Accuracy of Ionospheric Models (AIM) at Mid-Latitudes

NSWP/NSF

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Digression

AbbyNormal

D-Region
&
HF Absorption Model

Dr. Frederick Frankenstein: Igor, would you mind telling me whose brain I did put in?
Igor: And you won't be angry?
Dr. Frederick Frankenstein: I will NOT be angry.
Igor: Abby someone.
Dr. Frederick Frankenstein: Abby someone. Abby who?
Igor: Abby Normal.

Accuracy of Ionospheric Models

- AIM package to be placed at the Community Coordinated Modeling Center (CCMC) for use with any CCMC-deployed ionosphere model.
- Initial assessment uses observations from the Arecibo Incoherent Scatter Radar (ISR).
  - ***Provide reliable assessment for users represented by agencies of the National Space Weather Program.***
  - ***Provide useful reports for model developers that identifies when model results are adequate and inadequate.***

Assessment of Ionospheric Models Database

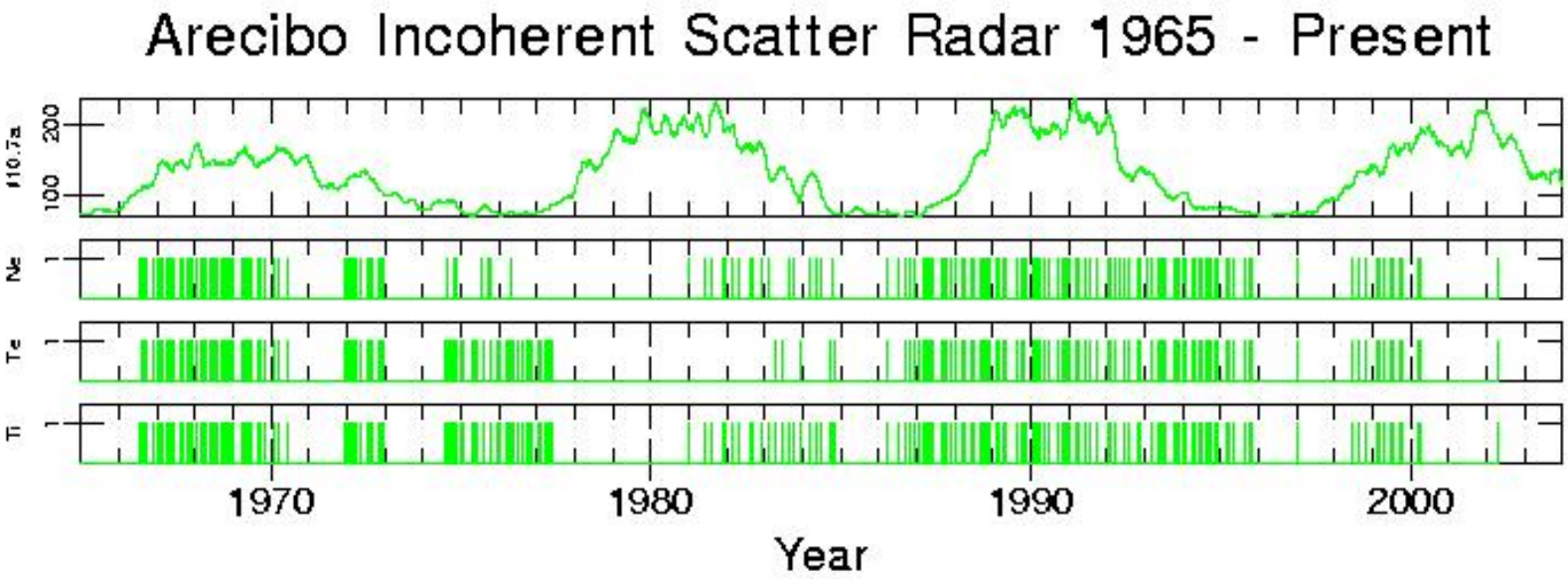
(AIM Database)

Using Arecibo Radar Ionospheric Measurements

AIM Database

- "ground truth" database (Arecibo Radar)
  - ***Extent***
  - ***Character***
  - ***Instrument/Analysis uncertainty***
  - ***Climatological average***
  - ***Weather variances within the climatology***
  - ***Periods of continuous measurements for weather studies***

AIM Database

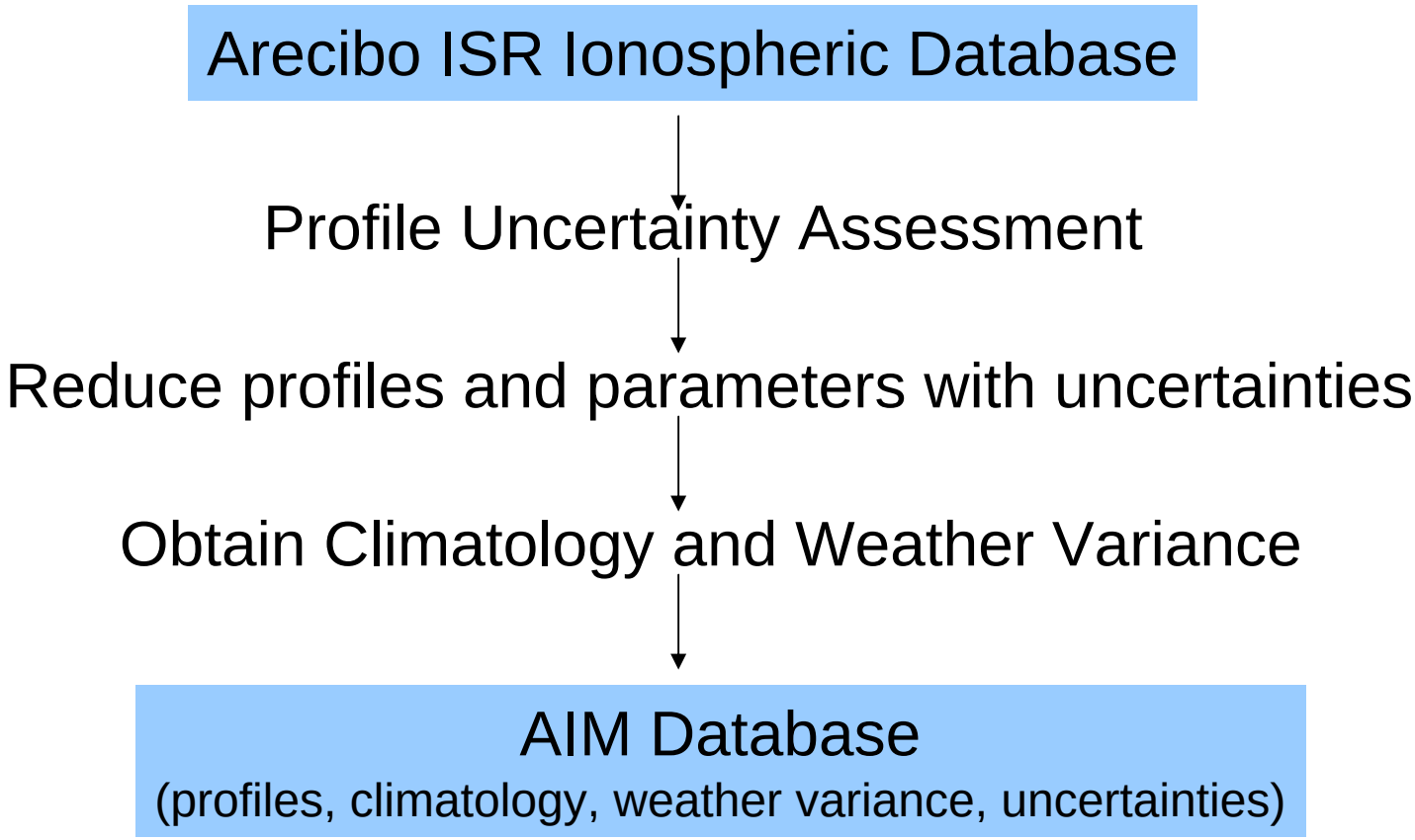


- 3+ solar cycles of Ne, Te, Ti profiles.
- Very few observations of full days.
- Fewer contiguous-continuous days.
- This year Hien Vo finish analysis of data from 2002 to 2006. (Some of the best data)

