A Rice Cooker Theory -- the Equally Important Quality of Model/Algorithm & Input Parameters in Producing the GSSTF Datasets

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“Rice Cooker Theory”

Fine ‘Rice Cooker’/‘Model-Algorithm’

+ Good-quality ‘Raw Rice’/‘Input Data’

= Delicious ‘Cooked Rice’/Reliable ‘Output Data’
SSM/I Obs

Why me?

SOS!

NCEP Model

Chef C.

Deputy S.

GSSTF Hybrid

GSSTF1

GSSTF2

GSSTF2c

GSSTF2b

GSSTF3
Bulk Aerodynamic Algorithm

\[ LHF = \rho_a L_v C_E (U-U_s)(q_s - q_a) \]
\[ SHF = \rho_a c_p C_H (U-U_s)(\theta_s - \theta_a) \]
\[ WST = \rho_a C_D (U-U_s)^2 \]

- Physical constants  \([L_v, c_p]\)
- State Variable  \([\rho_a, U, q_s, q_a, \theta_s, \theta_a]\)
- Bulk Transfer/Turbulent Exchange Coefficients  \([C_E, C_H, C_D]\)
The EOF Method for Qa Retrieval
(Chou et al., 1995 & 1997)

\[ q(t, r, \sigma) = \bar{q}(\sigma) + \sum_{i=1}^{n} C_i(t, r) F_i(\sigma) \]  

\[ Q(t, r) = \bar{Q} + C_1(t, r) Q_1 + C_2(t, r) Q_2 \]  
\[ W(t, r) = \bar{W} + C_1(t, r) W_1 + C_2(t, r) W_2 \]  
\[ W_B(t, r) = \bar{W}_B + C_1(t, r) W_{B1} + C_2(t, r) W_{B2} \]

\( \bar{Q}, Q_1, \) and \( Q_2 \) are the values of \( \bar{q}, F_1, \) and \( F_2 \) at \( \sigma = 1; \) \( \bar{W}, W_1, W_2 \) and \( \bar{W}_B, W_{B1}, W_{B2} \) are the total and bottom-layer precipitable water corresponding to the profiles of \( \bar{q}, F_1, \) and \( F_2, \)
\( C_1 \) and \( C_2 \) are the principal components for the first and second EOFs.

The WB(mm)-TB(K) Relation
(Schulz et al. 1993)

\[ WB = -59.339 + 0.3697 \ T19V - 0.2390 \ T19H + 0.1559 \ T22V - 0.0497 \ T37V \]
GSSTF2b, GSSTF2c & GSSTF3

Input Parameters:

GSSTF2: SSM/I V4 (TB/WB & W → Q; U)
NCEP-NCAR R1 (SKT; T2m; SLP)
VAM (Wind Vectors)

GSSTF2b: SSM/I V6; NCEP-DOE R2; CCMP/VAM L3

GSSTF2c: Corrected V6 TB (EIA drifting removed)

GSSTF3: 1x1 degree → 0.25x0.25 degree; Q retrieval (Bentamy et al. 2003)

Bentamy et al. [2003] Qa (g/kg) - TB (K) relationship:
Qa = -55.9227 + 0.4035 T19V - 0.2944 T19H + 0.3511 T22V - 0.2395 T37V

Output Parameters:

1. Latent Heat Flux
2. Zonal Wind Stress
3. Meridional Wind Stress
4. Sensible Heat Flux
GSSTF2b(V6) / GSSTF2(V4)/Id eal(GO) vs. Obs (82)
The general level of performance of the 11 data products compared: The products are put into one of three categories: **A** for the “best performing”, **C** for the “worst performing”, and **B** for those in between. Products in each category are listed in alphabetical order.

(Courtesy of Brunke et al. 2011)

