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# Asimilación de datos del FFGS y control de calidad

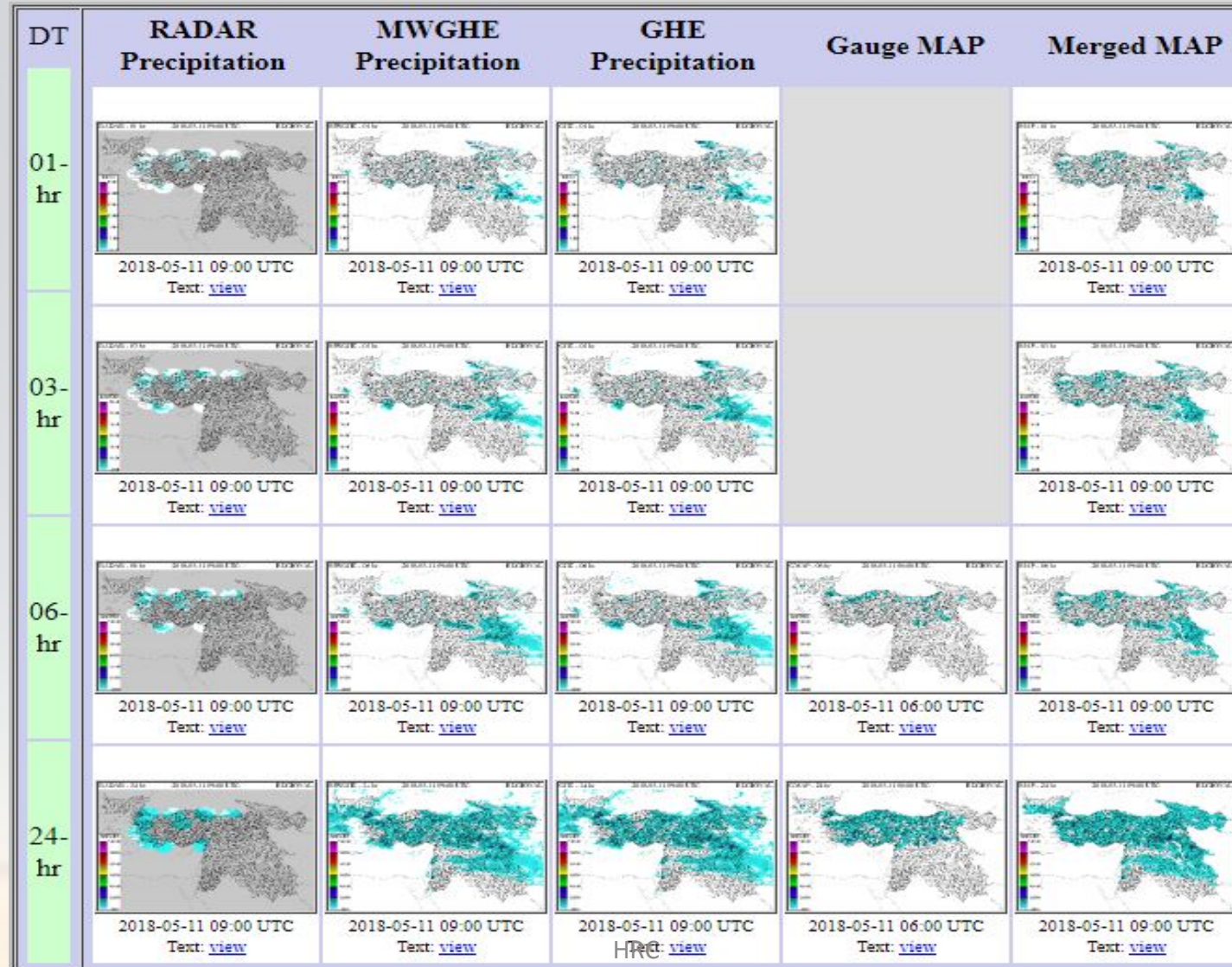
Konstantine P. Georgakakos, Sc.D.

HYDROLOGIC RESEARCH CENTER

23 Mayo 2018

# Ejemplo de interfaz de datos

Productos derivados de los datos observados y de datos cuya calidad ha sido controlada



# Ejemplo de interfaz de usuario para datos

## Datos observados in-situ

Composite Product: <a href="#">text</a> , <a href="#">CSV</a> , <a href="#">CSVt</a>						SFTP data transfer (requires SFTP Client): <a href="#">EXPORTS REGIONAL/2018/05/11</a>					
Surfmet Gauge Observations at 2018-05-11 06:00 UTC											
<a href="#">Station Identifier</a>	<a href="#">Station Name</a>	<a href="#">Accumulated Precipitation (mm/06hr)</a>	<a href="#">Average Temperature (C)</a>	<a href="#">Snow Depth (cm)</a>	<a href="#">Snow Cover (Index)</a>	<a href="#">Region</a>	<a href="#">Latitude</a>	<a href="#">Longitude</a>	<a href="#">Elevation</a>	<a href="#">Enable Precipitation Flag</a>	<a href="#">Enable Temperature Flag</a>
<a href="#">15502</a>	Vidin	0.00	16.20	No Report	No Report	BULGARIA	43.9942	22.8525	31	Enabled	Enabled
<a href="#">15525</a>	Lovech	0.10	14.50	No Report	No Report	BULGARIA	43.1631	24.7006	220	Enabled	Enabled
<a href="#">15549</a>	Razgrad	1.40	13.40	No Report	No Report	BULGARIA	43.5661	26.5078	346	Enabled	Enabled
<a href="#">15552</a>	Varna	0.00	16.25	No Report	No Report	BULGARIA	43.2125	27.9522	39	Enabled	Enabled
<a href="#">15600</a>	Murgash	9.00	5.25	No Report	No Report	BULGARIA	42.8333	23.6683	1687	Enabled	Enabled
<a href="#">15614</a>	Sofia	0.30	13.40	No Report	No Report	BULGARIA	42.6553	23.3847	586	Enabled	Enabled

<b>Station Identifier</b>	17204
<b>Station Name</b>	Mus
<b>Region</b>	TURKEY
<b>Latitude</b>	38.7509
<b>Longitude</b>	41.5023
<b>Elevation (m)</b>	1322
<b>Agency</b>	TURKEY
<b>Type</b>	SYNOP
<b>Precipitation Enabled Flag</b>	Enabled
<b>Temperature Enabled Flag</b>	Enabled

Reported Surfmet Gauge Observations from Station '17204' within the past 30 days					
<a href="#">Station Identifier</a>	<a href="#">Observation Date &amp; Time</a>	<a href="#">Precipitation (mm/06hr)</a>	<a href="#">Temperature (C)</a>	<a href="#">Snow Depth (cm)</a>	<a href="#">Snow Cover (Index)</a>
17204	2018-05-11 06:00:00-00	2.40	10.30	No Data	No Data
17204	2018-05-11 00:00:00-00	0.60	10.85	No Data	No Data
17204	2018-05-10 18:00:00-00	0.10	14.15	No Data	No Data
17204	2018-05-10 12:00:00-00	0.00	16.03	No Data	No Data
17204	2018-05-10 06:00:00-00	0.00	10.15	No Data	No Data
17204	2018-05-10 00:00:00-00	0.00	9.27	No Data	No Data
17204	2018-05-09 18:00:00-00	1.00	10.77	No Data	No Data
17204	2018-05-09 12:00:00-00	2.00	10.55	No Data	No Data
17204	2018-05-09 06:00:00-00	19.00	8.07	No Data	No Data
17204	2018-05-09 00:00:00-00	3.00	8.05	No Data	No Data
17204	2018-05-08 18:00:00-00	1.00	9.28	No Data	No Data
17204	2018-05-08 12:00:00-00	16.00	9.30	No Data	No Data
17204	2018-05-08 06:00:00-00	0.80	12.33	No Data	No Data
17204	2018-05-08 00:00:00-00	0.00	12.68	No Data	No Data
17204	2018-05-07 18:00:00-00	12.00	11.17	No Data	No Data
17204	2018-05-07 12:00:00-00	12.00	11.53	No Data	No Data
17204	2018-05-07 06:00:00-00	1.00	11.35	No Data	No Data
17204	2018-05-07 00:00:00-00	0.00	12.48	No Data	No Data
17204	2018-05-06 18:00:00-00	0.00	16.37	No Data	No Data

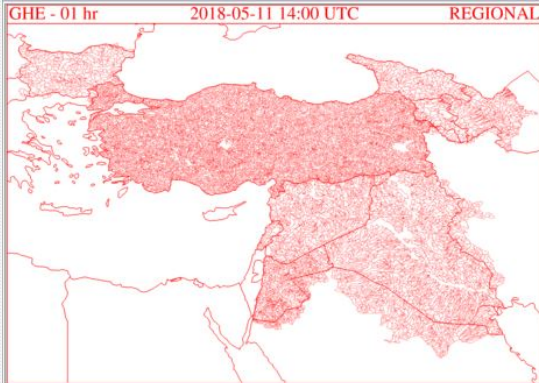
# Ejemplo de interfaz de usuario para datos

## Panel – para datos , estatus del servidor y salud

2018-05-11 17:22:14 EET
**BSMEFFG - Real-Time Status Dashboard**
2018-05-11 15:23:14 UTC

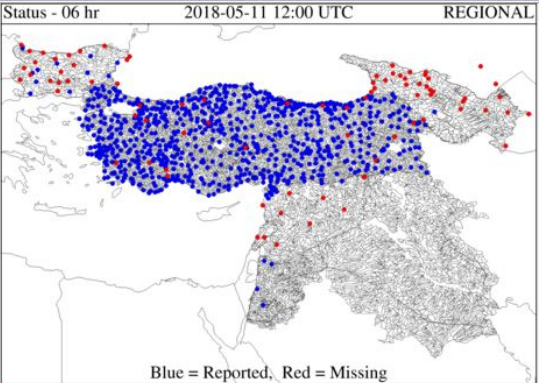
**Image Products**

**GHE - 01 hr** 2018-05-11 14:00 UTC REGIONAL



Animate 01-hr Sat Precip - 24 Images - (Pop-Up Window)