AIM Database Distribution

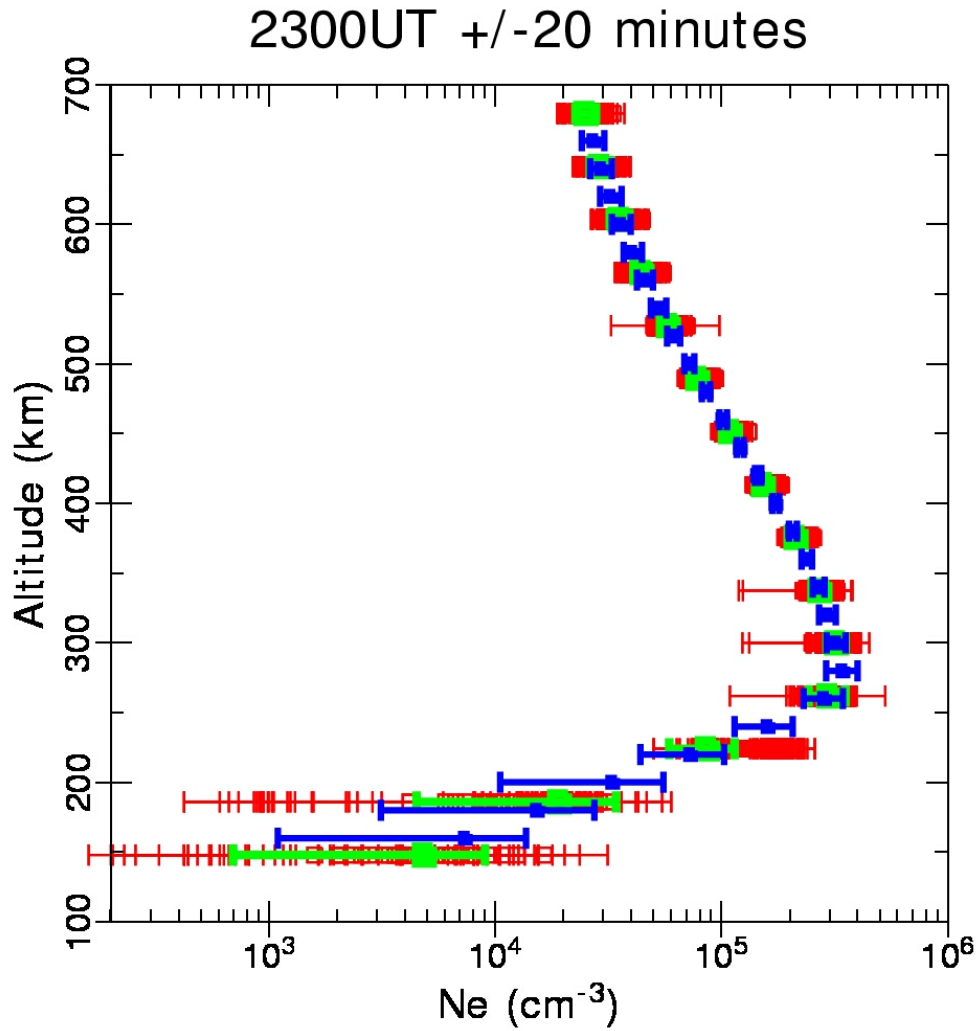
F10.7a	60-90	91-140	141-180	>=181	Kp
Winter					
Low	2.6	9.9	5.7	8.2	**0 to 2**
Med	3.6	26.	4.9	9.1	**2+ to 4**
High	0.5	0	1.5	3.8	**4+ up**
Spring					
Low	6.3	9.1	1.7	6.8	**0 to 2**
Med	2.1	17.	5.9	16.	**2+ to 4**
High	3.6	0.6	0	0.4	**4+ up**
Summer					
Low	3.7	11.	10.	1.1	**0 to 2**
Med	1.2	15.	1.5	2.3	**2+ to 4**
High	0	0	2.0	3.4	**4+ up**
Fall					
Low	2.7	7.1	6.3	0	**0 to 2**
Med	14.	9.8	7.8	6.8	**2+ to 4**
High	8.1	4.8	5.2	2.1	**4+ up**

AIM_DB


Arecibo ISR Ionospheric Database
Profile Uncertainty Assessment
Reduce profiles and parameters with uncertainties
Obtain Climatology and Weather Variance
AIM Database
(profiles, climatology, weather variance, uncertainties)

