CWB衛星資料監測系統

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大綱

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前言

- 衛星資料具有高覆蓋率的特性，為缺乏傳統觀測資料的海洋、高空區域提供了許多資訊，進而提升全球預報模式的預報準確度。
- 然而衛星觀測資料本身具有誤差，若誤差過大，反而會影響預報表現，因此在使用衛星需進行偏差校正，使衛星資料能有效的被利用 。
- 現行作業系統中，衛星資料的使用量佔全部資料量的九成，因此，如何進行衛星資料的偏差校正及監測便是一件重要的課題。

偏差校正(Bias Correction)

cost function

$$J(\mathrm{x}) = \frac{1}{2}(\mathrm{x} - \mathrm{x}_b)^T \mathbf{B}^{-1}(\mathrm{x} - \mathrm{x}_b) + \frac{1}{2}[\mathrm{y} - h(\mathrm{x})]^T \mathbf{R}^{-1}[\mathrm{y} - h(\mathrm{x})]$$

with bias correction

$$\tilde{h}(\mathrm{x}, \beta) = h(\mathrm{x}) + b^{air}(\mathrm{x}, \beta) + b^{angle}$$ (Harris and Kelly 2001; Dee 2004)

b^{air}: air-mass component, b^{angle} :scan angle component

$$b^{air}(\mathrm{x}, \beta) = \beta_0 + \sum_{k=1}^{N} \beta_k p_k(\mathrm{x}) \qquad b^{angle} = \sum_{k=1}^{K} \beta_{N+k} \phi^k \qquad N = 4, K = 4$$

β: predictor coefficient, p: predictor, ϕ: scan angle.

b^{air} update with inner loop and b^{angle} update with outer loop

CWB前代作業版本GSI，為NCEP 2012年上線之版本。衛星資料同化需要較長時間的調整，以得到較好的偏差校正。

偏差校正(Bias Correction)

combine b^{air} and b^{angle} (Zhu et al. 2013)

$$\tilde{h}(\mathrm{x},\beta) = h(\mathrm{x}) + \sum_{k=0}^{N+K} \beta_k p_k(\mathrm{x})$$

new cost function

$$J(\mathrm{x},\beta) = \frac{1}{2}(\mathrm{x}-\mathrm{x}_b)^T \mathrm{B}_{\mathrm{x}}^{-1}(\mathrm{x}-\mathrm{x}_b) + \frac{1}{2}(\beta-\beta_b)^T \mathbf{B}_{\beta}^{-1}(\beta-\beta_b) + \frac{1}{2}[\mathrm{y}-\tilde{h}(\mathrm{x},\beta)]^T \mathbf{R}^{-1}[\mathrm{y}-\tilde{h}(\mathrm{x},\beta)]$$

let $\mathrm{x} = \mathrm{x}_a$ and minimizing the predictor coefficient function F

$$F(\beta) = \frac{1}{2}(\beta-\beta_b)^T \mathbf{B}_{\beta}^{-1}(\beta-\beta_b) + \frac{1}{2}[\mathrm{y}-\tilde{h}(\mathrm{x}_a,\beta)]^T \mathbf{R}^{-1}[\mathrm{y}-\tilde{h}(\mathrm{x}_a,\beta)]$$

CWB今年五月上線之GSI，為NCEP EMC trunk r55323版本，衛星資料的偏差校正可以快速地得到調整。

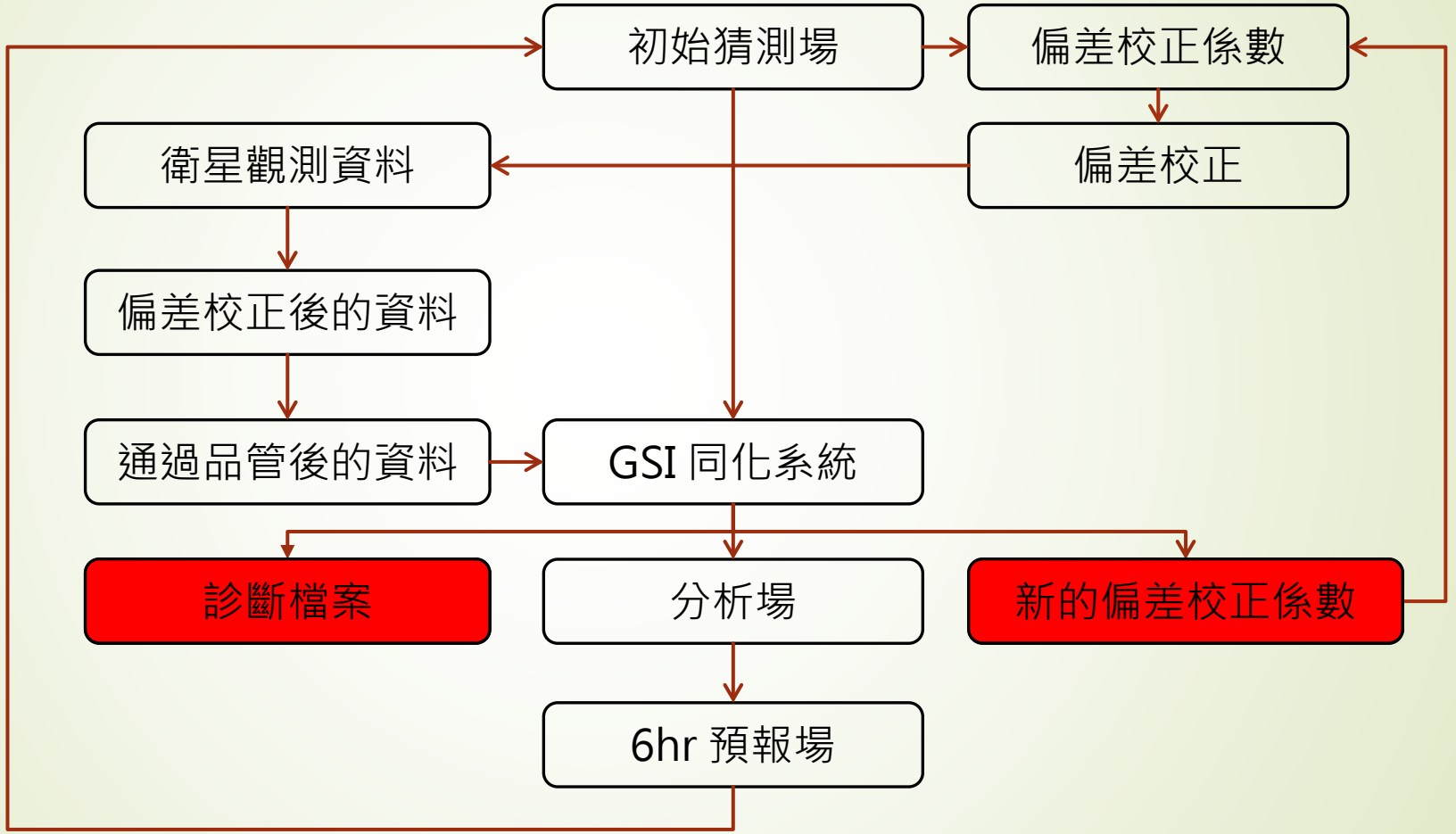
偏差校正(Bias Correction)