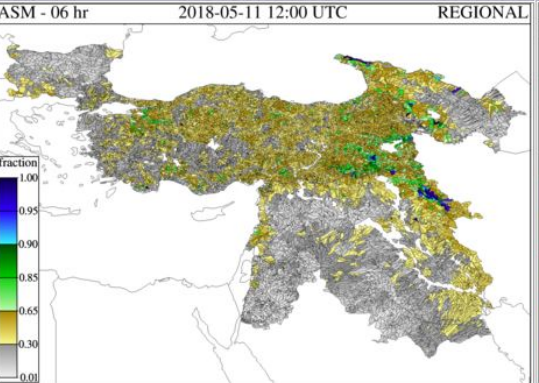
**Status - 06 hr** 2018-05-11 12:00 UTC REGIONAL



No Animation Available for this Image

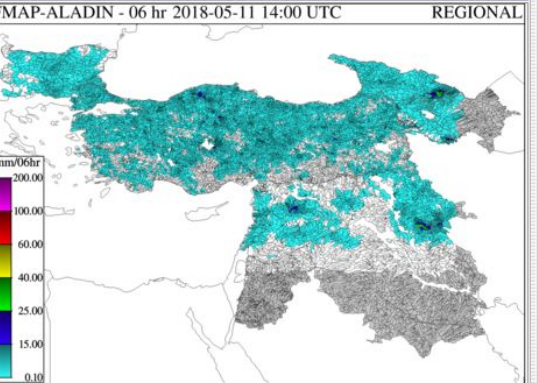
Blue = Reported, Red = Missing

**ASM - 06 hr** 2018-05-11 12:00 UTC REGIONAL



Animate 06-hr ASM - 24 Images - (Pop-Up Window)

**FMAP-ALADIN - 06 hr** 2018-05-11 14:00 UTC REGIONAL



Animate 06-hr FMAP - 24 Images - (Pop-Up Window)

**Real-Time Data Download and Inventory Status**

NESDIS GHE Download					GAUGE Download					IMS Download					RADAR Download					ALADIN Download					NESDIS MWGHE Download					IFS Download					WRF Download				
ENABLED					ENABLED					ENABLED					ENABLED					ENABLED					ENABLED					ENABLED									
SUCCESS					SUCCESS					SUCCESS					SUCCESS					SUCCESS					SUCCESS					SUCCESS									
May-07	May-08	May-09	May-10	May-11	May-07	May-08	May-09	May-10	May-11	May-07	May-08	May-09	May-10	May-11	May-07	May-08	May-09	May-10	May-11	May-07	May-08	May-09	May-10	May-11	May-07	May-08	May-09	May-10	May-11	May-07	May-08	May-09	May-10	May-11	May-07	May-08	May-09	May-10	May-11
24	24	24	24	14	91%	91%	91%	91%	90%	1	1	1	1	1	239	240	240	240	154	0	0	0	0	0	24	24	24	24	14	0	0	0	0	0	0	0	0	0	0

**Real-Time Data Processing Status**

NESDIS GHE Data Processing		GAUGE Data Processing		IMS Data Processing		RADAR Data Processing		ALADIN Data Processing		NESDIS MWGHE Data Processing		IFS Data Processing		WRF Data Processing	
ENABLED		ENABLED		ENABLED		ENABLED		ENABLED		ENABLED		ENABLED		ENABLED	
SUCCESS		SUCCESS		SUCCESS		PENDING		PENDING		SUCCESS		SUCCESS		PENDING	

**Model Processing Status**

SNOW Model Processing		SACSMA & FFG Model Processing	
ENABLED		ENABLED	
SUCCESS		SUCCESS	

**Export Processing Status**

Text/CSV Exports		Image Exports	
ENABLED		ENABLED	
SUCCESS		PENDING	

**Computational Server Status**

General Info				Processing Load				CPU Activity				Disk Activity			Storage			
IP Address	Hostname	Uptime	Active Logins	1-Min	5-Min	15-Min	Swap Used	User	System	IOWait	Idle	Transfers	Read	Write	Free	Used	% Used	Days to Filled
192.168.2.78	BSMEFFG-CS	465.09 days	0	22.62%	20.16%	18.66%	144817 KB	16.11%	0.88%	0.00%	83.01%	494.80 t/s	2.00 KB/s	8.723.20 KB/s	10,374,189 MB	5,301,008 MB	34%	2026 days

**Dissemination Server Status**

General Info				Processing Load				CPU Activity				Disk Activity			Storage			
IP Address	Hostname	Uptime	Active Logins	1-Min	5-Min	15-Min	Swap Used	System	User	IOWait	Idle	Transfers	Read	Write	Free	Used	% Used	Days to Filled
192.168.2.79	BSMEFFG-DS	472.11 days	3	29.16%	29.00%	26.00%	1481636 KB	4.22%	0.75%	6.51%	88.52%	409.00 t/s	1,631.20 KB/s	43.60 KB/s	5,232,071 MB	10,443,129 MB	67%	1022 days

23 May 2018

Regional Armenia Azerbaijan Bulgaria Georgia Iraq Lebanon Syria Turkey Jordan

**HRC**

Go to Regional Product Console

4

BSMEFFG Real-Time Status Dashboard v.1.0, © 2013 Hydrologic Research Center

# Ejemplo de interfaz de usuario para datos

## Registro de procesos – Alertas, errores y resúmenes de procesos

### BSMEFFG - Black Sea Middle East Flash Flood Guidance System

Current Date: 2018-05-11 15:41 UTC      Nav Date: 2018-05-11 15:00 UTC

Year: 2018    Month: 05    Day: 11    Hour: 15    Submit

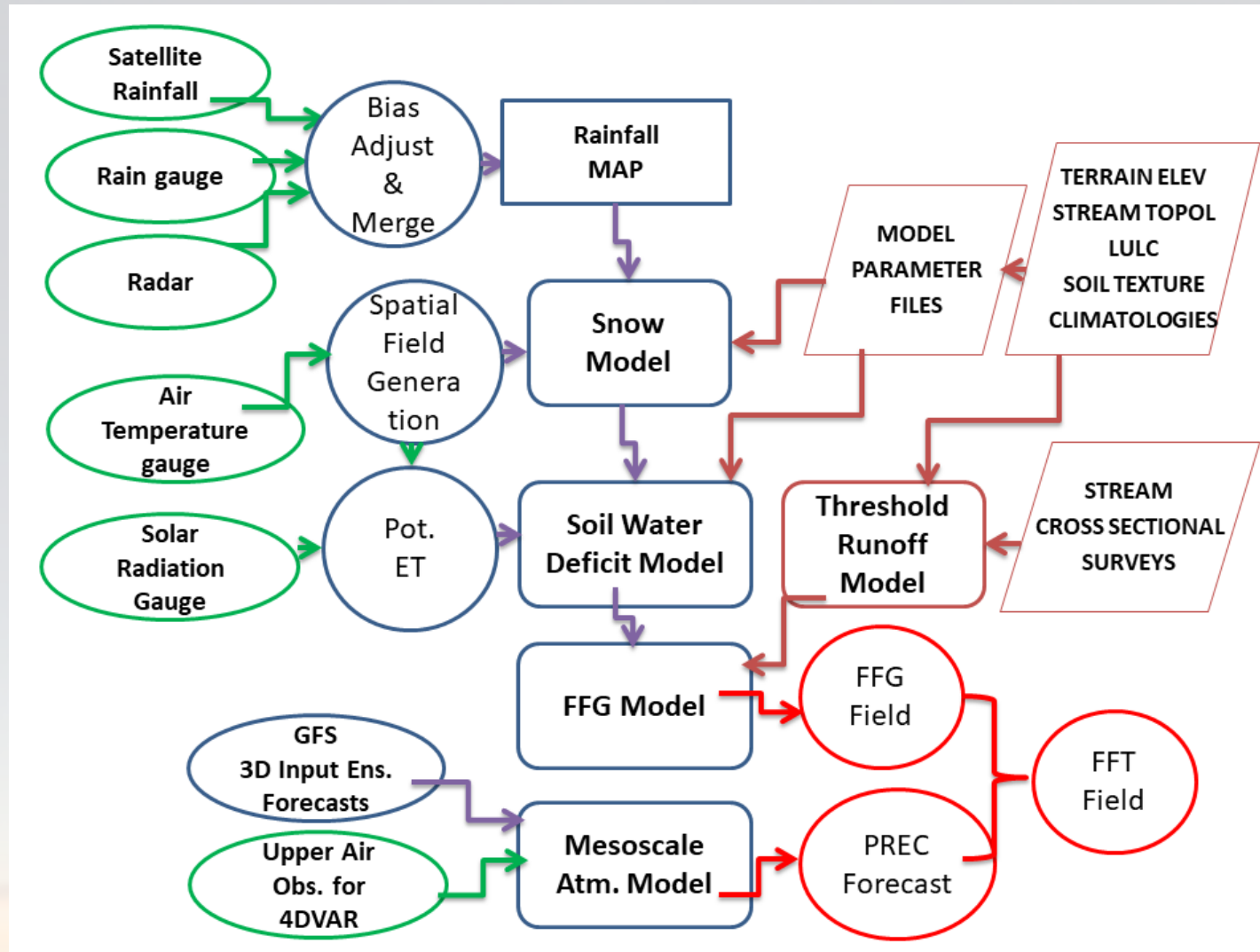
-1 Month   -1 Day   -6 Hours   -1 Hour   +1 Hour   +6 Hours   +1 Day   +1 Month

Prev 6-hr Interval (12 UTC)    Reset to Current    Next 6-hr Interval (18 UTC)