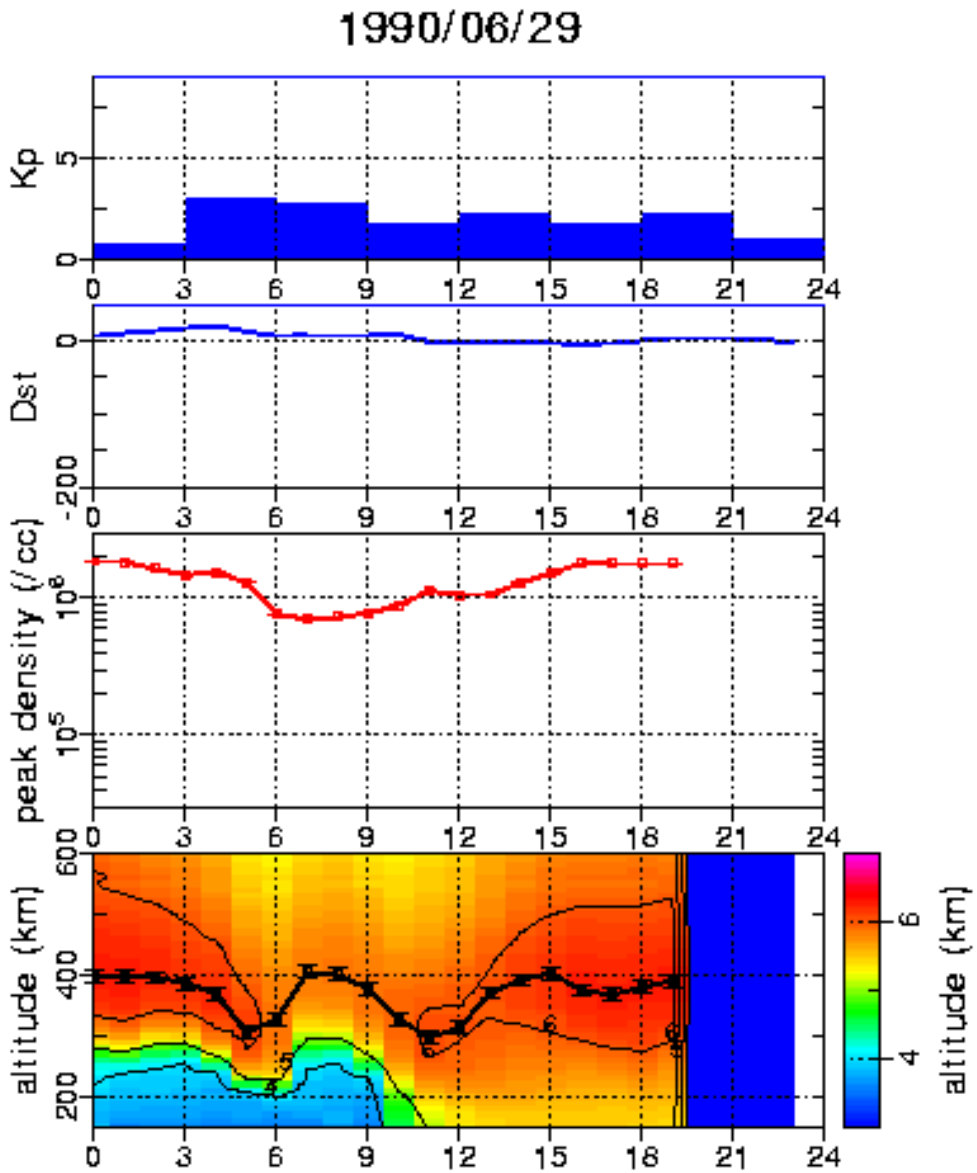
AIM Database

- AIM db Profiles
  - 1966 to 2006 data
  - Hourly profiles
  - 20-km steps
  - 160-700 km
  - Uncertainties



