March 8th , 2012

GRUAN meeting

Importance of Upper-Air Sonde Observation For Data Assimilation

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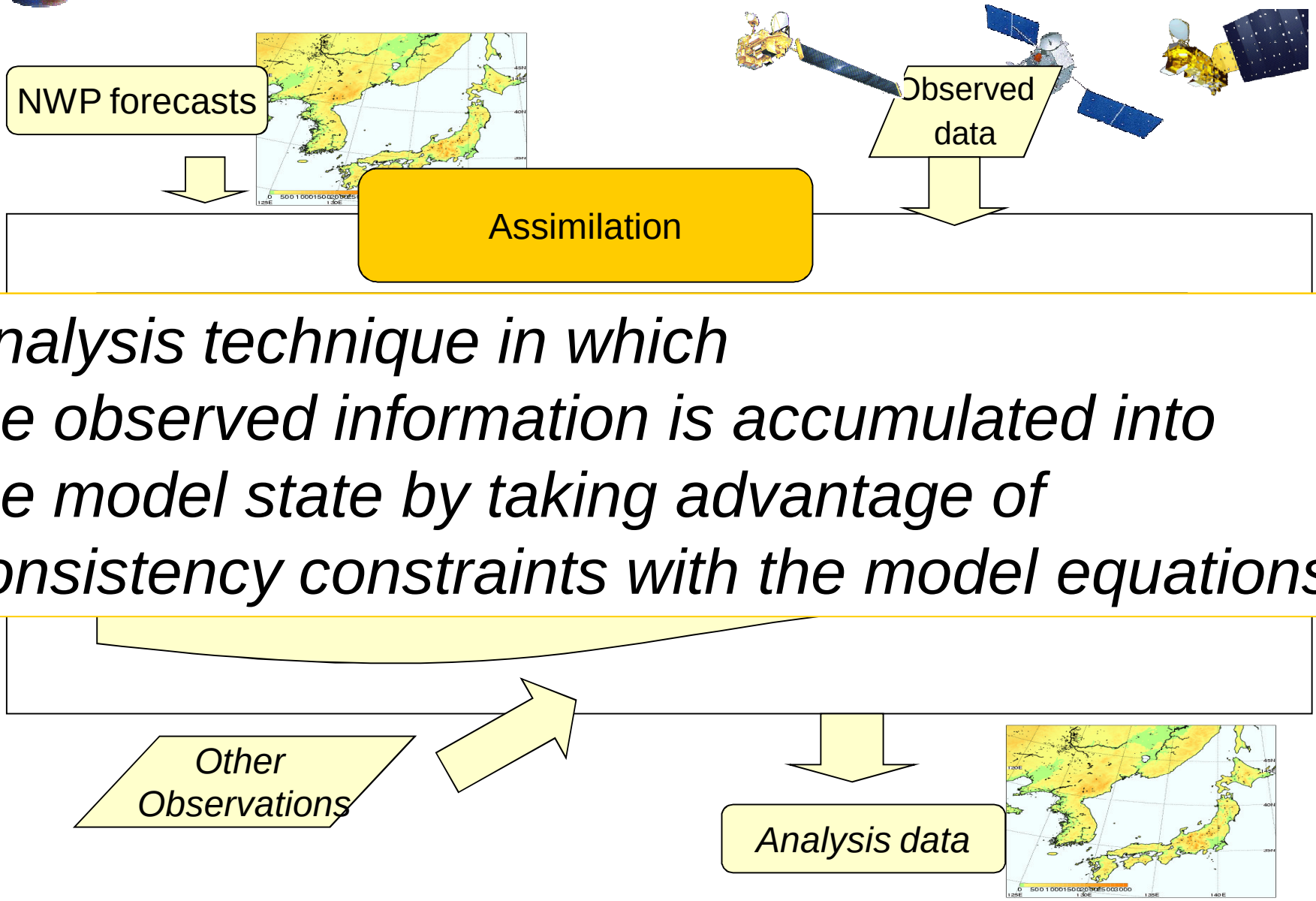
Outline

- What is “Data Assimilation”?
- Data Assimilation is essential for NWP systems
- MRI Research Projects on Data Assimilation
- Importance of Upper-Air Sonde Observation to Data Assimilation & Reanalysis
- Summary

What is “Data Assimilation”?