Return to Main

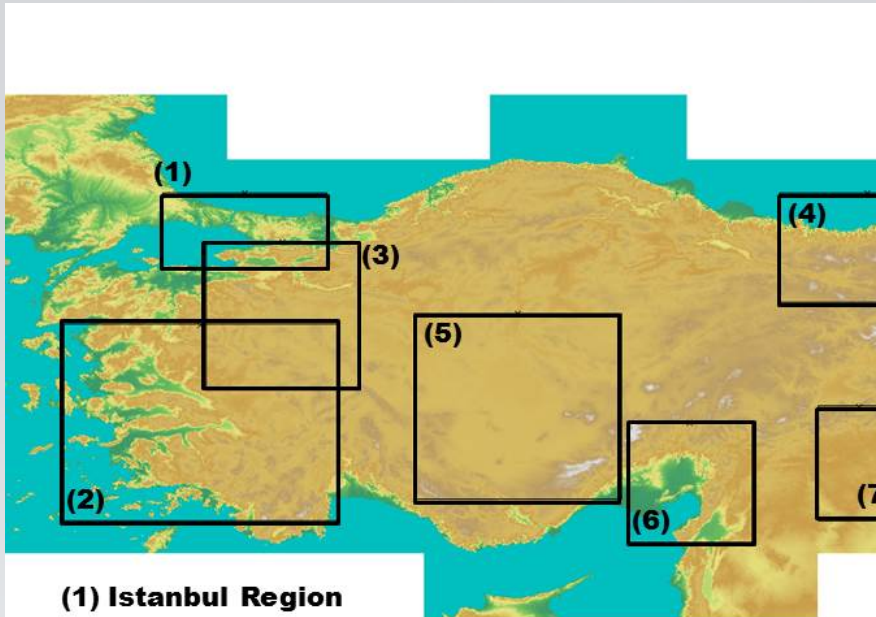
Selected Hourly Logs	Viewing Selected Log File
<a href="#">20180511-150000 99999 BSMEFFG-CS_warnings_summary.txt</a> <a href="#">20180511-150000 99999 BSMEFFG-CS_error_summary.txt</a> <a href="#">20180511-153246 99999 BSMEFFG-CS_process_branch_radar_precip_cron_log.txt</a> <a href="#">20180511-153214 99999 BSMEFFG-CS_process_branch_she_precip_cron_log.txt</a> <a href="#">20180511-153001 99999 BSMEFFG-CS_process_sequence_models_cron_log.txt</a> <a href="#">20180511-152501 99999 BSMEFFG-CS_process_sequence_she_precip_cron_log.txt</a> <a href="#">20180511-151755 99999 BSMEFFG-CS_process_branch_gauge_surfmet_cron_log.txt</a> <a href="#">20180511-151501 99999 BSMEFFG-CS_process_sequence_radar_precip_cron_log.txt</a> <a href="#">20180511-151501 99999 BSMEFFG-CS_process_sequence_gauge_surfmet_cron_log.txt</a> <a href="#">20180511-150731 99999 BSMEFFG-CS_process_branch_forecast2_precip_cron_log.txt</a> <a href="#">20180511-150701 99999 BSMEFFG-CS_process_branch_forecast1_precip_cron_log.txt</a> <a href="#">20180511-150252 99999 BSMEFFG-CS_process_branch_forecast2_precip_cron_log.txt</a> <a href="#">20180511-150124 99999 BSMEFFG-CS_process_branch_ims_snowcover_cron_log.txt</a> <a href="#">20180511-150120 99999 BSMEFFG-CS_process_branch_gfs_master_cron_log.txt</a> <a href="#">20180511-150102 99999 BSMEFFG-CS_process_sequence_ims_snowcover_cron_log.txt</a> <a href="#">20180511-150102 99999 BSMEFFG-CS_process_sequence_gfs_master_cron_log.txt</a> <a href="#">20180511-150102 99999 BSMEFFG-CS_process_sequence_forecast2_precip_cron_log.txt</a> <a href="#">20180511-150102 99999 BSMEFFG-CS_process_sequence_forecast1_precip_cron_log.txt</a>	<p>WARNING Summary Log last updated: Fri May 11 15:39:05 UTC 2018</p> <p>This is a collection of all logged WARNING messages for the current day and for any date within the TEMP processing directories.</p> <p>***** MESSAGES WITHIN /BSMEFFG/OPERATIONAL/TEMP *****</p> <p>20180511-153214_32118_export_product_image_gridded_precip_ghe.exe_bsmeffg/20180511-153214_32118_export_product_image_gridded_precip_ghe.exe_20180511-1500.</p> <p>***** MESSAGES FROM CRON LOGS WITHIN /BSMEFFG/OPERATIONAL/LOGS/2018/05/11 *****</p> <p>20180511-153001 99999 BSMEFFG-CS_process_sequence_models_cron_log.txt:WARNING: could not get flag value for environment variable named 'FFGS_MODULE_AGGREG.</p> <p>20180511-153001 99999 BSMEFFG-CS_process_sequence_models_cron_log.txt:WARNING: could not get flag value for environment variable named 'FFGS_MODULE_AGGREG.</p> <p>20180511-153001 99999 BSMEFFG-CS_process_sequence_models_cron_log.txt:WARNING: could not get flag value for environment variable named 'FFGS_MODULE_AGGREG.</p> <p>20180511-153001 99999 BSMEFFG-CS_process_sequence_models_cron_log.txt:WARNING: could not get flag value for environment variable named 'FFGS_MODULE_AGGREG.</p> <p>20180511-153001 99999 BSMEFFG-CS_process_sequence_models_cron_log.txt:WARNING: could not get flag value for environment variable named 'FFGS_MODULE_AGGREG.</p> <p>20180511-153001 99999 BSMEFFG-CS_process_sequence_models_cron_log.txt:WARNING: could not get flag value for environment variable named 'FFGS_MODULE_AGGREG.</p> <p>20180511-153001 99999 BSMEFFG-CS_process_sequence_models_cron_log.txt:WARNING: could not get flag value for environment variable named 'FFGS_MODULE_AGGREG.</p> <p>20180511-153001 99999 BSMEFFG-CS_process_sequence_models_cron_log.txt:WARNING: could not get flag value for environment variable named 'FFGS_MODULE_AGGREG.</p> <p>20180511-153001 99999 BSMEFFG-CS_process_sequence_models_cron_log.txt:WARNING: aggregate_product_selection_basin_map_merged.exe, initialize_aggregate_prod</p> <p>20180511-153001 99999 BSMEFFG-CS_process_sequence_models_cron_log.txt:WARNING: aggregate_product_selection_basin_map_merged.exe, initialize_aggregate_prod</p> <p>20180511-153001 99999 BSMEFFG-CS_process_sequence_models_cron_log.txt:WARNING: aggregate_product_selection_basin_map_merged.exe, initialize_aggregate_prod</p> <p>20180511-153001 99999 BSMEFFG-CS_process_sequence_models_cron_log.txt:WARNING: aggregate_product_selection_basin_map_merged.exe, initialize_aggregate_prod</p> <p>20180511-153001 99999 BSMEFFG-CS_process_sequence_models_cron_log.txt:WARNING: aggregate_product_selection_basin_map_merged.exe, initialize_aggregate_prod</p> <p>20180511-153001 99999 BSMEFFG-CS_process_sequence_models_cron_log.txt:WARNING: aggregate_product_selection_basin_map_merged.exe, initialize_aggregate_prod</p> <p>20180511-153001 99999 BSMEFFG-CS_process_sequence_models_cron_log.txt:WARNING: aggregate_product_selection_basin_map_merged.exe, initialize_aggregate_prod</p> <p>20180511-153001 99999 BSMEFFG-CS_process_sequence_models_cron_log.txt:WARNING: aggregate_product_selection_basin_map_merged.exe, initialize_aggregate_prod</p> <p>20180511-153001 99999 BSMEFFG-CS_process_sequence_models_cron_log.txt:WARNING: aggregate_product_selection_basin_map_merged.exe, initialize_aggregate_prod</p> <p>20180511-152501 99999 BSMEFFG-CS_process_sequence_ghe_precip_cron_log.txt:WARNING: extract_native_gridded_precip_ghe.exe, main(0): Unable to retrieve f.</p> <p>20180511-152501 99999 BSMEFFG-CS_process_sequence_ghe_precip_cron_log.txt:WARNING: extract_native_gridded_precip_ghe.exe, main(0): Unable to retrieve fi.</p> <p>20180511-152501 99999 BSMEFFG-CS_process_sequence_ghe_precip_cron_log.txt:WARNING: export_product_text_gridded_precip_ghe.exe, main(0): Processed data f.</p> <p>20180511-152501 99999 BSMEFFG-CS_process_sequence_ghe_precip_cron_log.txt:WARNING: export_product_image_gridded_precip_ghe.exe, main(0): Processed data f.</p> <p>20180511-152501 99999 BSMEFFG-CS_process_sequence_ghe_precip_cron_log.txt:WARNING: aggregate_area_average_basin_map_ghe.exe, main(0): Unable to retrieve</p> <p>20180511-152501 99999 BSMEFFG-CS_process_sequence_ghe_precip_cron_log.txt:WARNING: aggregate_area_average_basin_map_ghe.exe, main(0): Processed NESDIS (</p> <p>20180511-152501 99999 BSMEFFG-CS_process_sequence_ghe_precip_cron_log.txt:WARNING: acquire_remote_realtime_ghe_precip.exe, retrieve_remote_data_product (1)</p> <p>20180511-151501 99999 BSMEFFG-CS_process_sequence_gauge_surfmet_cron_log.txt:WARNING: hourly_process_sequence_gauge_surfmet.sh's crontab entry is active,</p> <p>20180511-150102 99999 BSMEFFG-CS_process_sequence_ims_snowcover_cron_log.txt:WARNING: hourly_process_sequence_ims_snowcover.sh's crontab entry is active,</p> <p>20180511-150102 99999 BSMEFFG-CS_process_sequence_gfs_master_cron_log.txt:WARNING: hourly_process_sequence_gfs_master.sh's crontab entry is active, but \$!</p> <p>20180511-150102 99999 BSMEFFG-CS_process_sequence_forecast3_precip_cron_log.txt:WARNING: hourly_process_sequence_forecast3_precip.sh's crontab entry is a</p> <p>20180511-150102 99999 BSMEFFG-CS_process_sequence_forecast2_precip_cron_log.txt:WARNING: hourly_process_sequence_forecast2_precip.sh's crontab entry is a</p> <p>20180511-150102 99999 BSMEFFG-CS_process_sequence_forecast1_precip_cron_log.txt:WARNING: hourly_process_sequence_forecast1_precip.sh's crontab entry is a</p> <p>20180511-144601 99999 BSMEFFG-CS_process_sequence_mwghc_precip_cron_log.txt:WARNING: extract_native_gridded_precip_mwghc.exe, main(0): Unable to retriev</p> <p>20180511-144601 99999 BSMEFFG-CS_process_sequence_mwghc_precip_cron_log.txt:WARNING: extract_native_gridded_precip_mwghc.exe, main(0): Unable to retriev</p> <p>20180511-144601 99999 BSMEFFG-CS_process_sequence_mwghc_precip_cron_log.txt:WARNING: export_product_text_gridded_precip_mwghc.exe, main(0): Processed da</p> <p>20180511-144601 99999 BSMEFFG-CS_process_sequence_mwghc_precip_cron_log.txt:WARNING: export_product_image_gridded_precip_mwghc.exe, main(0): Processed da</p>