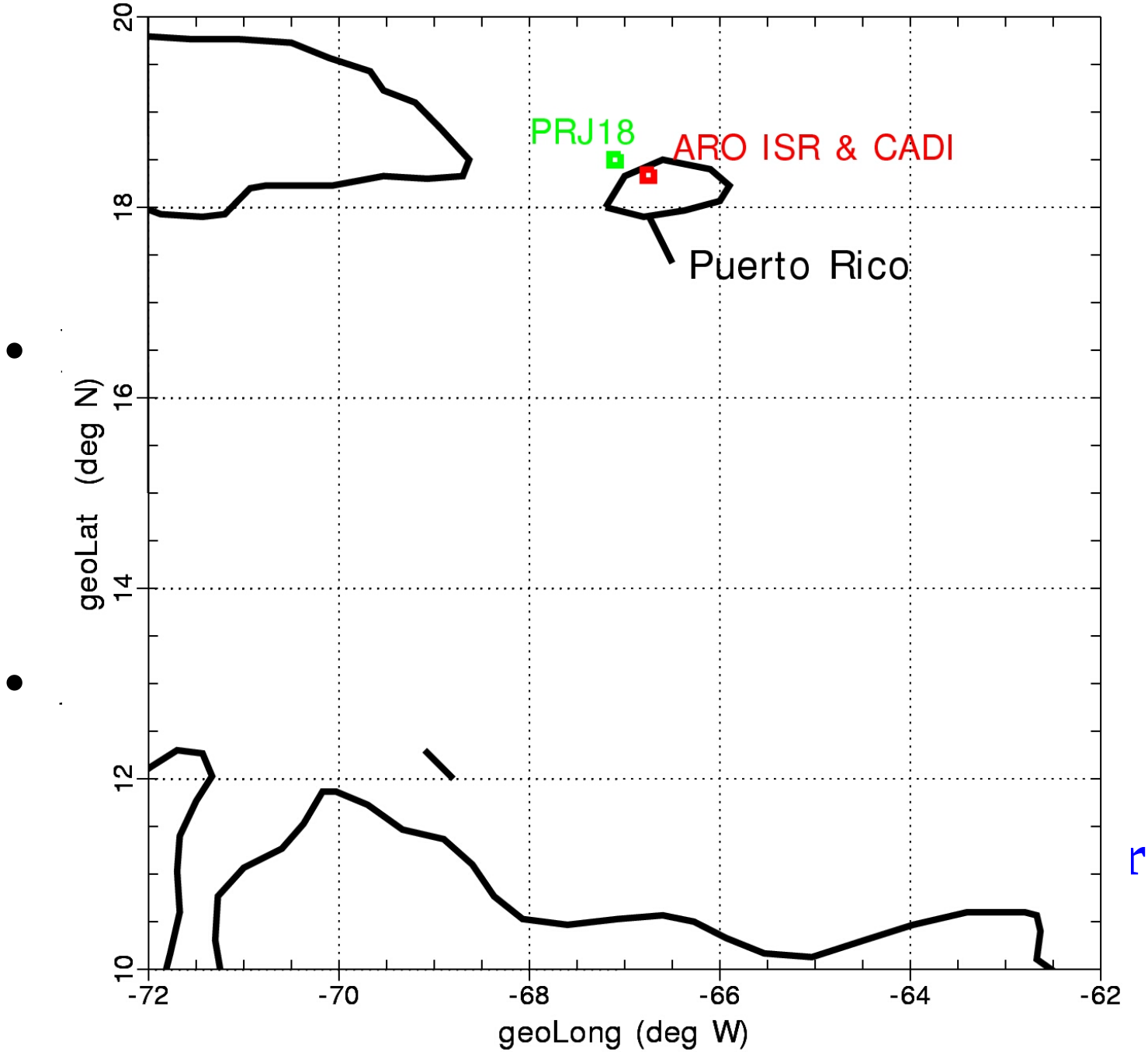
AIM Database

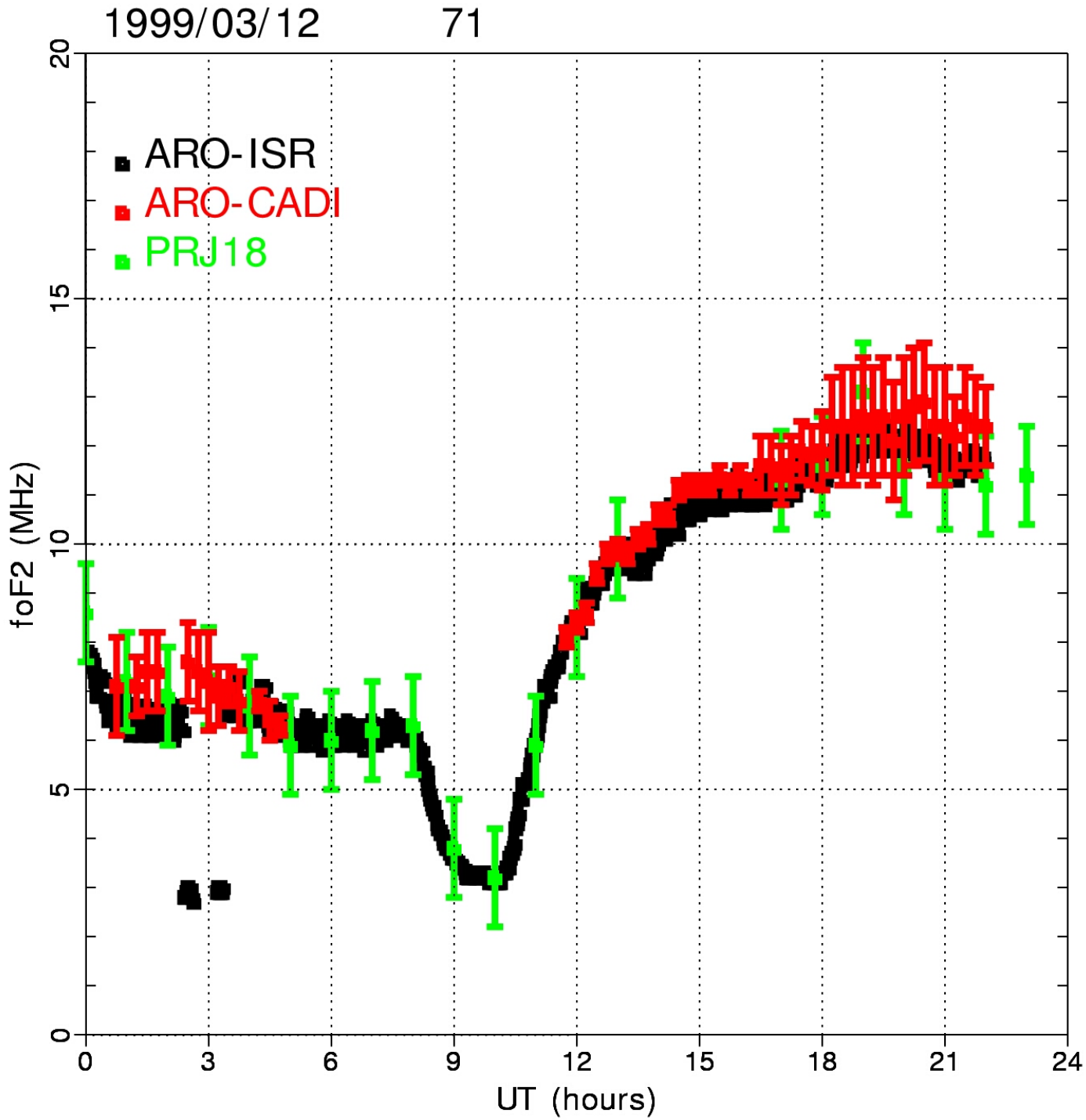
- AIM db Parameters
  - Peak density
  - Peak height
  - Topside profile shape
  - Bottomside profile shape