In new GSI, set **newpc4pred = .true. , adp_anglebc = .true. , emiss_bc = .true.**

there are 12 predictor p_k $k = 0{\sim}11$

	predictor	variable of plot	mean
air-mass bias correction	p_0	const (meqan bias)	global offset ($p_0 = 1$)
	p_1	scangl	zenith angle ($p_1 = 0$)
	p_2	clw	cloud liquid water
	p_3	lapse2	square of temperature lapse rate
	p_4	lapse	temperature lapse rate
only for SSMI	p_5	cos	(azimuth angle)*cos(lat)
	p_6	sin	sin(lat)
	p_7	emiss	emissivity sensitivity
scan angle bias correction	p_8	ordang4	(scan angle)^4
	p_9	ordang3	(scan angle)^3
	p_{10}	ordang2	(scan angle)^2
	p_{11}	ordang1	scan angle
		fixang	total scan angle bias correction

衛星資料同化流程圖



衛星監測系統利用GSI同化後產生之診斷檔案及偏差校正係數兩個檔案進行監測。

目前成果

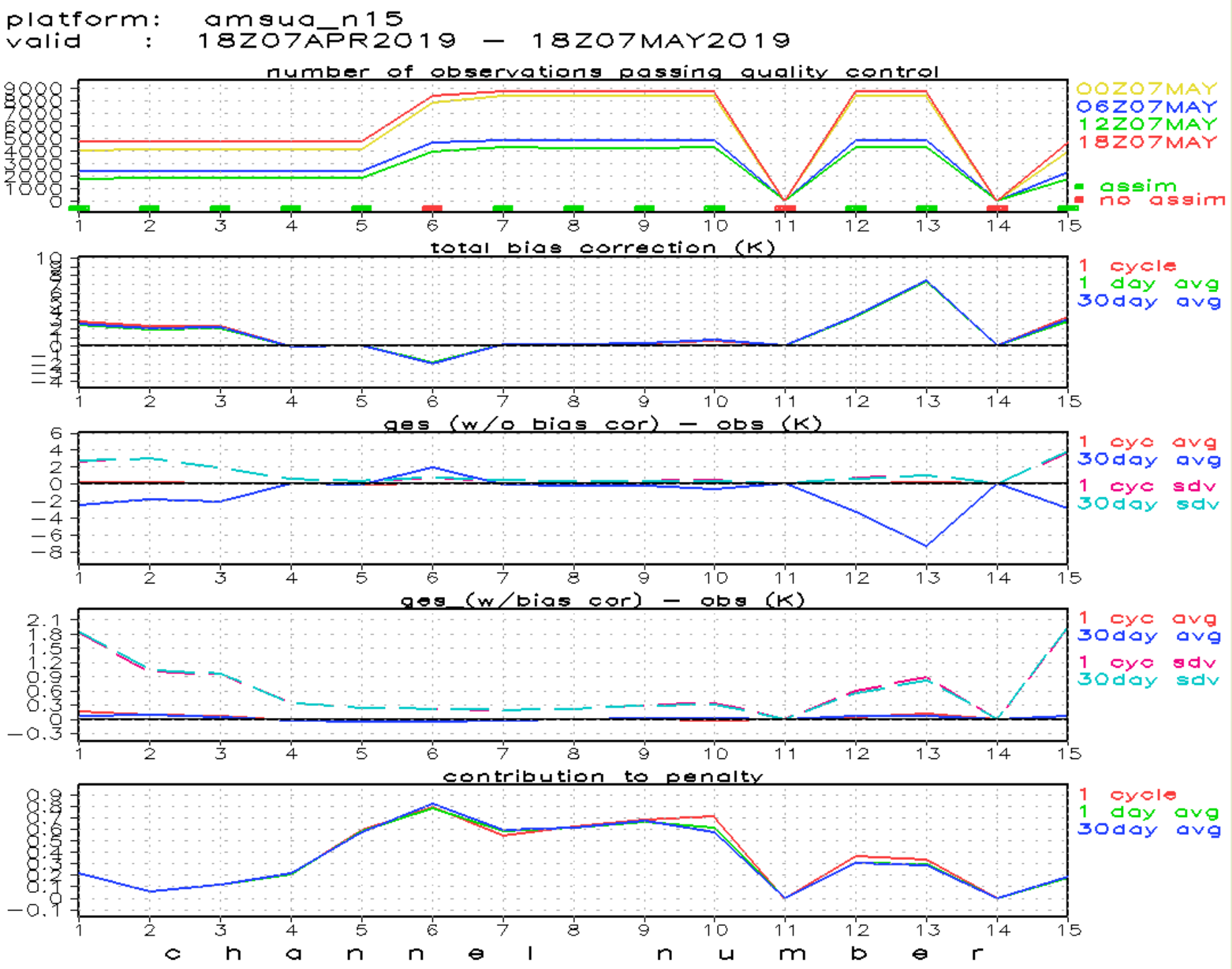
- 根據NCEP EMC 提供之shell script及程式，目前已經將此套系統建置於CWB，並完成衛星資料監測的資料處理以及重新編排繪圖，繪圖樣式包含