# Diagrama de flujo de datos y modelos

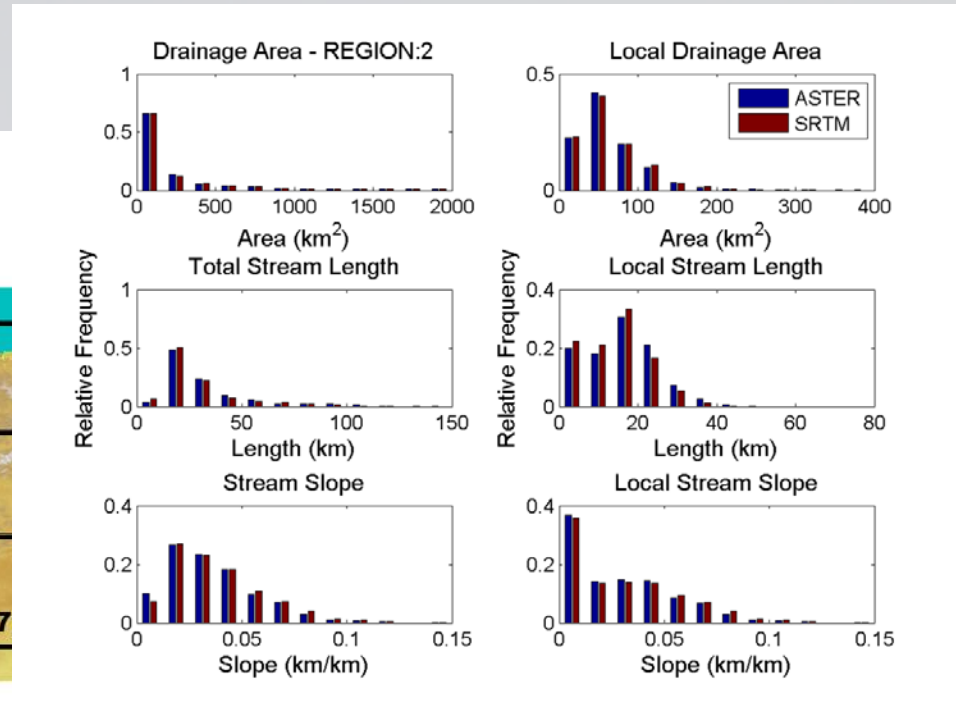


# Delineaciones alrededor del mundo

SRTM 90m versus ASTER 30m

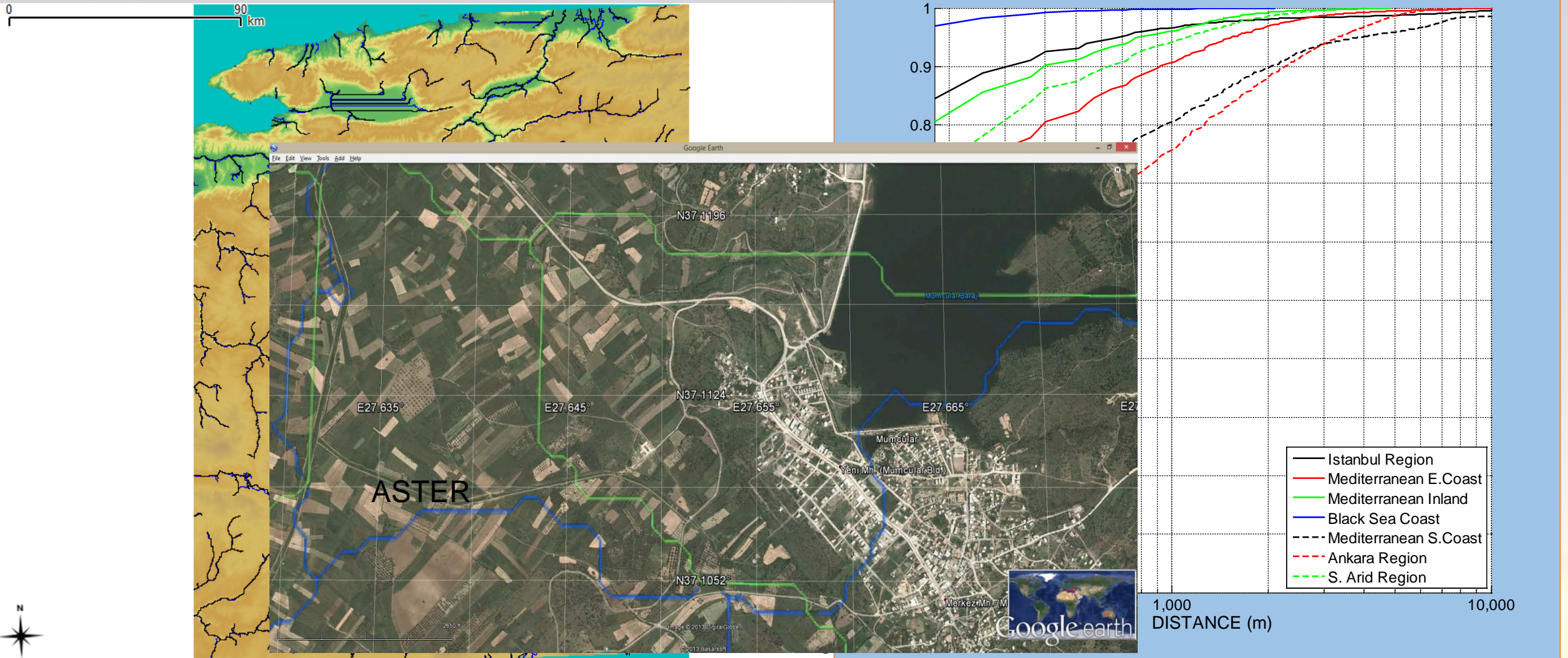


- (1) Istanbul Region**
- (2) Mediterranean Coast**
- (3) Mediterranean Inland**
- (4) Black Sea Coast**
- (5) Region South of Ankara**
- (6) South Mediterranean Coast**
- (7) Southern Arid Region**



