AN UPDATE ON THE HYCOM SOLAR RADIATION PENETRATION SCHEME

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Bulk Heat Flux Parameterization

- Total heat flux is available from archived products
  - o SST drifts if total flux alone is used to force an OGCM

- HYCOM uses model SST and a bulk heat flux parameterization
- Feedback between SST and heat flux to prevent SST drift
- No need for explicit relaxation to SST

- MICOM uses constant exchange coefficients
- HYCOM has
  - o several options for exchange coefficients
  - o a blackbody longwave correction

Subsurface Heating Parameterization

- Net heat flux at a given depth, z:

$$Q(z) = Q(0) + [Q_{\mathrm{SW}}(0) - Q_{\mathbf{sw}}(z)], \tag{1}$$

- Net heat flux absorbed at the sea surface, $z = 0$:

$$Q(0) = Q_{\mathrm{LW}} + Q_L + Q_S, \tag{2}$$

  - o Q_{LW}: net longwave radiation at the sea surface,
  - o Q_{SW}: net shortwave radiation at the sea surface,
  - o Q_L: latent heat flux,
  - o Q_S: sensible heat flux.

- NOTE:
  - o HYCOM's "surface" heat flux is not $Q(0)$, but
  - o rather the near surface flux absorbed in layer 1
  - o e.g., $Q(1)$ when the top model layer is 1 m thick.