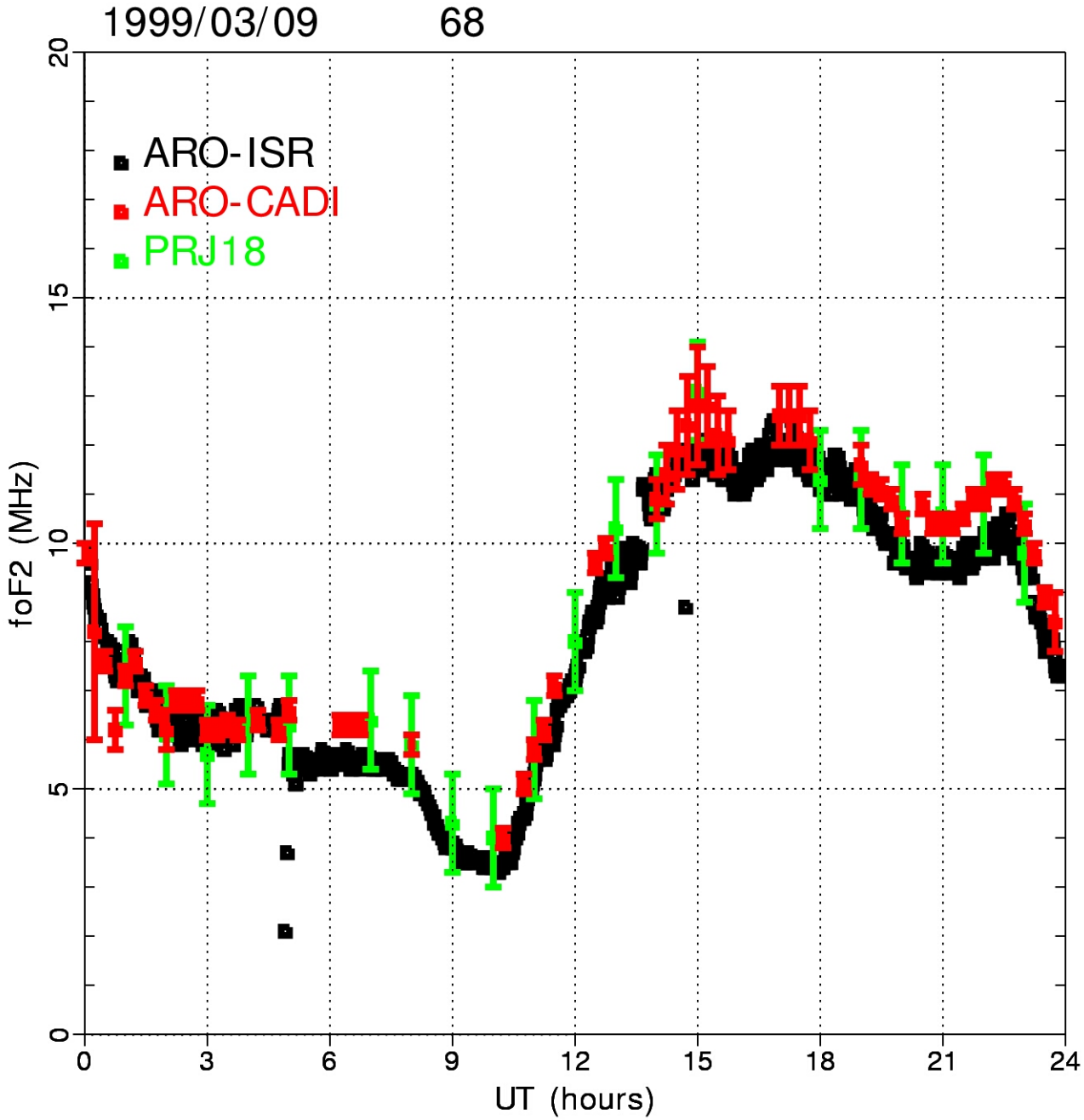


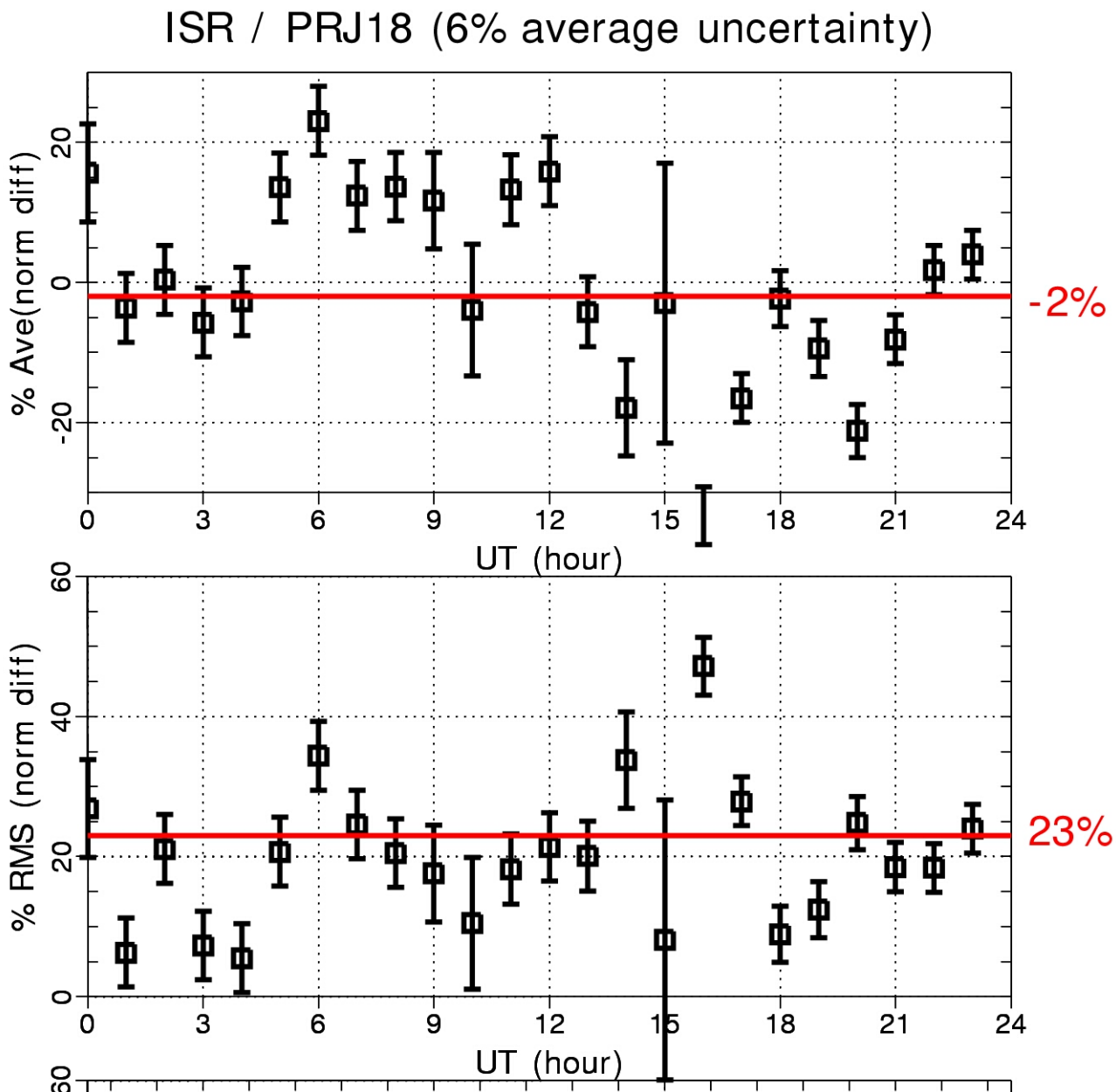
Normalization Error Bar

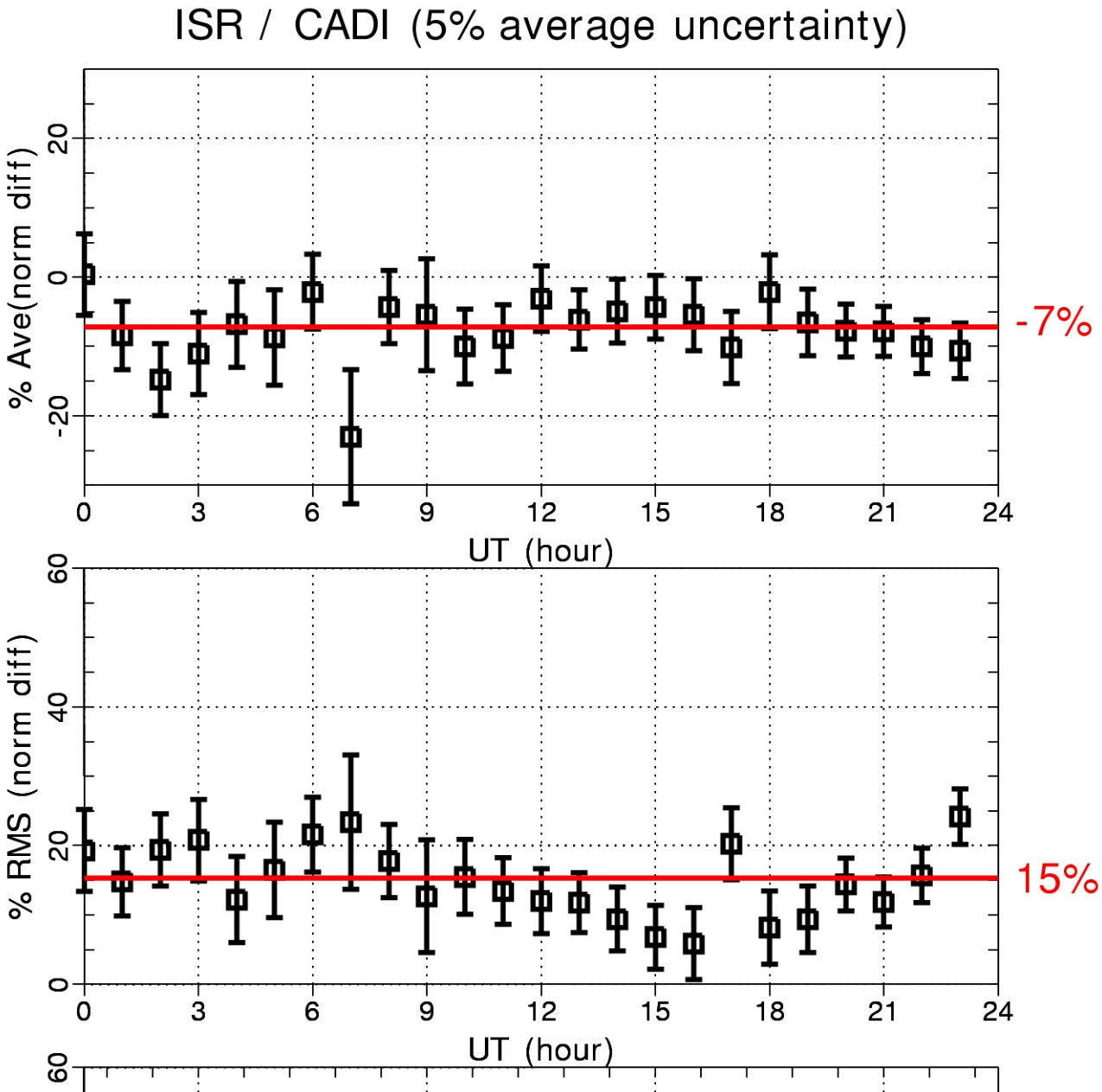
Normalizing the power profile with ionosonde f_oF_2