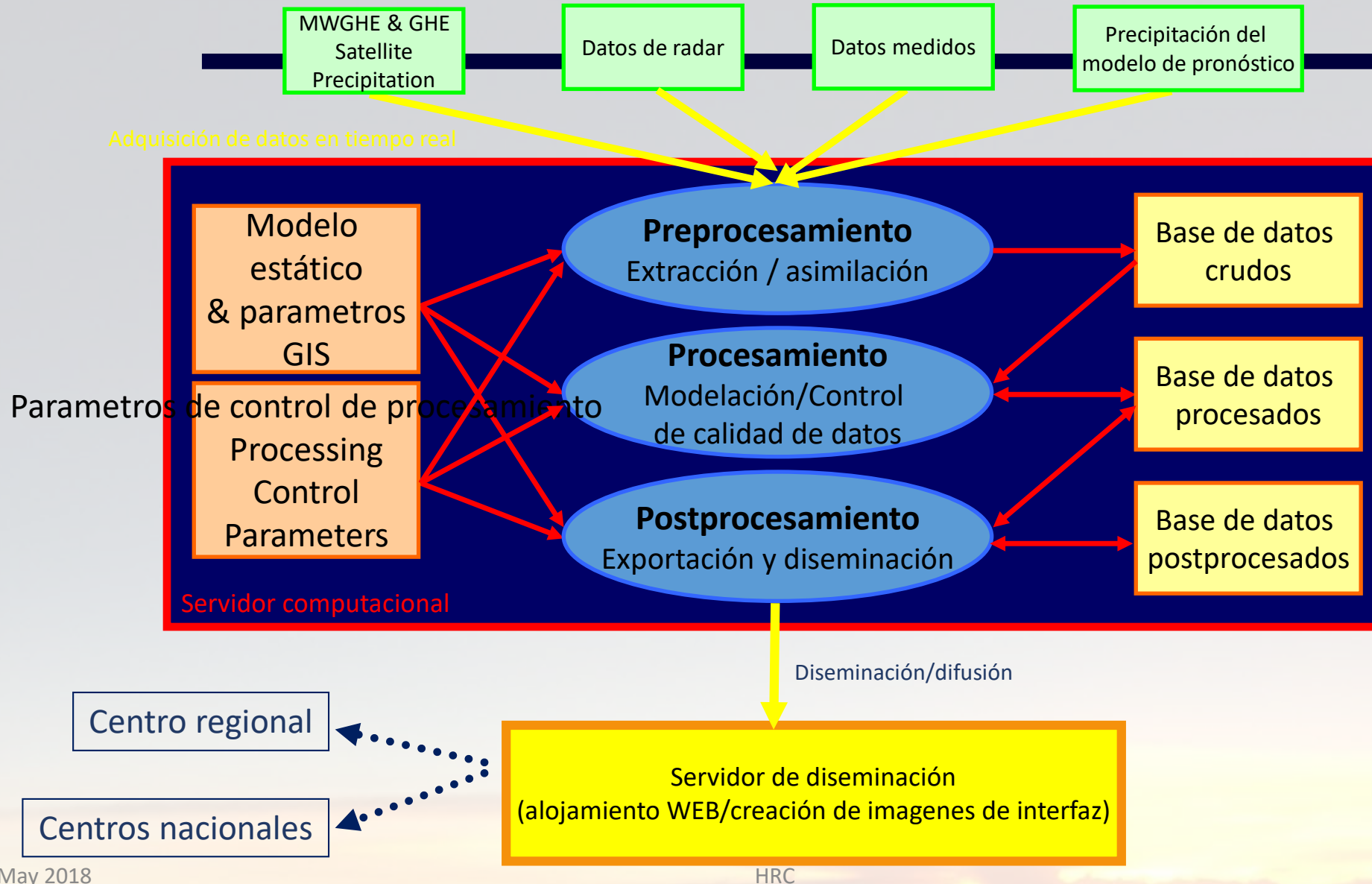
# Delineaciones alrededor del mundo

Antes de finalizar los “shapefiles” revisados por los países y los ajustes apropiados se hacen en HRC

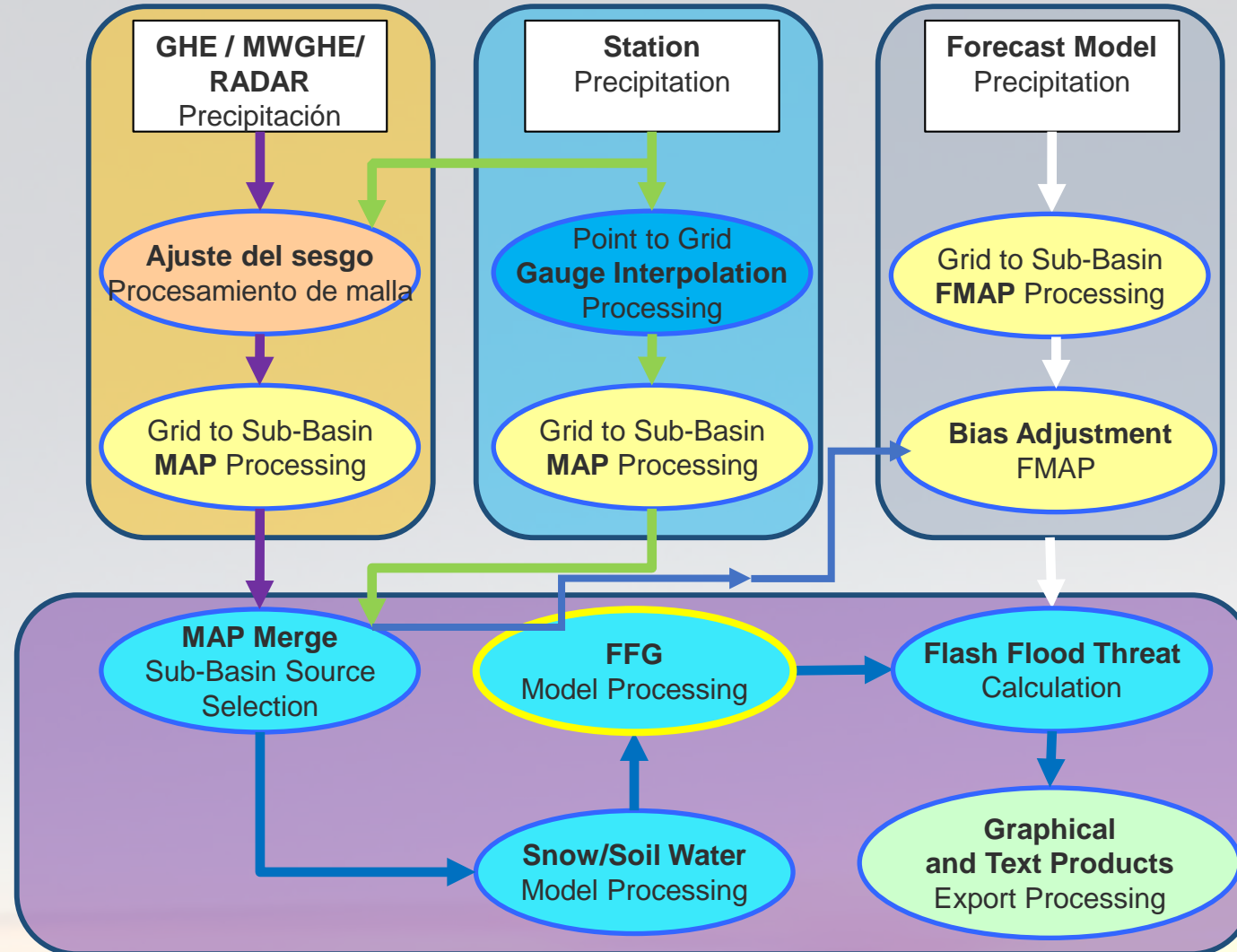




# Diseño del flujo general de procesamiento de datos del FFGS



# Procesamiento de la precipitación del FFGS



# Current Multi-Sensor Strategy

## *Global Data*

NESDIS GLOBAL HYDROESTIMATOR (IR, MODEL, OROGRAPHY) – Short Latency  
CMORPH (MW-BASED) – Longer latency

## *Regional and Local Data*

OPERATIONAL RADAR CAPPI (IF IN DIGITAL FORM) – Short latency  
OPERATIONAL PRECIPITATION GAUGES – Short Latency

## *Initial Quality Control – Requires historical data – Requires NMHS Agency Collaboration*

Snow Mask for CMORPH (IMS)

Radar CAPPI Analysis to develop Radar Mask of Invalid Data for Application

Raingauge data analysis for persistent errors and unrealistic values

## *Bias Adjustments – Requires historical data - Requires NMHS Agency Collaboration*

CMORPH + GHE → MWGHE (gridded)

MWGHE, Radar Data, Raingauge Data → MWGHE, Radar, Raingauge MAP

MWGHE MAP + Raingauge MAP → Bias Adj MWGHE MAP

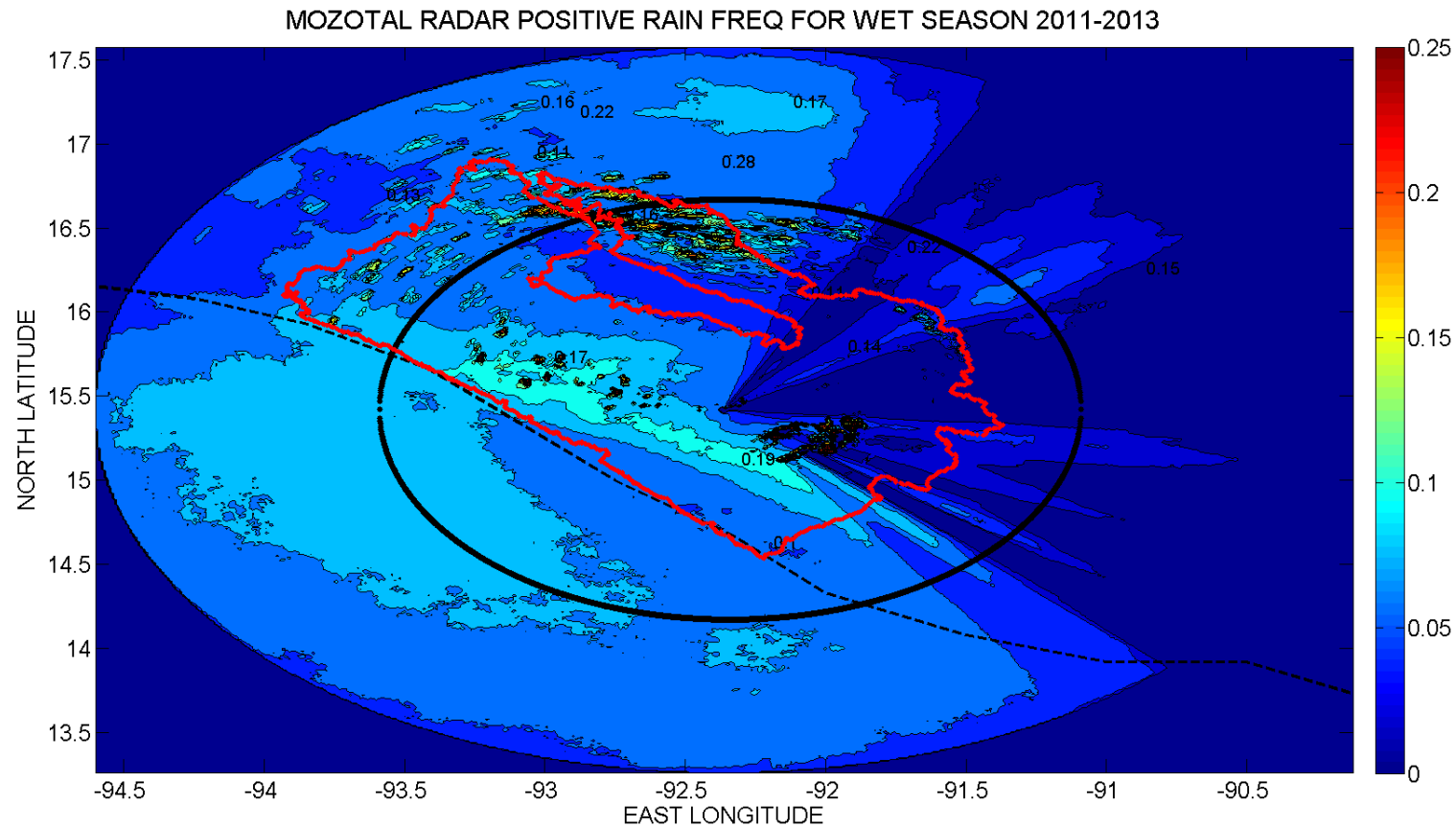
RADAR MAP + Raingauge MAP → Bias Adj RADAR MAP