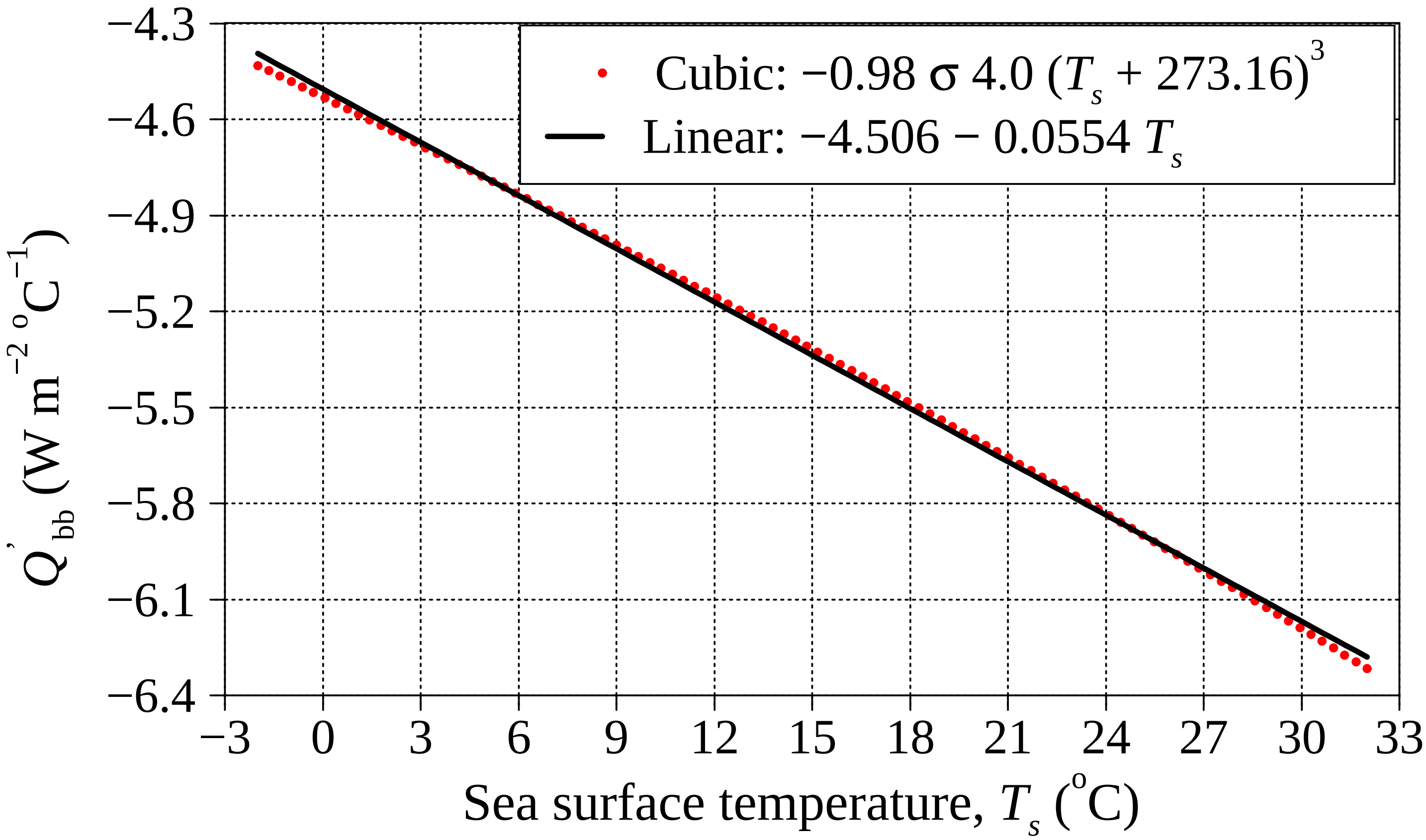
(1) Longwave Radiation

- Input from archived products (e.g., ECMWF, NCEP, etc)
- A correction is needed. Why ?
  - They use their model SST
  - Different from HYCOM SST
- HYCOM uses a **blackbody correction** (Kara et al 2004a):

$$Q_{\mathrm{LW}}(T_s) = Q_{\mathrm{LW}}(T_{sa}) - (4.506 - 0.0554\, T_s)(T_s - T_{sa}).$$

  - T_s: HYCOM SST
  - T_{sa}: Atmospheric model SST
- The effects of clouds are independent of SST

A linear approximation to the blackbody radiation



- Cubic formulation (Josey et al. 2003)
- Linear approximation (Kara et al. 2004a)

(2) Shortwave Radiation

- Previous parameterizations in HYCOM
  - o Jerlov water types (Halliwell 2004)
  - o 2–band scheme (Kara et al. 2004b)
    - o Turbidity–dependent split: red and blue spectrums.
    - o Based on SeaWiFS k_{PAR} climatology (2004c).
    - o Attenuation coefficient, k_{PAR}: **depth–independent**