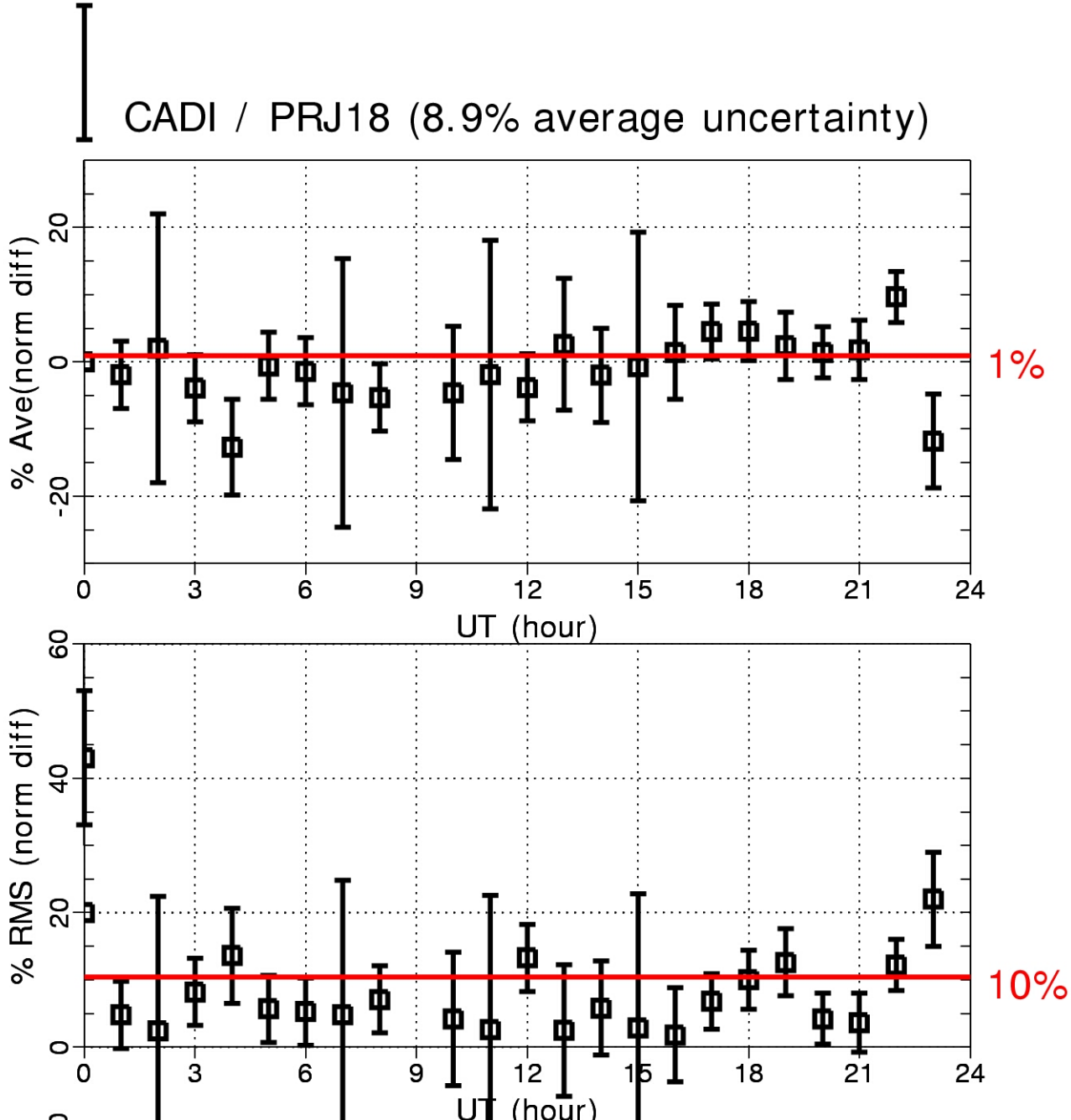

PRJ18
ARO ISR & CADI
Puerto Rico
geoLat (deg N)
geoLong (deg W)
20
18
16
14
12
10
-72
-70
-68
-66
-64
-62


1999/03/12 71
ARO-ISR
ARO-CADI
PRJ18
foF2 (MHz)
UT (hours)
0
5
10
15
20
0
3
6
9
12
15
18
21
24


1999/03/09 68
ARO-ISR
ARO-CADI
PRJ18
foF2 (MHz)
UT (hours)
0
5
10
15
20
0
3
6
9
12
15
18
21
24

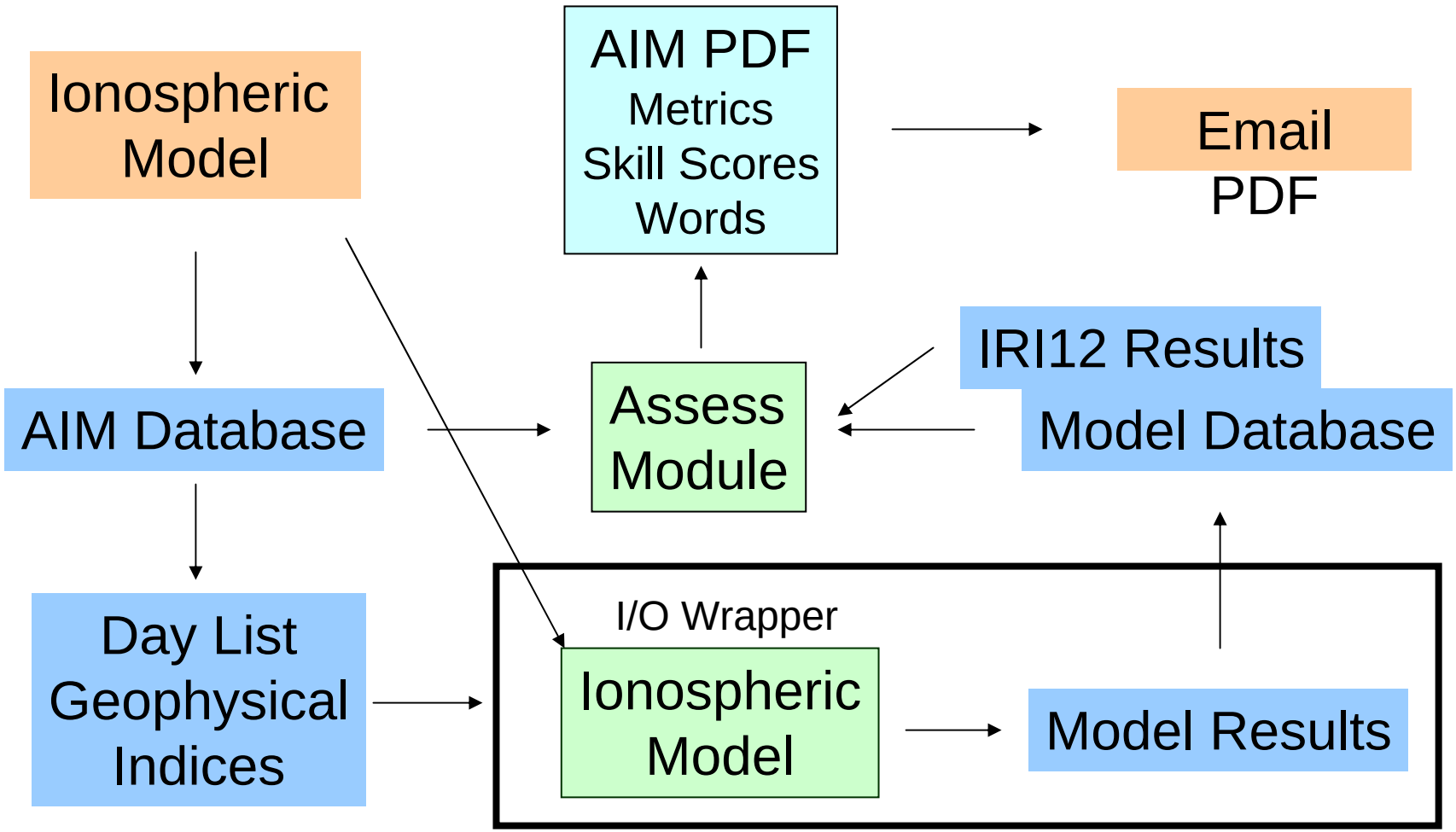

ISR / PRJ18 (6% average uncertainty)
% Ave(norm diff)
20
0
-20
0
3
6
9
12
15
18
21
24
UT (hour)
-2%
% RMS (norm diff)
60
40
20
0
0
3
6
9
12
15
18
21
24
UT (hour)
23%