*Merging: Bias Adj RADAR MAP – Bias Adj MWGHE MAP - ....*

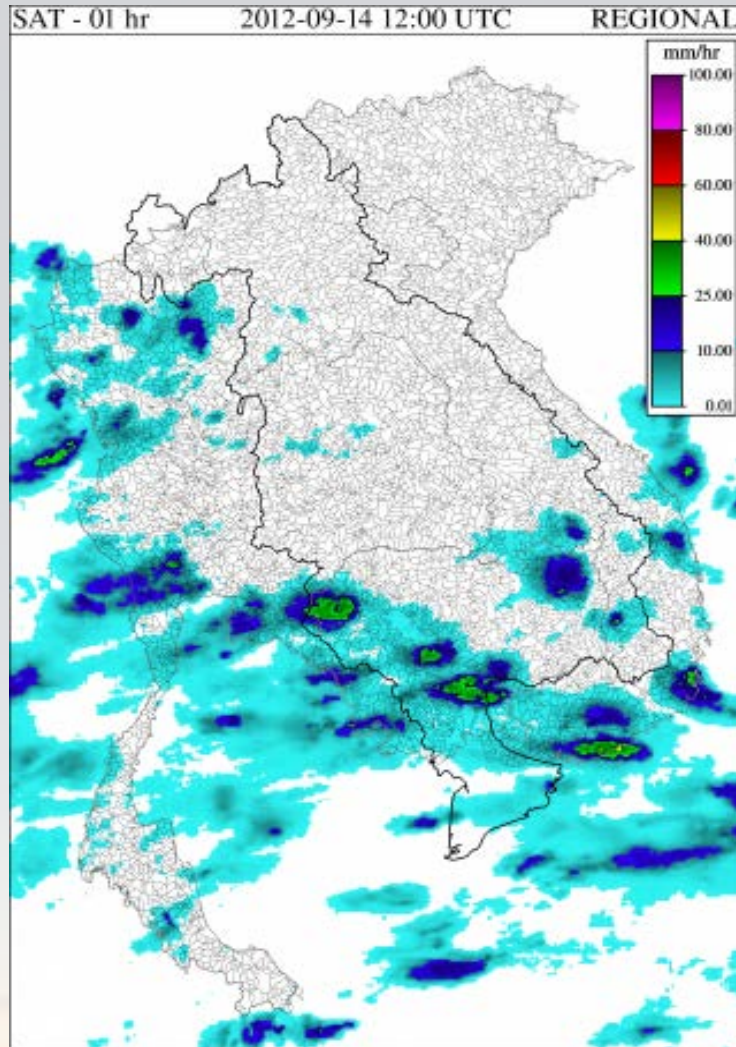
# Example Positive Rainfall Frequency

C-band (1 degree beam width) Radar at ~3 km altitude ; 4km CAPPI

Gauges with < 20% of time missing data used for reference



# Satellite Precipitation – NESDIS Global Hydroestimator (GHE)



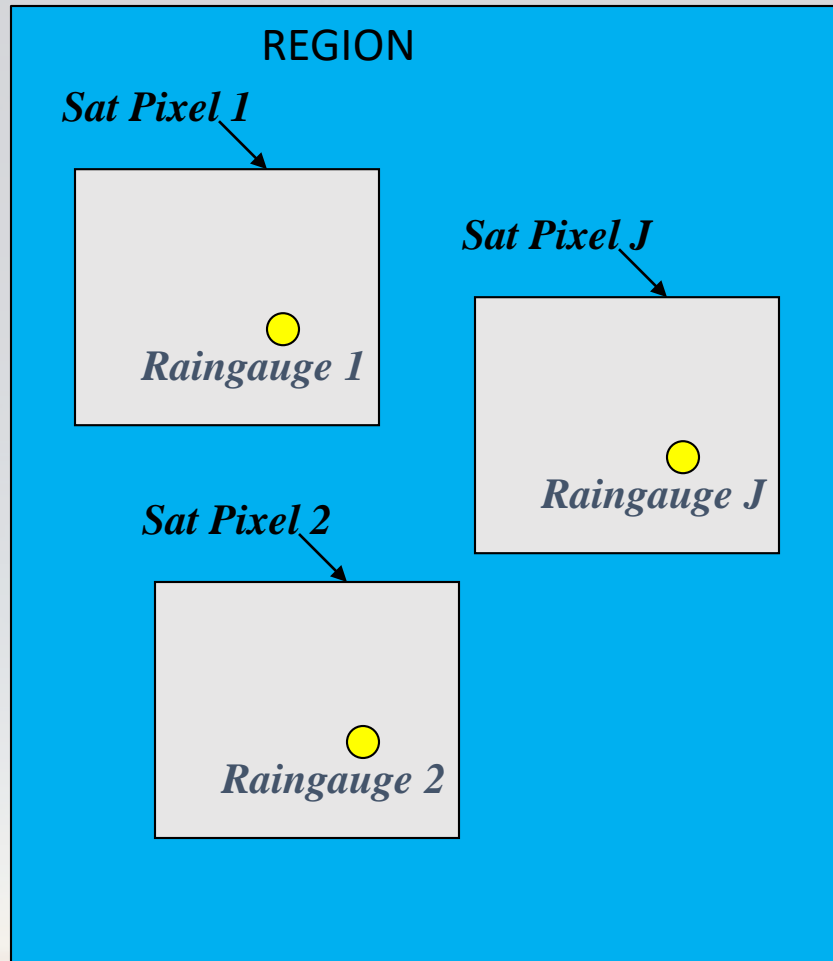
- IR based (10.7  $\mu\text{m}$ )
- Short latency

Rain Rate =  
Function of brightness temperature

Enhanced for:

1. Atmospheric moisture effects
2. Orography (upslope/downslope)
3. Convective Equilibrium Level (warm-top convection)
4. Local pixel T difference with surroundings
5. Convective core/no-core region

# Bias and Log-Bias Factors



Log-Bias

$$\beta_t = \ln \left[ \frac{\sum_{j=1}^{N_g} R_g(t, j)}{\sum_{j=1}^{N_g} R_s(t, j)} \right]$$

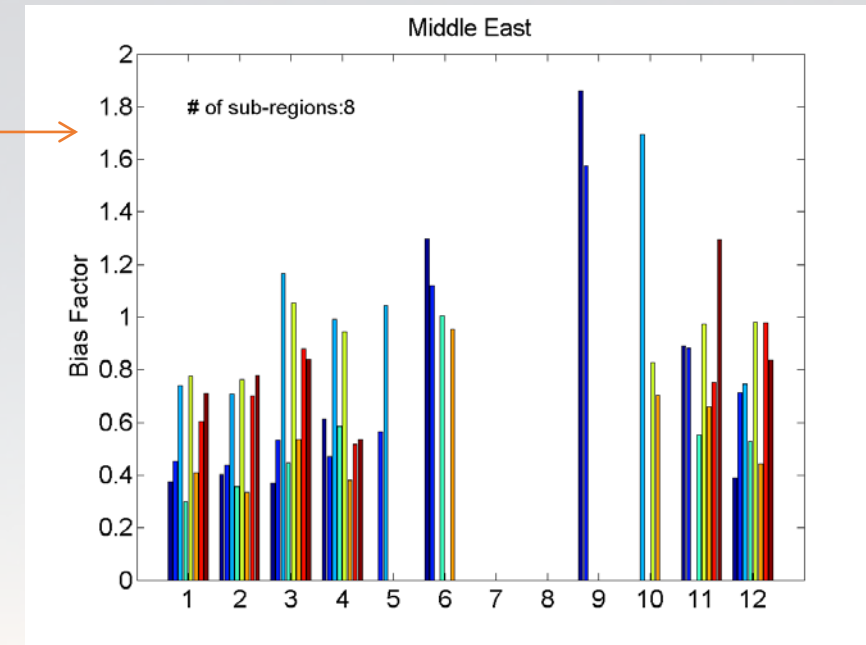
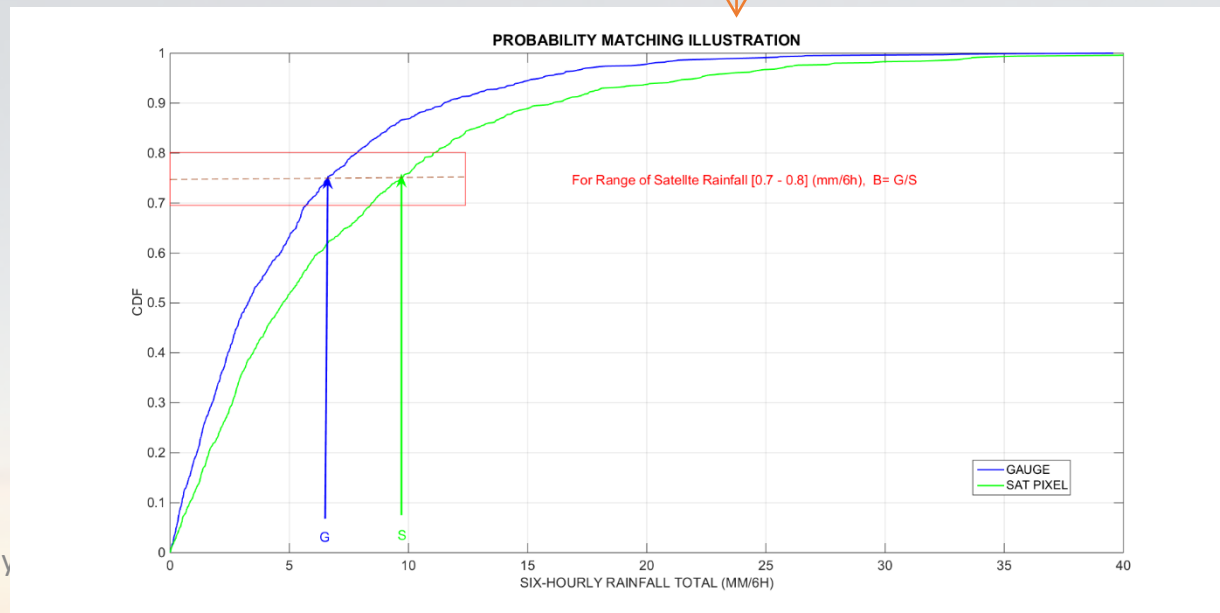
**Bias (B)**