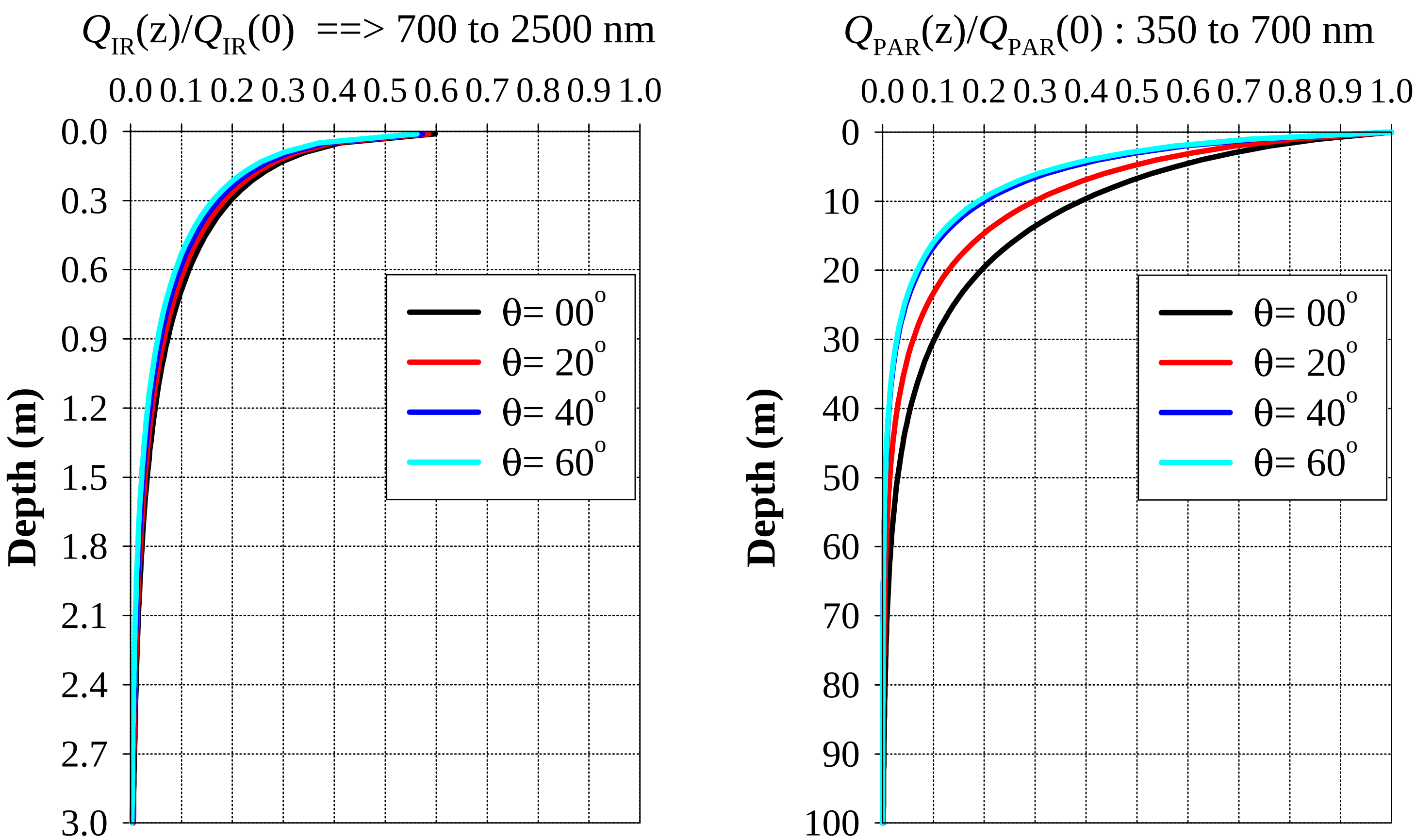
- New parameterization in HYCOM (in progress)
  - o Fixed frequency ranges:
    - o visible spectrum (350–700 nm), also called PAR
    - o infrared spectrum (700–2400 nm)
  - o Will use absorption and backscattering coefficients
  - o k_{PAR} depends on **depth and solar angle**

The shortwave radiation at a given depth (z) is split into two parts:

$$Q_{\mathrm{SW}}(z) = Q_{\mathrm{PAR}}(z) + Q_{\mathrm{IR}}(z), \quad (3)$$

$$Q_{\mathrm{PAR}}(z) = Q_{\mathrm{PAR}}(0)\exp(-\mathrm{z}\ \mathrm{k}_{\mathrm{PAR}}), \quad (4)$$