  1. summary
  2. horiz (horizontal)
  3. time(time series)
  4. angle (scan angle statistics)
  5. bcoef (bias correction coefficients)
  6. bcor (bias correction)

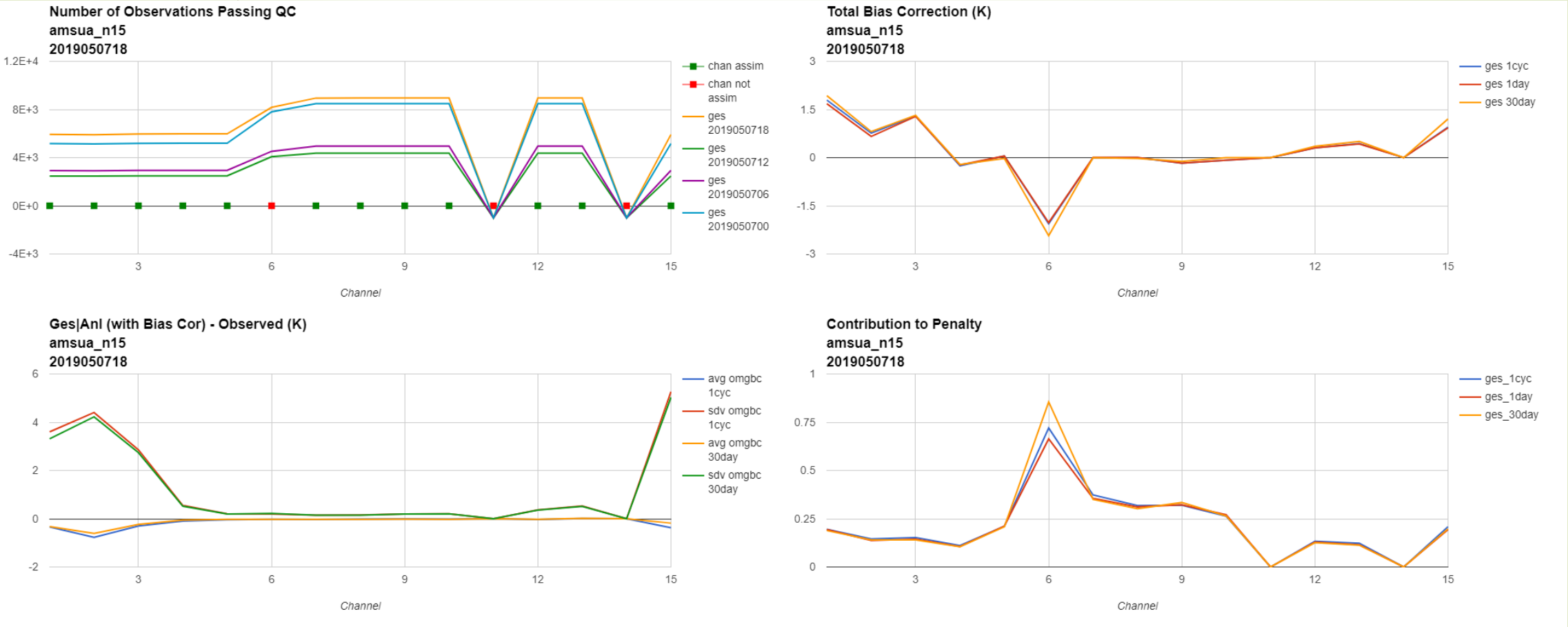
- 若將所有的繪圖選項打開，則一個dtg會產出近13萬張圖。考慮電腦資源與研究效益，目前只繪製summary 、time及horiz三種圖，並設定繪製全球區域中，所有頻道omg及oma的監測圖。

summary

count : number of observations passing QC
total : total bias correction
omgnbc : obs - ges without bias correction
omgbc : obs – ges with bias correction
penalty : $[\mathrm{y} - \tilde{h}(\mathrm{x}, \beta)]^T \mathbf{R}^{-1} [\mathrm{y} - \tilde{h}(\mathrm{x}, \beta)]$


platform: amsua_n15
valid : 18Z07APR2019 — 18Z07MAY2019
number of observations passing quality control
00Z07MAY
06Z07MAY
12Z07MAY
18Z07MAY
assim
no assim
total bias correction (K)
1 cycle
1 day avg
30day avg
ges (w/o bias cor) — obs (K)
1 cyc avg
30day avg
1 cyc sdv
30day sdv
ges (w/bias cor) — obs (K)
1 cyc avg
30day avg
1 cyc sdv
30day sdv
contribution to penalty
1 cycle
1 day avg
30day avg
channel number