Definition of Data Assimilation



Analysis technique in which the observed information is accumulated into the model state by taking advantage of consistency constraints with the model equations

Statistical approach to produce analysis data

- Conditional PDF of X given obs. Y:

$$P_{rof}(X \mid Y) \propto P_{rof}(Y \mid X) P_{rof}(X)$$

- Modeling the PDF of first guess and observation error:

$$P_{rof}(X) = P_{rof}(\varepsilon^{f})$$

$$\varepsilon^{f} = X - X^{f}$$

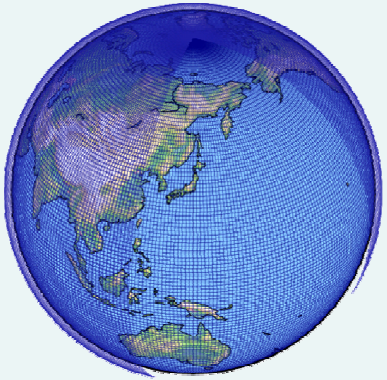
$$P_{rof}(Y \mid X) = P_{rof}(\varepsilon^{o})$$

$$\varepsilon^{o} = Y - H(X)$$

- Find optimal values that maximize the PDF.

Data Assimilation is essential for NWP systems

Major NWP models at JMA



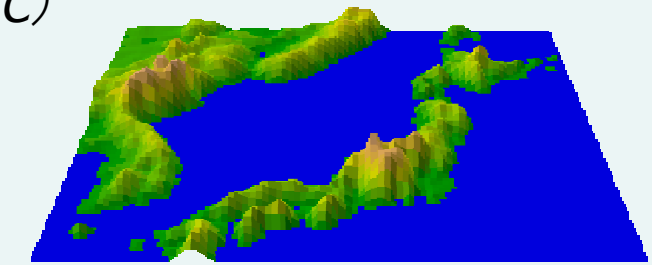
GSM: Global Spectral Model

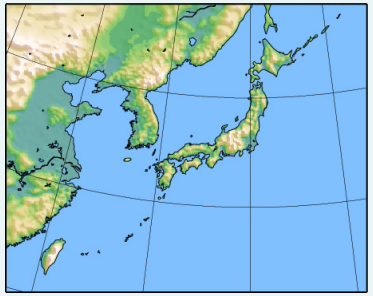
TL959(0.1875deg(20km)) / 60levels(top 0.1hPa)

84 hour forecasts

216 hour forecasts (12UTC)

Data assimilation: 4DVAR





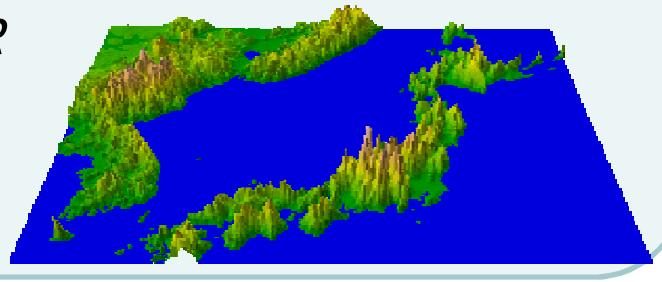
MSM: Meso-Scale Model

5km (3600x2880km) / 50leves(top 22km)

15 hour forecasts(00,06,12,18UTC)

33 hour forecasts(03,09,15,21UTC)

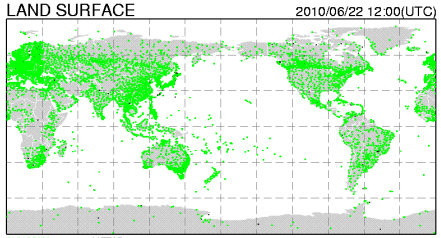
Data Assimilation: 4DVAR



Data used in the assimilation cycles (Jun 22, 2011)