ISR / CADI (5% average uncertainty)
% Ave(norm diff)
20
0
-20
-7%
0
3
6
9
12
15
18
21
24
UT (hour)
% RMS (norm diff)
60
40
20
0
15%
UT (hour)
60


CADI / PRJ18 (8.9% average uncertainty)
% Ave(norm diff)
20
0
-20
0
3
6
9
12
15
18
21
24
UT (hour)
1%
% RMS (norm diff)
60
40
20
0
0
3
6
9
12
15
18
21
24
UT (hour)
10%

AIM METRICS

AIM Design


Ionospheric Model
AIM PDF
Metrics
Skill Scores
Words
Email PDF
AIM Database
Assess Module
IRI12 Results
Model Database
Day List Geophysical Indices
I/O Wrapper
Ionospheric Model
Model Results

AIM - Metrics

- Profile parameter metrics & skill scores
  - NmF2
  - HmF2
  - TEC
  - Topside Scale Height (or shape)
  - Bottomside shape
- IRI-91 Will be the standard for skill scores to help monitor improvement of models

Assessment

- Metrics for climatology & weather
- Skill Score based on comparison with IRI12 results.

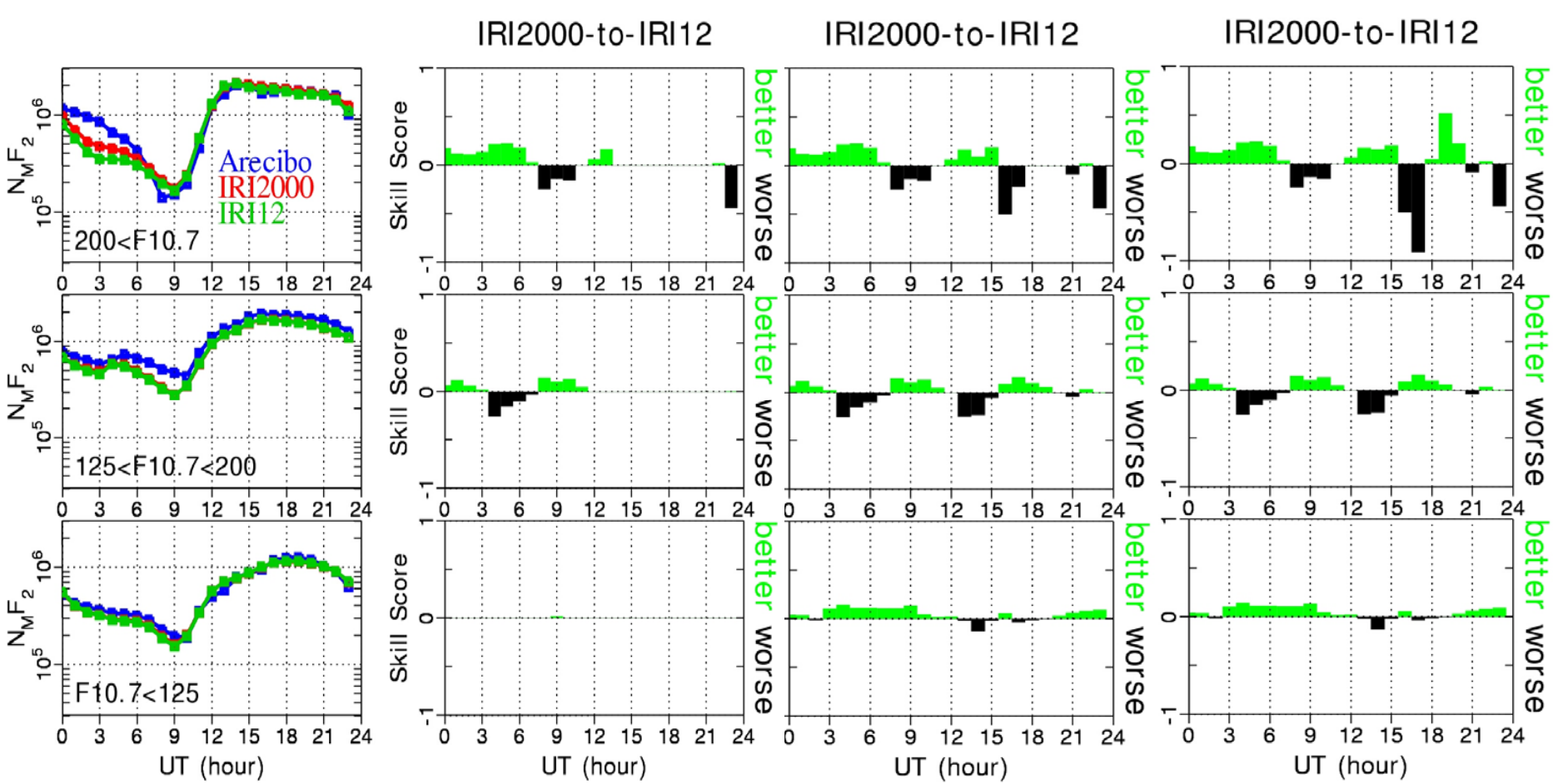
- Climatology

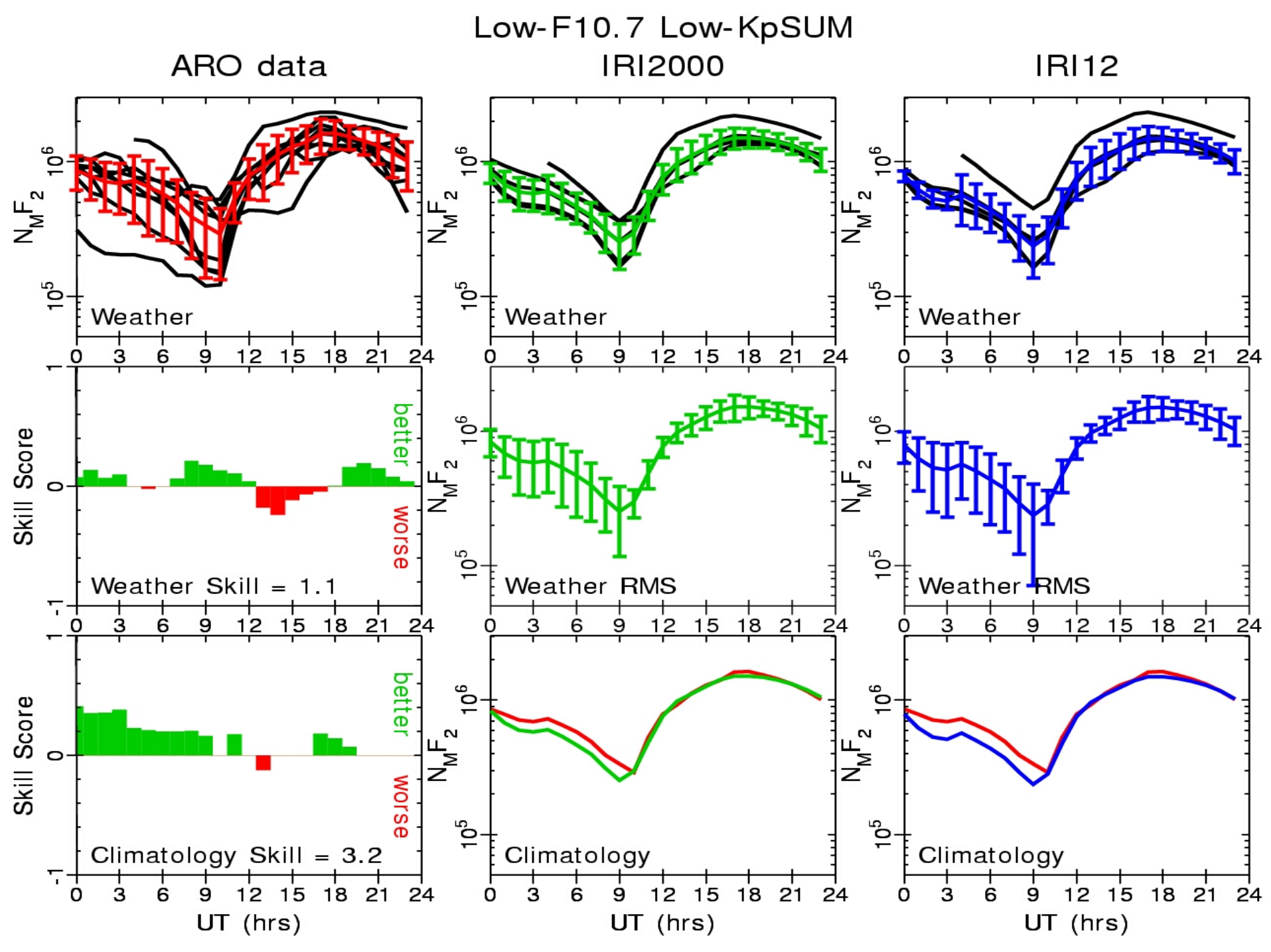
$$S = 1 - \frac{RMS_{Model}}{RMS_{IRI12}}$$

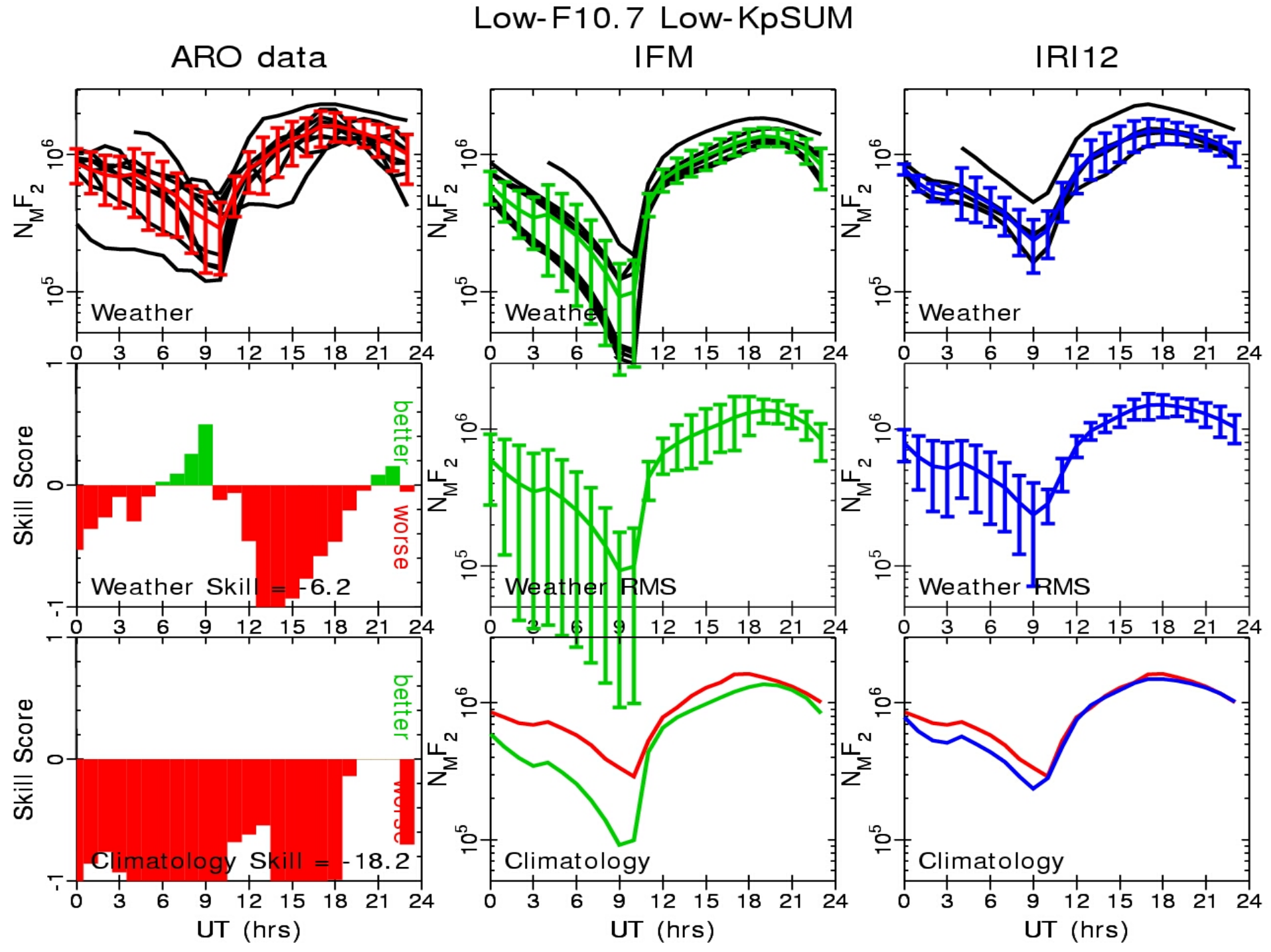
- Weather