NCEP EMC Radiance Monitor System (summary)



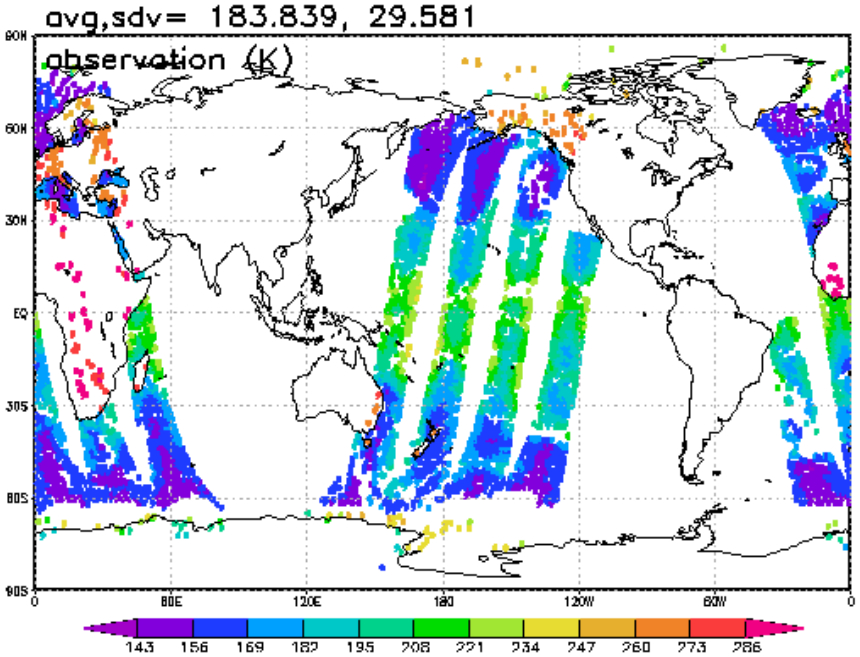
http://www.emc.ncep.noaa.gov/gmb/gdas/radiance/esafford/wopr/index.html

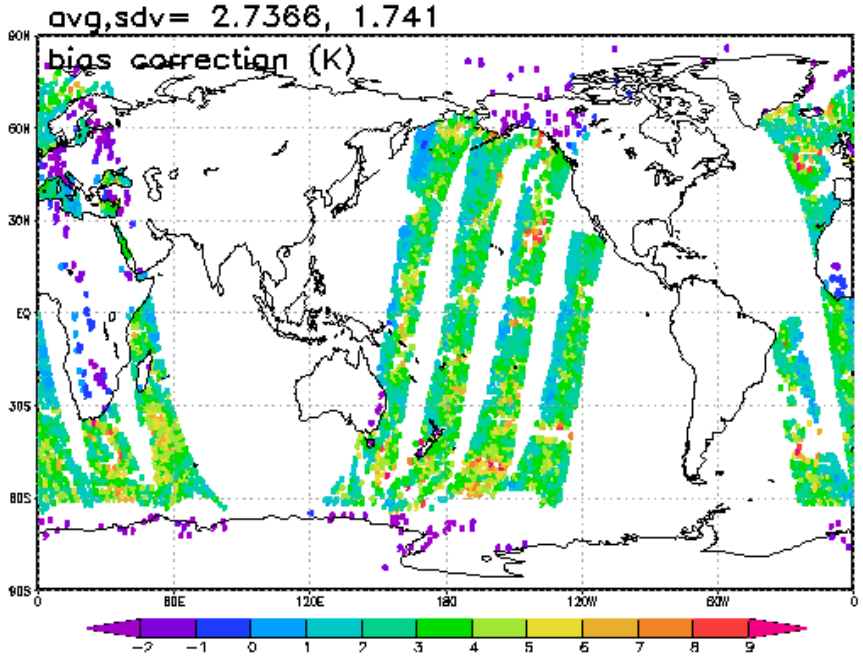
horiz

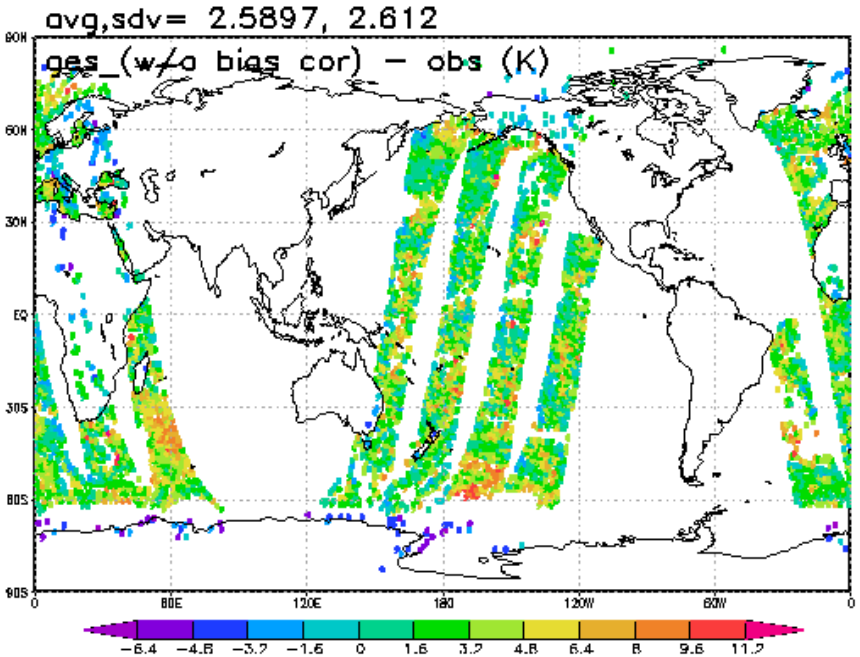
obs : observations
bor : total bias correction
omgnbc : obs - ges without bias correction
omgbc : obs – ges with bias correction