$$Q_{\mathrm{IR}}(z) = Q_{\mathrm{IR}}(0)\exp(-z\ k_{\mathrm{IR}}), \quad (5)$$



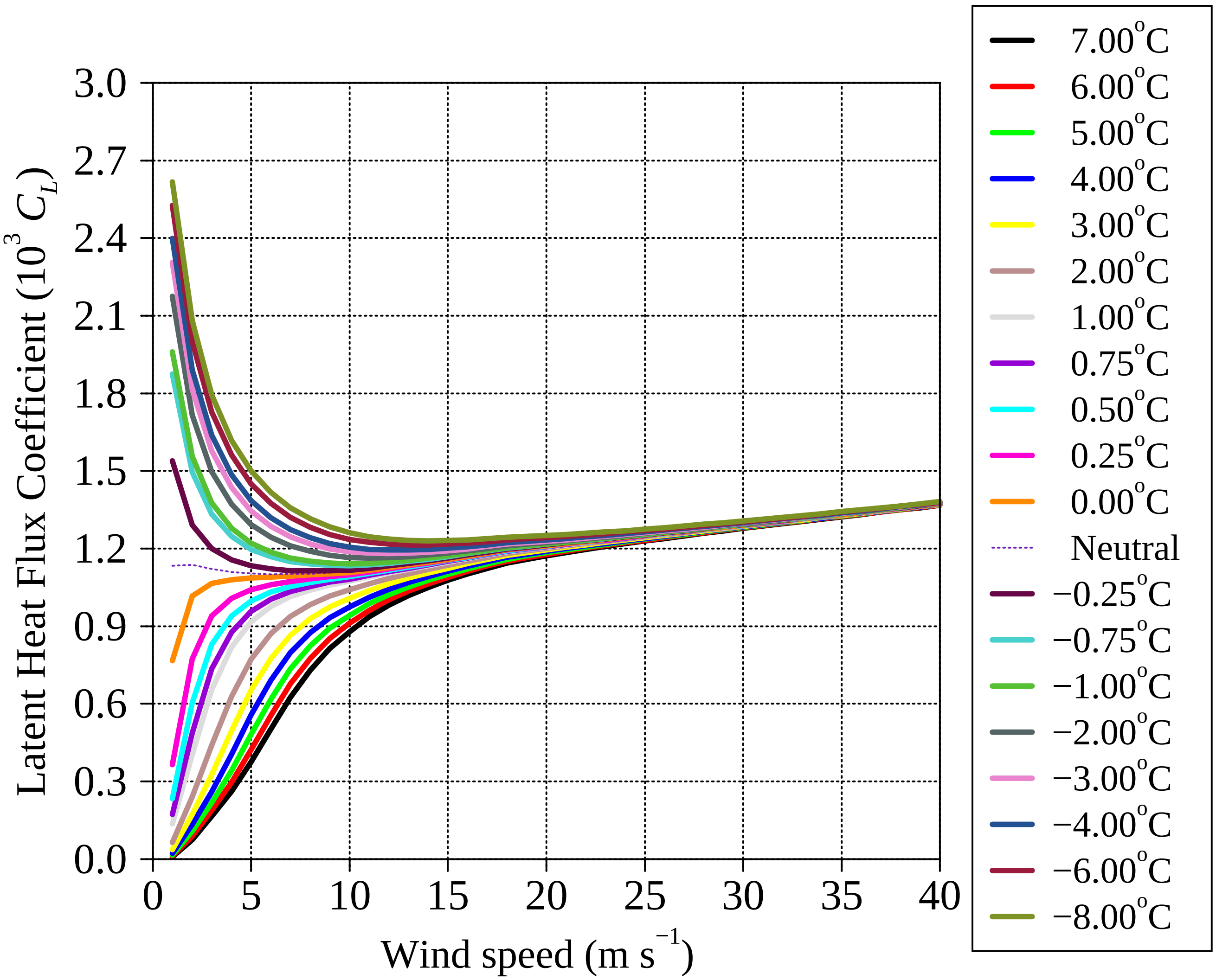
(3) Latent Heat Flux

- Bulk formulation: $Q_L = \rho_a \, C_L \, L \, V_a \, (q_a - q_s)$
- Previous exchange coefficient (C_L) in HYCOM (Kara et al. 2002):
  - o based the COARE (v2.6) algorithm (Fairall et al. 1996)
  - o excluded $V_a < 4 \mathrm{~m~s}^{-1}$, $V_a > 20 \mathrm{~m~s}^{-1}$
  - o C_L was dependent on (T_a–T_s) and V_a

- New C_L parameterization in HYCOM (Kara et al. 2004d)
  - o based on the COARE (v3.0) algorithm (Fairall et al. 2003)
  - o includes V_a from 1 to $40 \mathrm{~m~s}^{-1}$
  - o C_L is dependent on (T_a–T_s), V_a, and RH as well