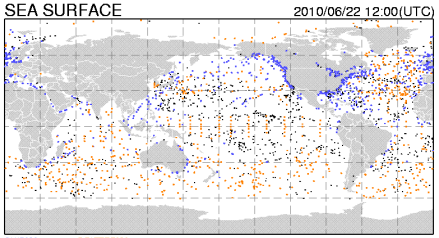
JMA GLOBAL ANALYSIS – DATA COVERAGE MAP – 1 (Da12ps): 2010/06/22 12:00(UTC)

LAND SURFACE 2010/06/22 12:00(UTC)



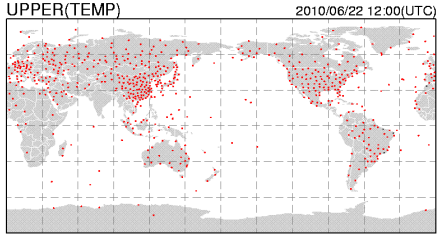
SYNOP(●): 5724 METAR
NOUSE[●]: 10039 NOUSE[●]: 3505
ALL: 15763 ALL: 3505

SEA SURFACE 2010/06/22 12:00(UTC)



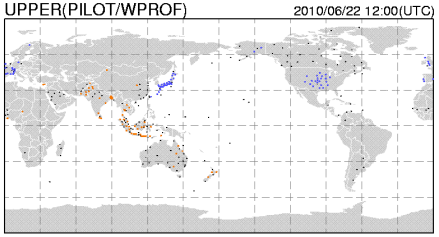
SHIP(●): 739 DRIFTER(●): 690
NOUSE[●]: 2836 NOUSE[●]: 10035
ALL: 3575 ALL: 10725

UPPER(TEMP) 2010/06/22 12:00(UTC)



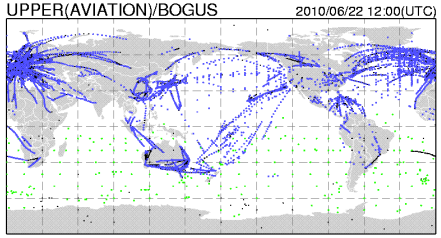
TEMP(●): 630
NOUSE[●]: 5
ALL: 635

UPPER(PILOT/WPROF) 2010/06/22 12:00(UTC)



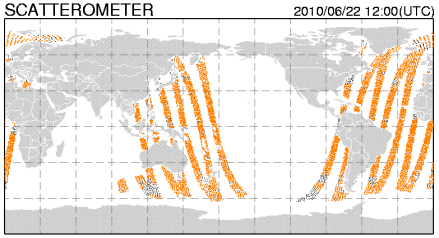
PILOT(●): 61 WPROF(●): 74
NOUSE[●]: 205 NOUSE[●]: 1754
ALL: 266 ALL: 1828

UPPER(AVIATION)/BOGUS 2010/06/22 12:00(UTC)



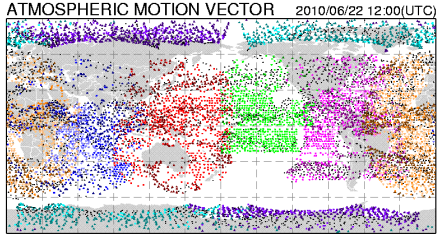
TYBOGUS(●): 0 YHTC PACOB(●): 241 AVIATION(●): 4840
NOUSE[●]: 0 NOUSE[▼]: 0 NOUSE[●]: 74 NOUSE[●]: 25846
ALL: 0 ALL: 0 ALL: 315 ALL: 30686

SCATTEROMETER 2010/06/22 12:00(UTC)



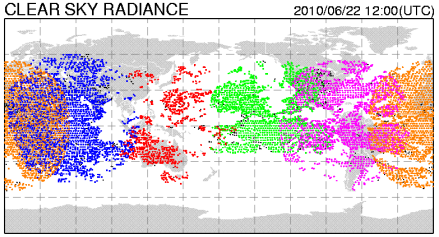
METOP-2
ASCAT(●): 4687
NOUSE[●]: 1033
ALL: 5720

ATMOSPHERIC MOTION VECTOR 2010/06/22 12:00(UTC)