$$S = 1 - \frac{\max(\text{target}, RMS_{\text{model}})}{\max(\text{target}, RMS_{IRI12})}$$

$$S = 1 - \frac{RMS_{\text{model}}}{RMS_{IRI12}}$$




Low-F10.7 Low-KpSUM
ARO data
IRI2000
IRI12
N_MF_2
10^6
10^5
Weather
Weather
Weather
Skill Score
better
worse
Weather Skill = 1.1
Weather RMS
Weather RMS
Climatology Skill = 3.2
Climatology
Climatology
0 3 6 9 12 15 18 21 24
UT (hrs)
UT (hrs)
UT (hrs)


Low-F10.7 Low-KpSUM
ARO data
IFM
IRI12
N_MF_2
10^6
10^5
Weather
Weather RMS
Climatology
Skill Score
better
worse
Weather Skill = -6.2
Climatology Skill = -18.2
0 3 6 9 12 15 18 21 24
UT (hrs)

Profile Metrics

- **IRI12**
- **IRI1995**
- **IRI2000**
- **IFM**
- **DATA**

QuickTime™ and a
H.264 decompressor
are needed to see this picture.

Implementation

- **We have all the data now (1966-2006)**
- **All data has been reduced and cleaned**
- **Climatology is almost complete with full data set**
- **IRI, IFM, SAMI2 are being run now for example benchmarks.**
- **AIM Database at CCMC in December 2007.**
- **First package at CCMC in February 2008.**
- **Final interation at CCMC in May 2008**