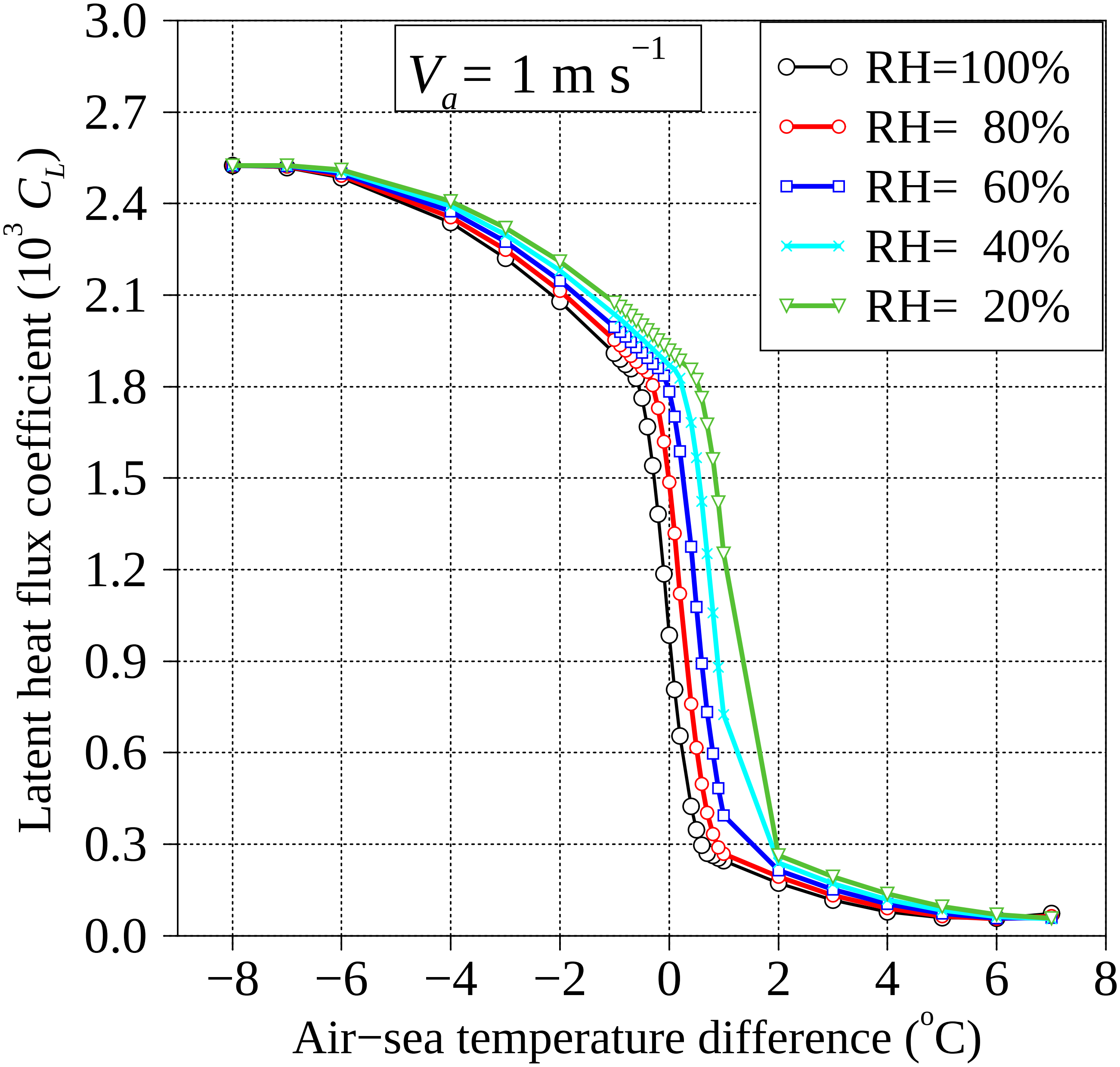
- NOTE: Calculate Q_L using HYCOM SST at each time step

Previous exchange coefficients for the latent heat flux (RH=100%)