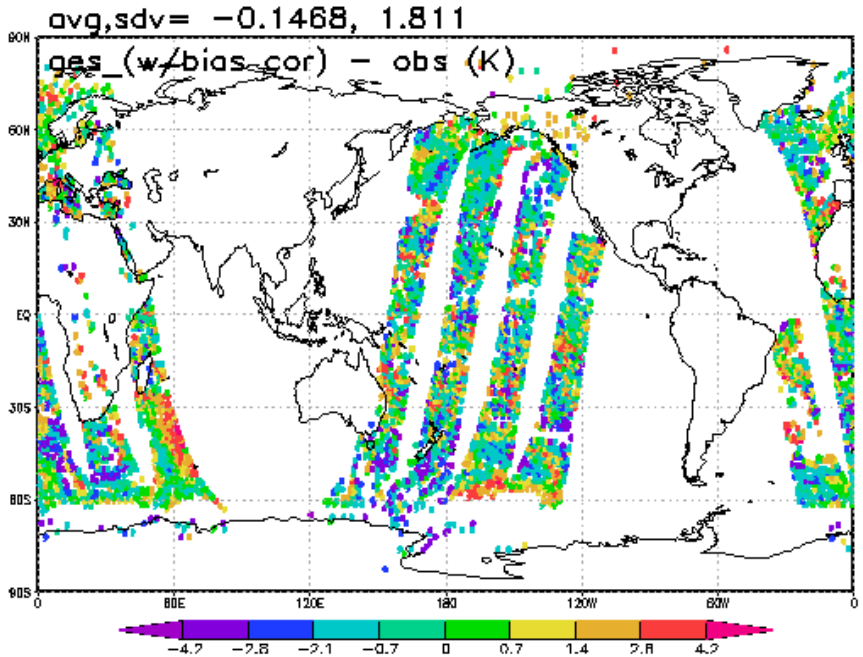
platform: amsua n15 channel 1
VT: 18Z07MAY2019 COUNT= 4711