# Climatological Adjustment Using Gauges and Corresponding Satellite Pixel Data

- Historical Data for regions of uniform hydroclimatology, terrain and gauge density
- Usually done for an given month or season
- Result is bias factor for each region and month/season

Bias Factor computed from:

- (1) Mean values
- (2) Probability matching considerations



# Dynamic Bias Adjustment Basics

$$\beta_t = \ln \left[ \frac{\sum_{j=1}^{N_g} R_g(t, j)}{\sum_{j=1}^{N_g} R_s(t, j)} \right]$$
$$\beta_{t+1} = \beta_t + w_{t+1}$$
$$z_{t+1} = \beta_{t+1} + v_{t+1}$$

## Kalman Filter Stochastic Approximations

- N pairs of consecutive values
- At least 20% raingauges with rain
- Conditional Mean > Threshold (mm/h)  
(satellite/radar and gauge)

**Bias (B)**

**Important issue:**  
Gauge data quality control



# Multi-Spectral Satellite Rainfall

## HE

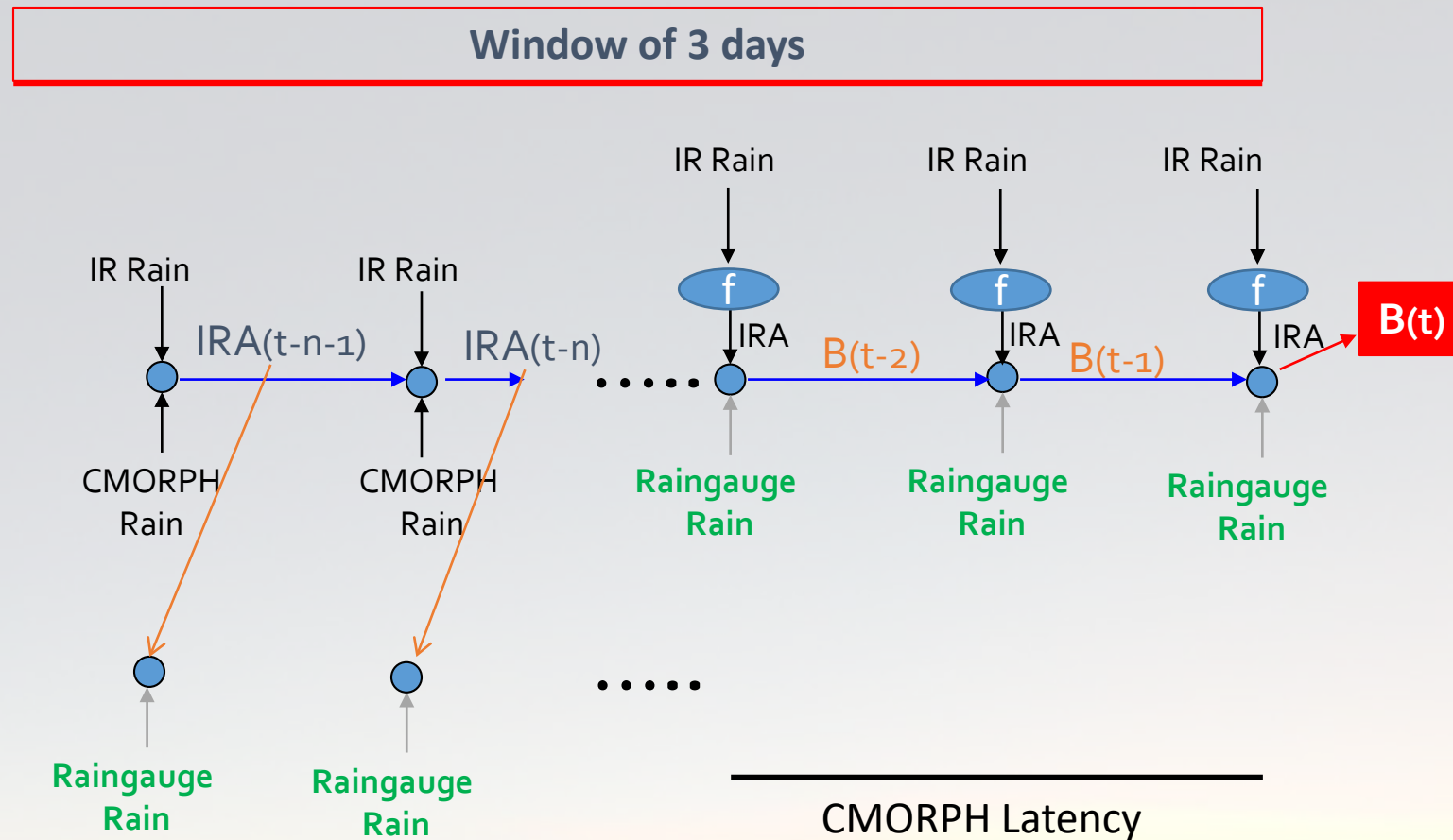
IR – Based  
30-min latency in operations  
Based on measurements of top  
cloud brightness temperature

## CMORPH

MW – Based  
18-26 hour latency in operations  
Based on measurements of  
microwave scattering from raindrops

New global FFGS product combines IR-based HE rainfall with MW-based CMORPH rainfall

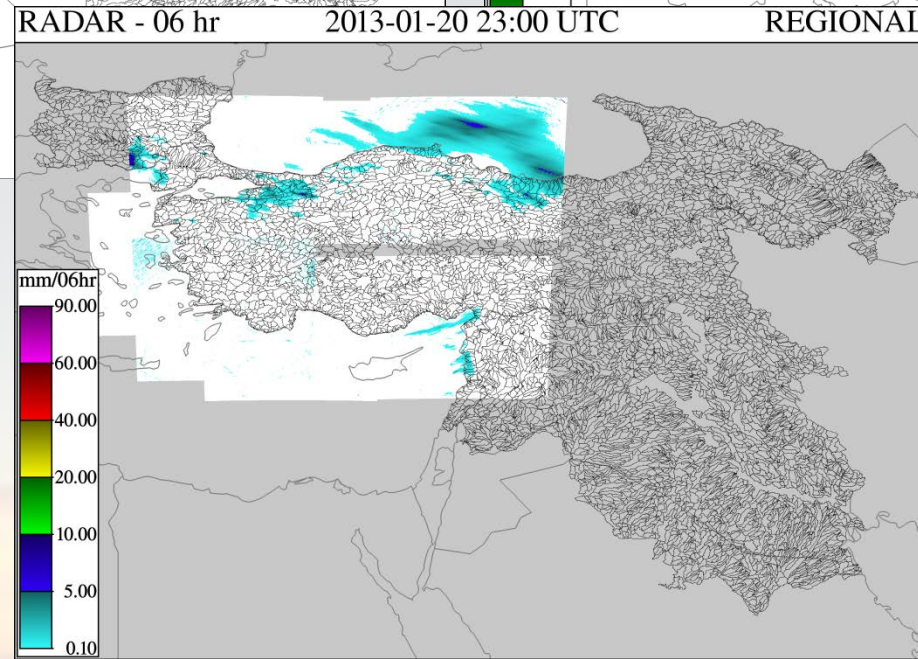
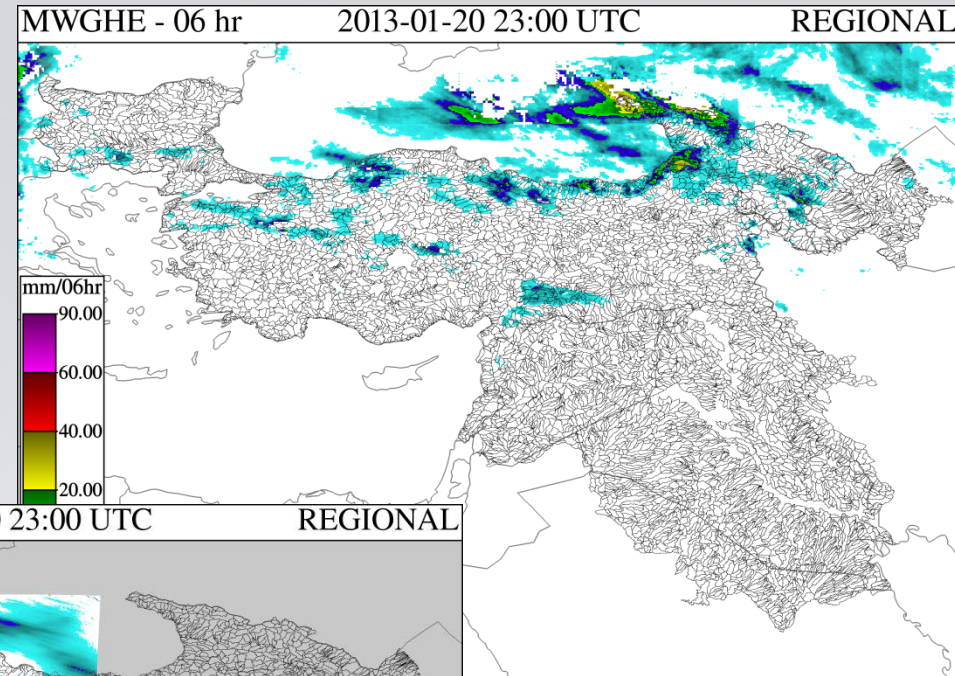
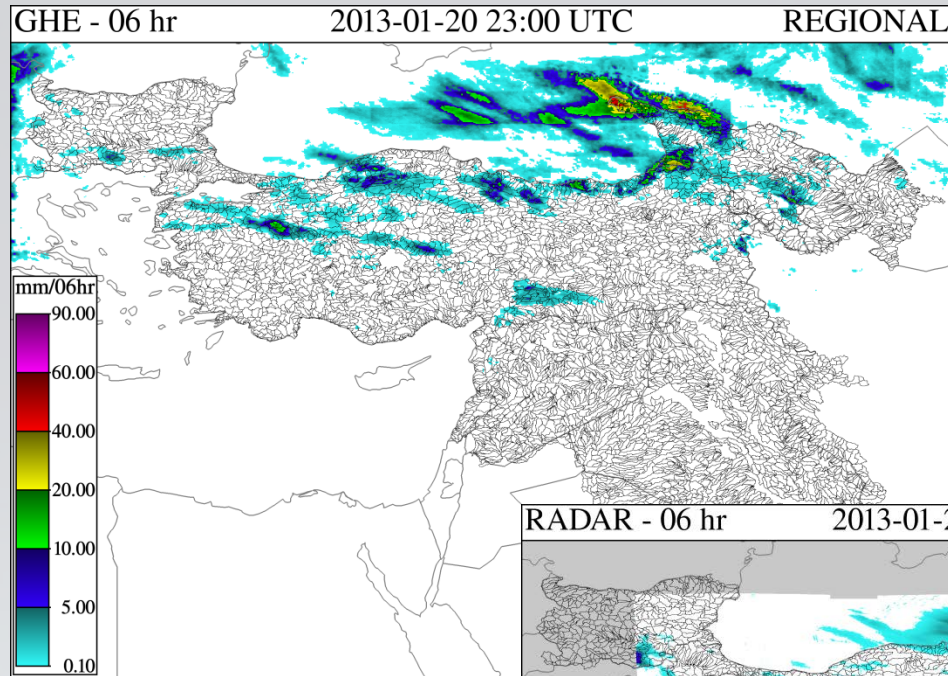
# Multi-Spectral Satellite Rainfall for FFG Systems