<table>
<thead>
<tr>
<th>Group</th>
<th>LH flux</th>
<th>SH flux</th>
<th>Wind stress</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>ERA-40</td>
<td>GSSTF2b</td>
<td>ERA-40</td>
</tr>
<tr>
<td></td>
<td>ERA-Interim</td>
<td>MERRA</td>
<td>ERA-Interim</td>
</tr>
<tr>
<td></td>
<td>GSSTF2b</td>
<td>NCEP/DOE</td>
<td>MERRA</td>
</tr>
<tr>
<td></td>
<td>MERRA</td>
<td>OAFlux</td>
<td>NCEP/DOE</td>
</tr>
<tr>
<td>B</td>
<td>CFSR</td>
<td>CFSR</td>
<td>CFSR</td>
</tr>
<tr>
<td></td>
<td>J-OFURO</td>
<td>ERA-40</td>
<td>GSSTF2</td>
</tr>
<tr>
<td></td>
<td>NCEP/NCAR</td>
<td>ERA-Interim</td>
<td>GSSTF2b</td>
</tr>
<tr>
<td></td>
<td>OAFlux</td>
<td>HOAPS</td>
<td>NCEP/NCAR</td>
</tr>
<tr>
<td>C</td>
<td>HOAPS</td>
<td>GSSTF2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>GSSTF2</td>
<td>J-OFURO</td>
<td></td>
</tr>
<tr>
<td></td>
<td>NCEP/DOE</td>
<td>NCEP/NCAR</td>
<td></td>
</tr>
</tbody>
</table>
Earth Incidence Angle (deg) 
θ is the angle between B (boresight vector: S looking at ground G) and g₃ (z-axis at G).

Time series of the averaged Earth incidence angles (EIA) from the individual SSM/I satellites (i.e., F08, F10, F11, F13, F14, and F15) (produced by K. Hilburn). The brightness temperature (TB) that was affected by the variations of the Earth incidence angles has contributed to the temporal trends of the retrieved WB, Qa and subsequently LHF in GSSTF2b.  (Courtesy of Hilburn and Shie, 2011)
Earth Incidence Angle Corrections (Hilburn & Shie 2011)

- Earth Incidence Angle Corrections
- WB: Qa -3.2%/dec (g2b) -0.5%/dec (g2c)
- 19V (k): Qa 0.5%/dec (g2c)
- 37V (k): WB 1.56%/dec -0.08%/dec (g3)
- 37H (k): WB 1.97%/dec -0.5%/dec (g2b)
- 22V (k): WB -1.97%/dec (g2b) -1.56%/dec (g3)
- QA (g/kg): Qa -0.5%/dec (g2c) -0.08%/dec (g3)
GSSTF2c-F13/GSSTF3-F13 vs. Obs (22/22)


LHF (Wm⁻²)

Qa (g kg⁻¹)
Globally Mean Monthly LHF 1988-2005

STD (5 data) 3.42 (W/m²)

STD (7 data) 3.60 (W/m²)
Globally Mean Monthly DQ 1988-2005

STD (5 data) 0.09 (g/kg²)

0-360/80S-80N

Globally Mean Monthly U 1988-2005

STD (5 data) 0.31 (m/s)

0-360/80S-80N
### LHF Statistics (order: 1, 2, 3, 4, 5) (large → small)

<table>
<thead>
<tr>
<th>LHF (W m⁻²)</th>
<th>GSSTF2c</th>
<th>GSSTF3</th>
<th>HOAPS3</th>
<th>JOFURO2</th>
<th>OAFlux</th>
<th>Ensemble</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mean</strong></td>
<td>100.26</td>
<td>94.03</td>
<td>100.14</td>
<td>95.28</td>
<td>93.51</td>
<td>96.64</td>
</tr>
<tr>
<td><strong>DQ</strong></td>
<td>28.69</td>
<td>27.49</td>
<td>29.28</td>
<td>28.17</td>
<td>25.44</td>
<td>27.79</td>
</tr>
</tbody>
</table>

### Qa Statistics (order: 1, 2, 3, 4, 5) (large → small)

<table>
<thead>
<tr>
<th>Qa (g kg⁻¹)</th>
<th>GSSTF2c</th>
<th>GSSTF3</th>
<th>HOAPS3</th>
<th>JOFURO2</th>
<th>OAFlux</th>
<th>Ensemble</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mean</strong></td>
<td>11.59</td>
<td>11.79</td>
<td>11.86</td>
<td>12.11</td>
<td>11.53</td>
<td>11.78</td>
</tr>
</tbody>
</table>

### Qs Statistics (order: 1, 2, 3, 4, 5) (large → small)

<table>
<thead>
<tr>
<th>Qs (g kg⁻¹)</th>
<th>GSSTF2c</th>
<th>GSSTF3</th>
<th>HOAPS3</th>
<th>JOFURO2</th>
<th>OAFlux</th>
<th>Ensemble</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mean</strong></td>
<td>15.39</td>
<td>15.46</td>
<td>15.58</td>
<td>15.85</td>
<td>15.29</td>
<td>15.51</td>
</tr>
</tbody>
</table>