frequency: 23.80 GHz
wavelength: 12596.13 μm



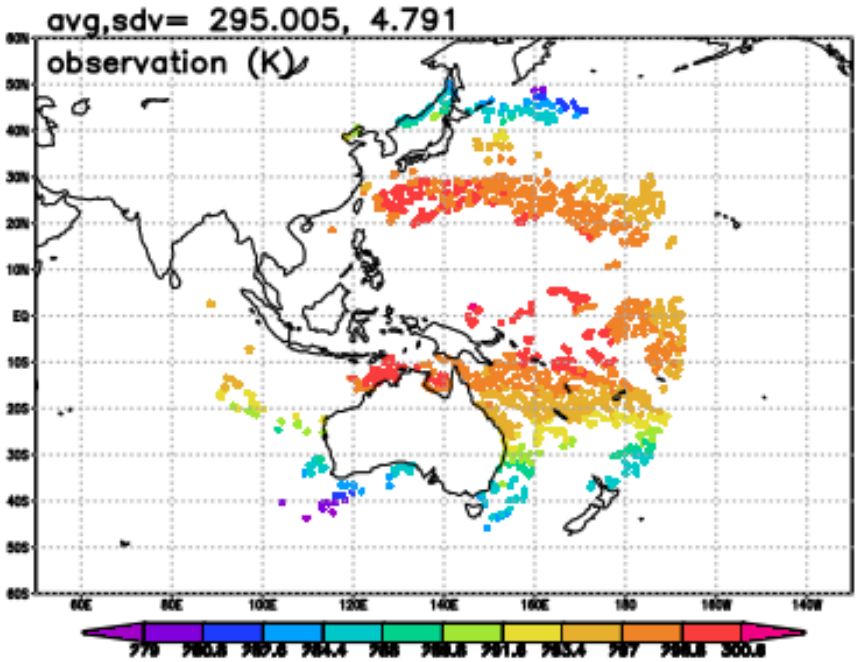


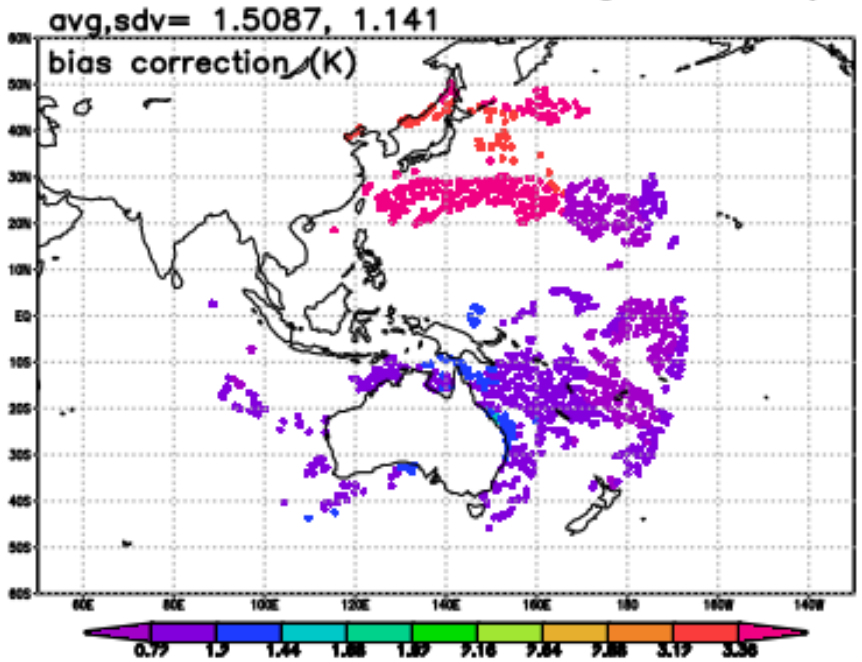


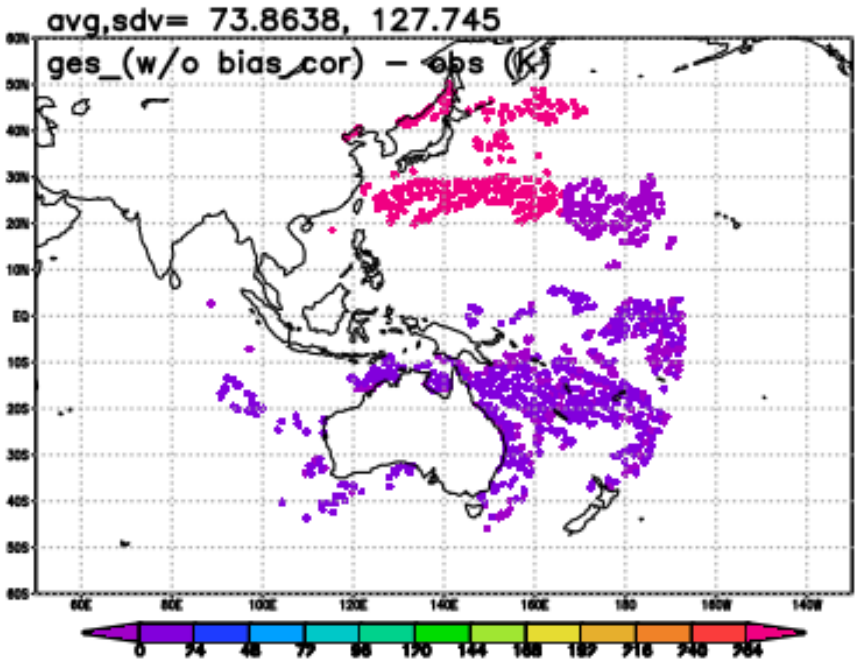


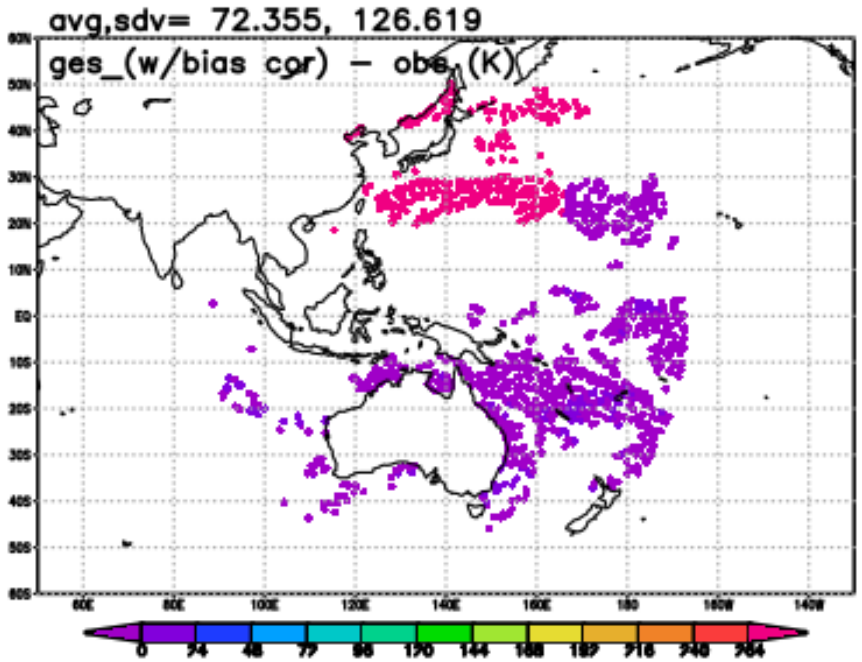
platform: ahi himawari8 channel chan (NOT ASSIMILATED)
VT: 12Z30SEP2016 COUNT= 1108