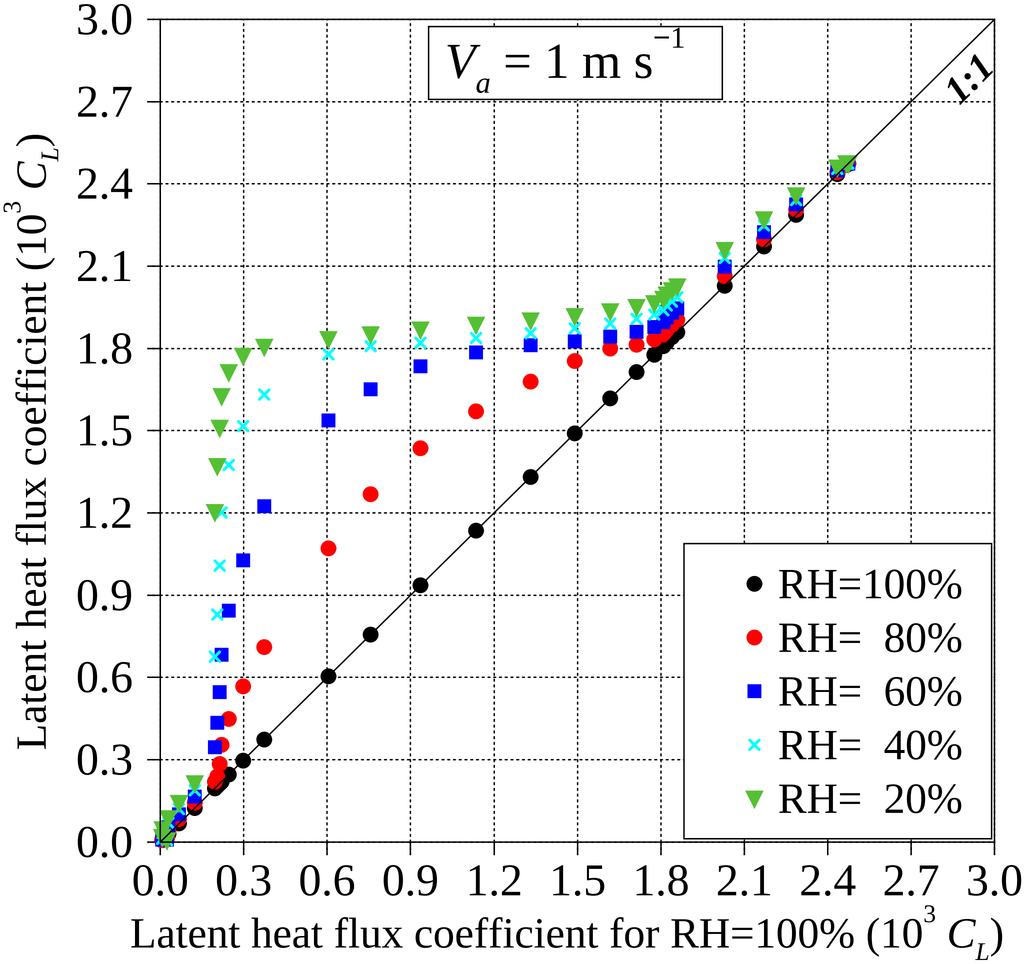


New exchange coefficients for the latent heat flux (for varying RH)

Is including relative humidity in C_L important?



What could be the typical error in latent heat flux without RH?



	Latent heat flux (W m^{-2})		
	$V_a = 1$ m s^{-1}	$V_a = 2$ m s^{-1}	$V_a = 6$ m s^{-1}
100%	**1.9**	**5.7**	**50.1**
80%	**2.1**	**6.5**	**52.6**
60%	**3.4**	**7.2**	**54.3**
40%	**6.6**	**8.0**	**56.2**
20%	**11.8**	**8.9**	**58.0**
00%	**15.9**	**10.3**	**58.9**

$Q_L = \rho_a C_L L V_a (q_a - q_s)$, where $T_a - T_s = 2°\text{C}$, $q_a - q_s = 3$ g kg^{-1}

Summary

- Global HYCOM simulation with
  - the RH–dependent exchange coefficients
  - the depth–dependent shortwave radiation

- Shortwave radiation attenuation:
  - need two satellite–based input fields for HYCOM
  - (1) absorption coefficient
  - (2) backscattering coefficient
  - form a climatology (2001–2003) using MODIS

MODIS: Moderate Resolution Imaging Spectroradiometer