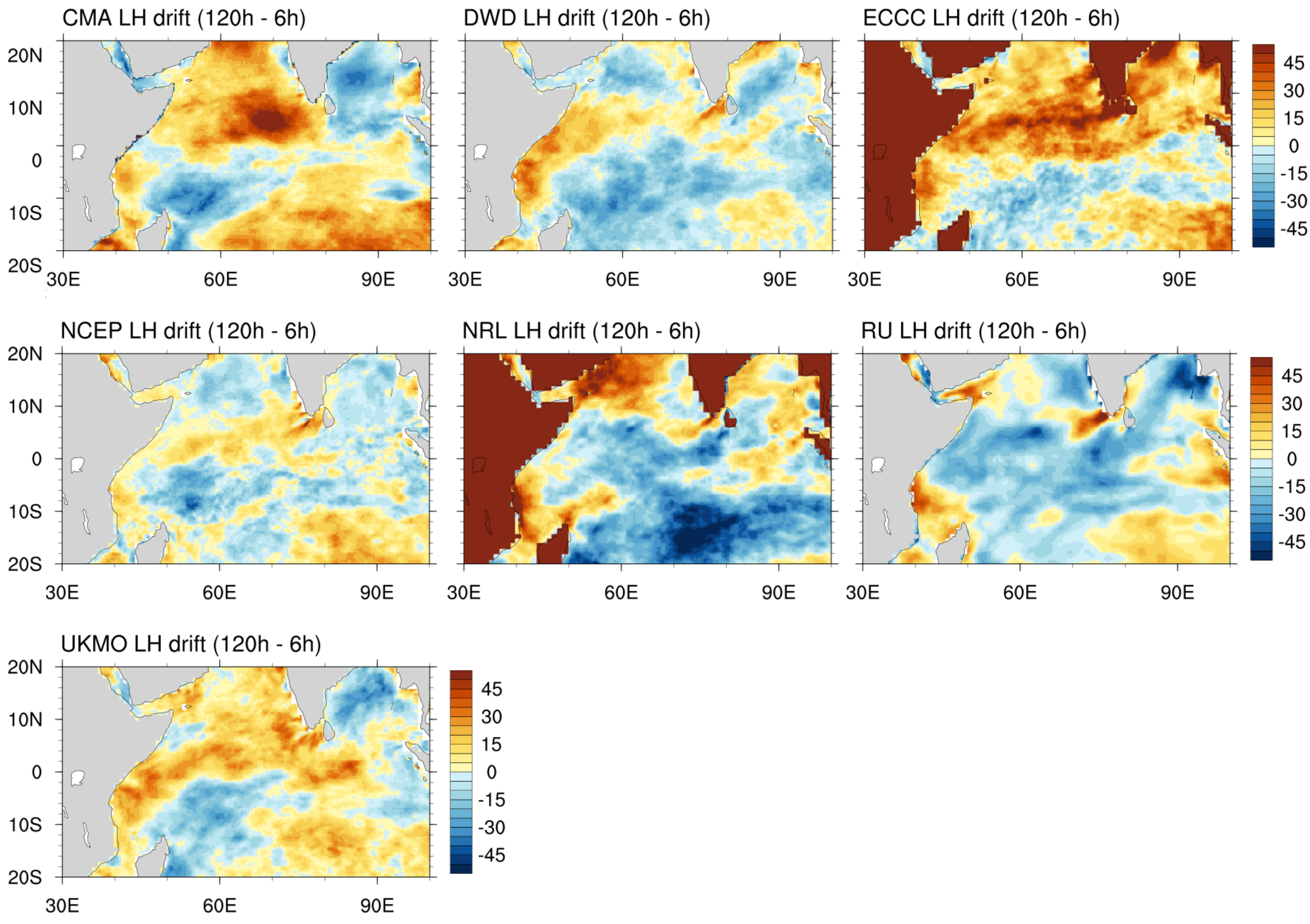
LH drift for (nearly) all models: LH for 201901





- models exhibit a variety of input drift.
- positive LH drift for large |V|, Δq: stability drift?