frequency: freq GHz
wavelength: wave μm



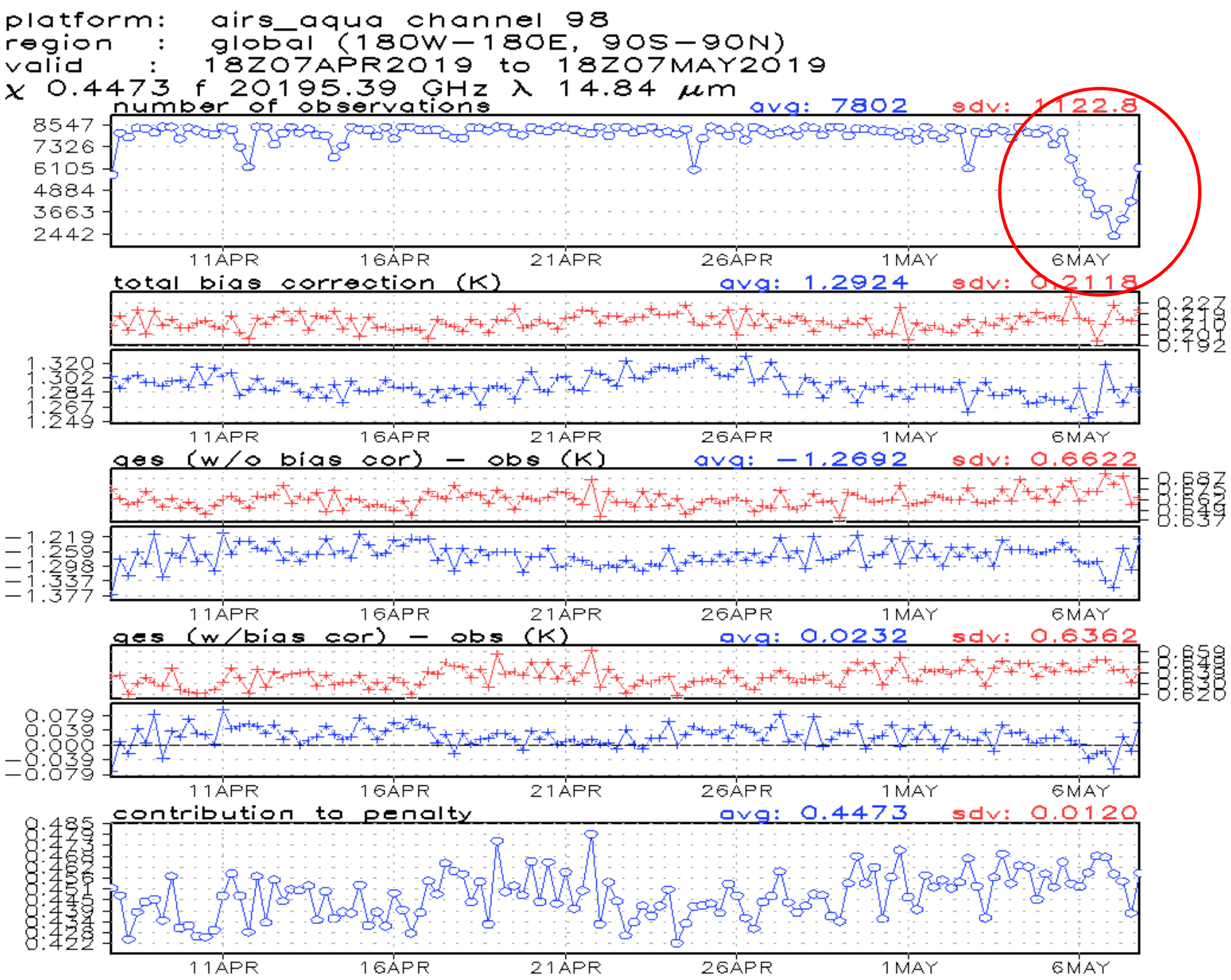




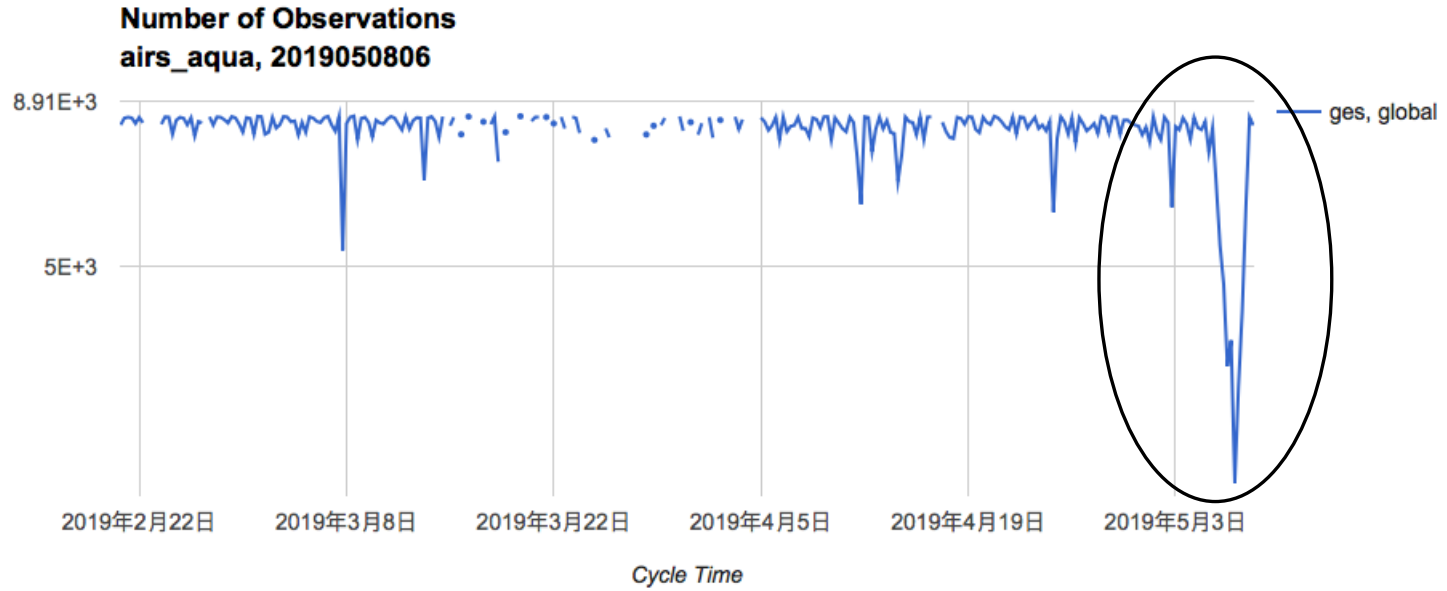


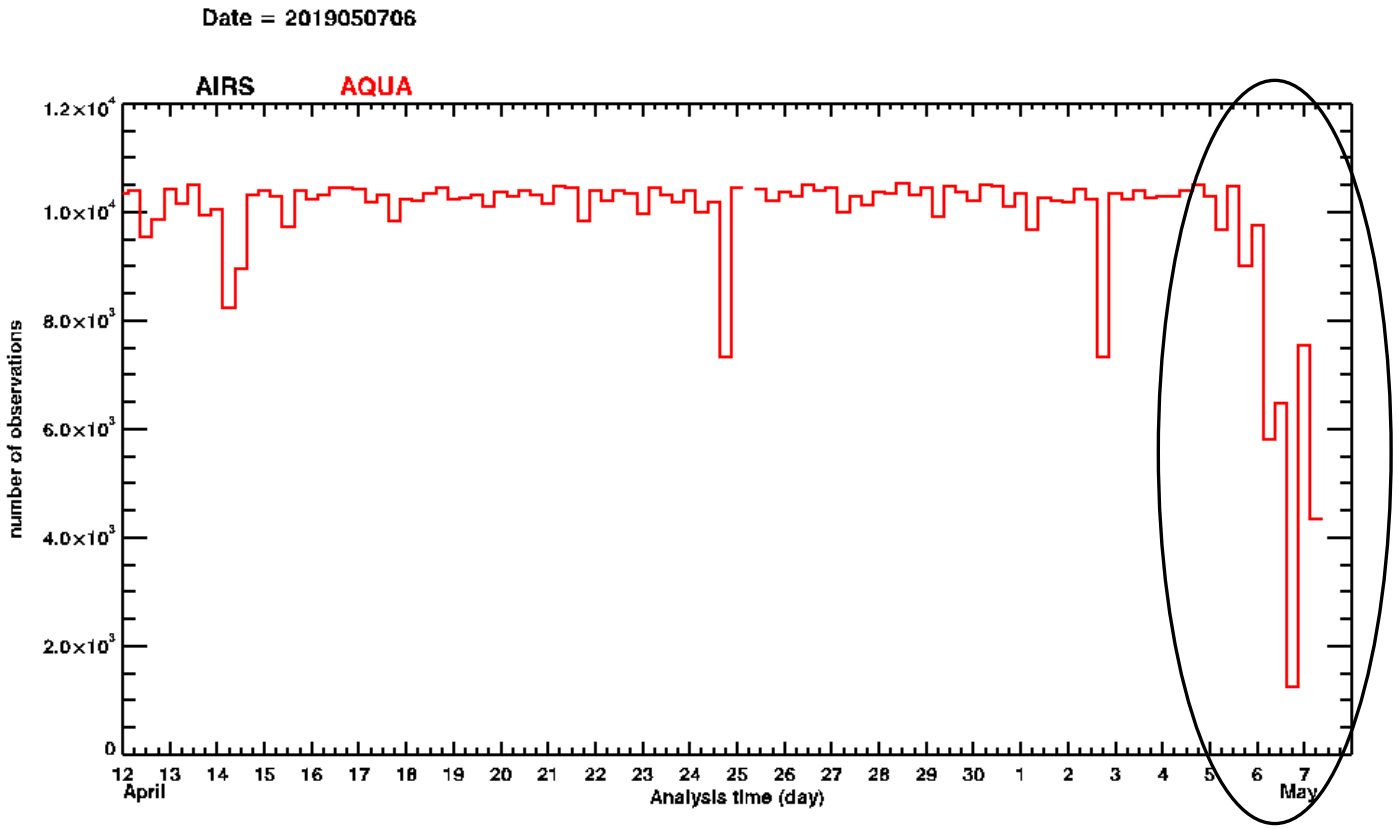
time

count : number of observations passing QC
total : total bias correction
omgnbc : obs - ges without bias correction
omgbc : obs – ges with bias correction
penalty : $[\mathrm{y} - \tilde{h}(\mathrm{x}, \beta)]^T \mathrm{R}^{-1} [\mathrm{y} - \tilde{h}(\mathrm{x}, \beta)]$


platform: airs_aqua channel 98
region : global (180W-180E, 90S-90N)
valid : 18Z07APR2019 to 18Z07MAY2019
χ 0.4473 f 20195.39 GHz λ 14.84 μm
number of observations
avg: 7802
sdv: 1122.8
8547
7326
6105
4884
3663
2442
11APR
16APR
21APR
26APR
1MAY
6MAY
total bias correction (K)
avg: 1.2924
sdv: 0.2118
1.320
1.302
1.284
1.267
1.249
ges (w/o bias cor) - obs (K)
avg: -1.2692
sdv: 0.6622
-1.219
-1.377
ges (w/bias cor) - obs (K)
avg: 0.0232
sdv: 0.6362
0.079
0.039
0.000
-0.039
-0.079
contribution to penalty
avg: 0.4473
sdv: 0.0120

NCEP EMC





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結論與未來展望

- 我們根據NCEP EMC 提供之shell script及程式，成功建置衛星資料監測系統於CWB，並根據CWB之需求，重新調整衛星資料監測系統的資料處理以及繪圖樣式與輸出。
- 本套系統經過測試後於今年五月正式上線，此套系統不僅可以了解衛星資料的使用情況，並能即時監控衛星資料的狀態。
- 目前的衛星資料同化設定參照NCEP，未來預計藉由衛星資料監控系統診斷及分析各衛星頻道的資料品質，調整衛星資料同化設定，得到更適合CWB GFS模式的衛星資料同化設定。

Thanks for listening