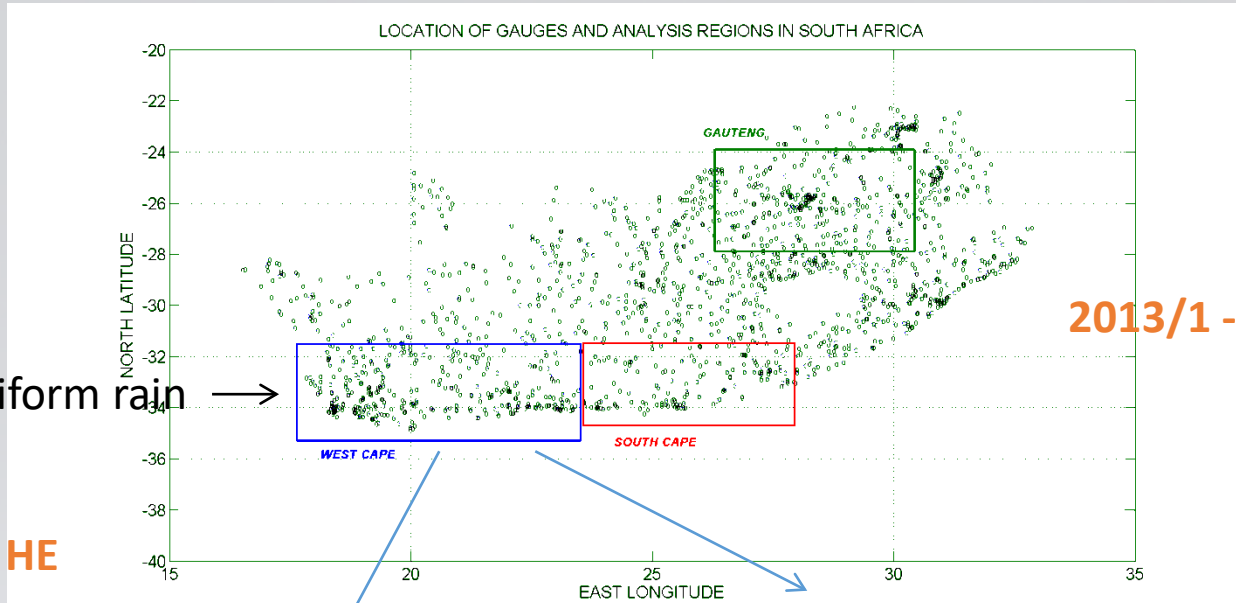
# Examples from BSMEFFG

Original GHE

Adjusted GHE



# Evaluation from SARFFG

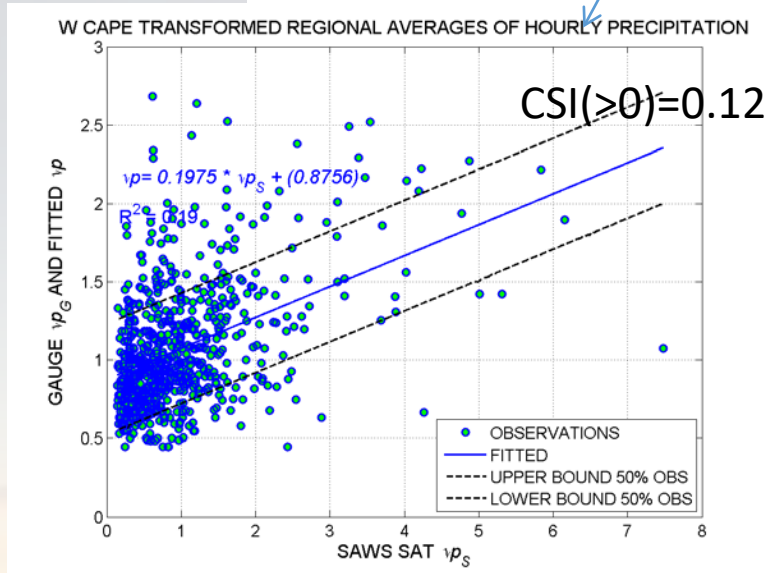


2013/1 - 2014/3

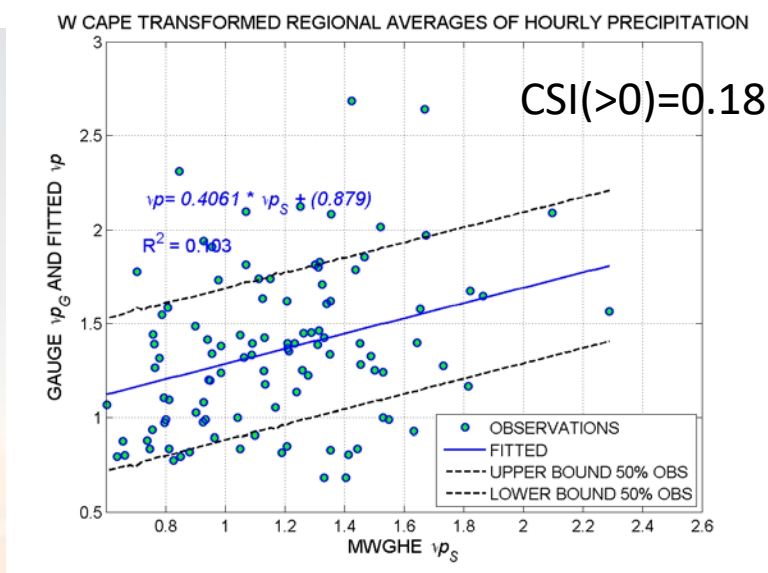
Low Level stratiform rain →

UM Adjusted HE

MWGHE



HRC



The background of the slide features a map of a geographical region, possibly a river basin, with a color scale on the right side. The map shows various shades of brown, green, and blue, indicating different levels of data or risk. The color scale on the right ranges from dark purple at the bottom to light yellow at the top, with numerical markers at 0.0, 10.0, 20.0, 30.0, 40.0, 50.0, 60.0, 70.0, 80.0, and 90.0. The map also includes a 20 km scale bar and the text 'HRC' and '109,000°' at the bottom.

# Challenges FFGS Had to Overcome

## Data and Information Focus

1. **Data Ingest** (format type variety, public versus private, asynchronous, variable space-time resolution)
2. **Measurement /Forecast Uncertainty** (climatological vs time varying, short records for reliability fine-tuning)
3. **Timely Product/Warning Generation** (computer and comm. requirements and constraints, timely forecaster adjustment and response)
4. **Products Easily Accessible and Searchable by NMHSs** (interface and database requirements, local versus regional data storage, requirement to use free and open source software for developing countries)
5. **Education and Training in Product Interpretation and Communication with DMAs** (diverse backgrounds, inter- and multi-disciplinary focus, cultural diversity in the perceived value of and the response to warnings)

# Gracias

The strong support of the country National Meteorological, Hydrological and Disaster Management Services has been essential for the useful operational utilization of the regional FFG systems.