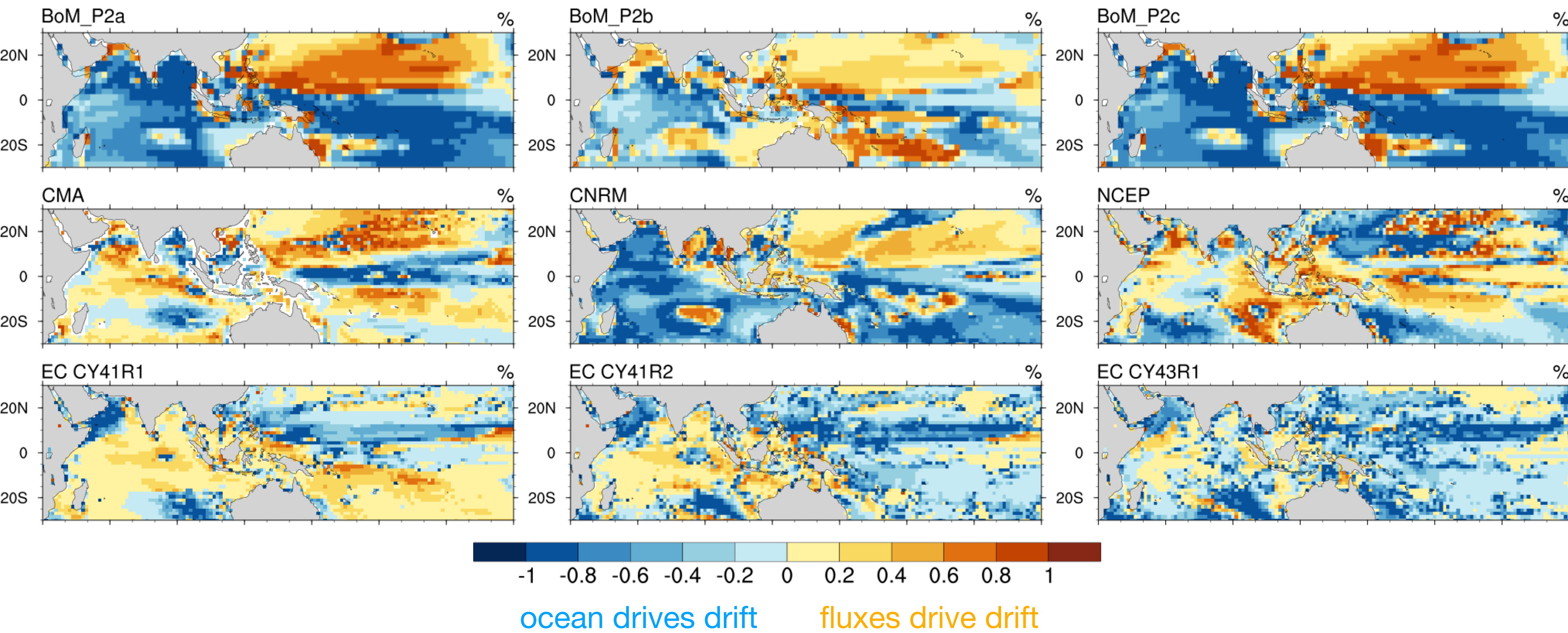
LH drift for (nearly) all models: LH for 201901



Additional analysis…

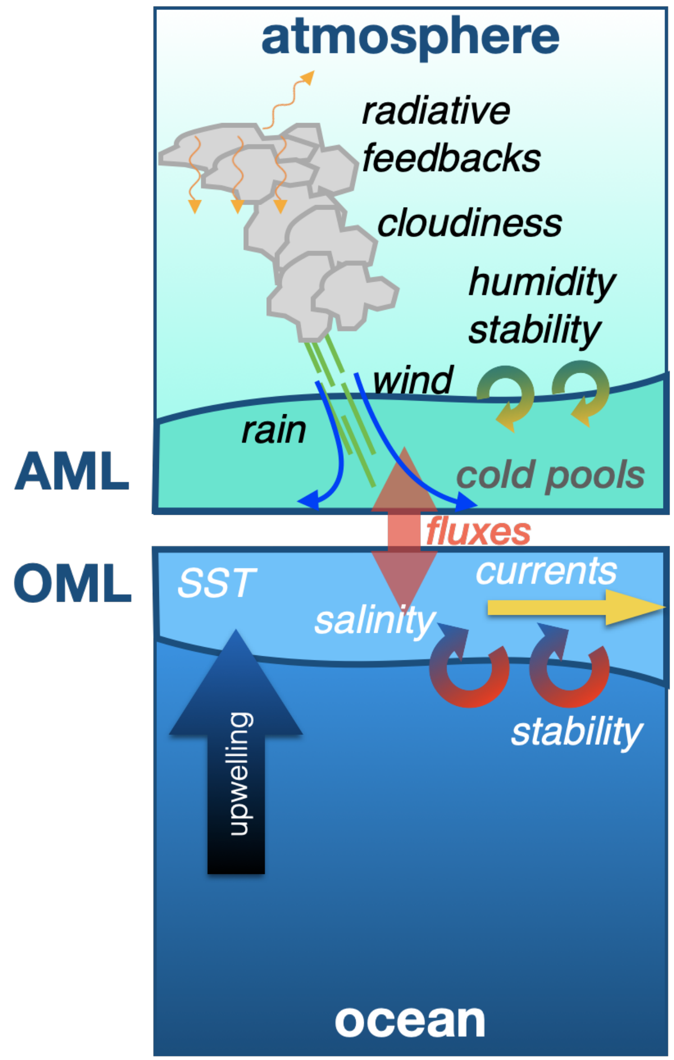
- globally, quantify LH drift contributions from |V|, q*, q2m (not shown here)
- diagnose mean SST tendency (drift) with net surface energy budget (S2S database example below)

S2S database examples



Other thoughts…

- additional ocean output will help shed light on sources of surface flux biases
  - surface fluxes are a coupled problem…
- how to attract effort these types of diagnostics?
  - large datasets (i.e., S2S, SubX):
    - can target a variety of scales (synoptic to subseasonal, and modulated by QBO, ENSO, etc)
    - require a lot of resources (personnel, hardware, time): FUNDING
  - small datasets (i.e., this project)
    - focus on fast processes
    - well suited to ad hoc analysis



Other thoughts…

- can a “small project” with plentiful ocean and atmosphere output help:
  - improve understanding of fine-scale processes?
  - identify needed improvements to model physics?
  - target locations of needed observations?