### DQ Statistics (order: 1, 2, 3, 4, 5) (large → small)

<table>
<thead>
<tr>
<th>DQ (g kg⁻¹)</th>
<th>GSSTF2c</th>
<th>GSSTF3</th>
<th>HOAPS3</th>
<th>JOFURO2</th>
<th>OAFlux</th>
<th>Ensemble</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mean</strong></td>
<td>3.80</td>
<td>3.66</td>
<td>3.72</td>
<td>3.64</td>
<td>3.65</td>
<td>3.69</td>
</tr>
</tbody>
</table>

### U Statistics (order: 1, 2, 3, 4, 5) (large → small)

<table>
<thead>
<tr>
<th>U (m s⁻¹)</th>
<th>GSSTF2c</th>
<th>GSSTF3</th>
<th>HOAPS3</th>
<th>JOFURO2</th>
<th>OAFlux</th>
<th>Ensemble</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mean</strong></td>
<td>7.55</td>
<td>7.51</td>
<td>7.87</td>
<td>7.74</td>
<td>6.97</td>
<td>7.53</td>
</tr>
</tbody>
</table>
Oceanic Environment involving Kuroshio Current during Typhoon Season (e.g., August)

(a) August Climatology (2002-2009) of SST (°C, shaded) and 850hPa vector winds (ms⁻¹).

(b) August Climatology (1988-2008) of LHF (Wm⁻², shaded) and wind speed at 2m (contour interval is 0.2 ms⁻¹).

(a) Zonal averages over the oceans for AIRS–MERRA (thin solid) and MERRA–MERRA (thin dash) total water vapor sink, MERRA P minus E (thin dash–dot), TRMM 3B42 P minus GSSTF2b E (thick solid), and GPCP P minus GSSTF2b E (thick dash). Data are averaged for (a) DJF and (b) JJA of 2004–08. (Courtesy of Wong et al. 2011, J. Climate)
GPCP vs MERRA
Rain Rate Climatology (mm/day)
1998-2004 (Courtesy of Gu 2010)

S. Asian Monsoon
(60E-110E)

E. Asian Monsoon
(110E-160E)

GSSTF2b Monthly Clim.: LHF (W/m²)
1988-2008 (Shie et al. 2010)

S. Asian Monsoon
(60E-110E)

E. Asian Monsoon
(110E-160E)
* GSSTF2b (Jul 1987-Dec 2008): global 1°x1° daily, monthly and climatology (monthly, seasonal and annual); individual SSM/I satellites, and the satellite-combined products. Distributed by GES DISC in Oct 2010.

* GSSTF2c (similar to GSSTF2b) with corrected TB. Released in Oct 2011:

* GSSTF3 (Jul 1987-Dec 2008) with a finer resolution of 0.25°x.25°. Released in Jun 2012 and updated in Nov 2012.

Digital Object Identifiers (DOI) is newly registered for each data product.
## A Summary of Performance Metrics Report for GSSTF2b*-2c**-3*** (Sep 2010-Sep 2012)

<table>
<thead>
<tr>
<th>Month Year</th>
<th>Item</th>
<th>Number of Distinct Users</th>
<th>Number of Products Delivered</th>
<th>Volume of Data Distributed (GB)</th>
<th>Volume of Data Available (GB)</th>
<th>Number of Services Provided</th>
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<tbody>
<tr>
<td>SOND 2010</td>
<td>40</td>
<td>8584</td>
<td>32.934</td>
<td>92.5*</td>
<td></td>
<td>90</td>
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<td>JFM 2011</td>
<td>46</td>
<td>56147</td>
<td>101.138</td>
<td>92.5</td>
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<td>58</td>
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<td>AMJ 2011</td>
<td>59</td>
<td>57128</td>
<td>59.636</td>
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<td>37</td>
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<td>JAS 2011</td>
<td>56</td>
<td>23126</td>
<td>55.896</td>
<td>92.5</td>
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<td>66</td>
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<td>OND 2011</td>
<td>50</td>
<td>16349</td>
<td>21.641</td>
<td>166.5**</td>
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<td>117</td>
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<tr>
<td>JFM 2012</td>
<td>38</td>
<td>44770</td>
<td>49.766</td>
<td>166.5</td>
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<td>60</td>
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<tr>
<td>AMJ 2012</td>
<td>46</td>
<td>41363</td>
<td>48.546</td>
<td>166.5</td>
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<td>59</td>
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<tr>
<td>JAS 2012</td>
<td>67</td>
<td>26849</td>
<td>190.639</td>
<td>721***</td>
<td></td>
<td>41</td>
</tr>
<tr>
<td>Total</td>
<td>402</td>
<td>274,316</td>
<td>560.196</td>
<td>813.5</td>
<td></td>
<td>528</td>
</tr>
</tbody>
</table>
Thank You!