MTSAT-1 GOSE-11 GOSE-13 Metecast-7 Metecast-9 Terra Aqua
IR(●): 573 IR(●): 643 IR(●): 428 IR(●): 232 IR(●): 343 IR(●): 467 IR(●): 285
VS(▼): 0 VS(▼): 0 VS(▼): 199 VS(▼): 248 VS(▼): 891
WV(▲): 419 WV(▲): 73 WV(▲): 357 WV(▲): 316 WV(▲): 571 WV(▲): 784 WV(▲): 791
NOUSE[●]: 234 NOUSE[●]: 558 NOUSE[●]: 1021 NOUSE[●]: 381 NOUSE[●]: 1082 NOUSE[●]: 605 NOUSE[●]: 528

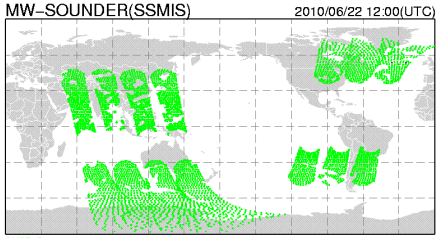
CLEAR SKY RADIANCE 2010/06/22 12:00(UTC)



MTSAT-1 GOES-11 GOES-13 Metecast-7 Metecast-9
IMAGER(●): 1117 IMAGER(●): 2091 IMAGER(●): 3069 MVIR(●): 4335 SEVIR(●): 5853
NOUSE[●]: 65 NOUSE[●]: 177 NOUSE[●]: 190 NOUSE[●]: 240 NOUSE[●]: 274
ALL: 1182 ALL: 2268 ALL: 3259 ALL: 4575 ALL: 5927

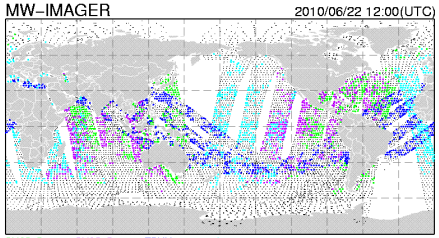
JMA GLOBAL ANALYSIS – DATA COVERAGE MAP – 2 (Da12ps): 2010/06/22 12:00(UTC)

MW-SOUNDER(SSMIS) 2010/06/22 12:00(UTC)



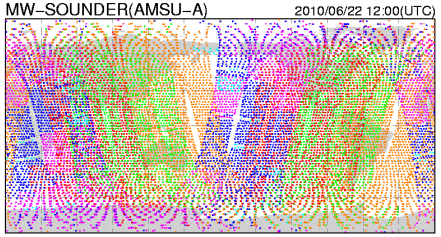
DMSP-F16
SSMIS(●): 4812
NOUSE[●]: 2
ALL: 4814

MW-IMAGER 2010/06/22 12:00(UTC)



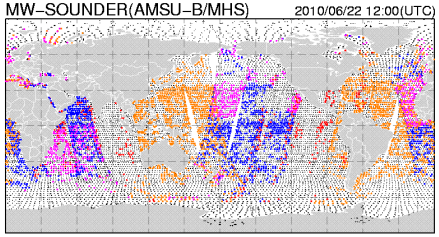
DMSP-F16 DMSP-F17 TRMM Aqua
SSMIS(●): 741 SSMIS(●): 900 TM(●): 884 AMSR-E(●): 855
NOUSE[●]: 2931 NOUSE[●]: 2847 NOUSE[●]: 1426 NOUSE[●]: 3264
ALL: 3672 ALL: 3747 ALL: 2310 ALL: 4119

MW-SOUNDER(AMSU-A) 2010/06/22 12:00(UTC)



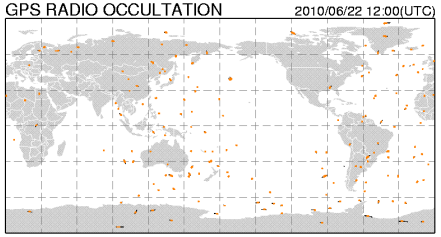
NOAA-15 NOAA-16 NOAA-18 NOAA-19 Aqua METOP-2
AMSU-A(●): 4212 AMSU-A(●): 4044 AMSU-A(●): 2868 AMSU-A(●): 2898 AMSU-A(●): 264 AMSU-A(●): 505

MW-SOUNDER(AMSU-B/MHS) 2010/06/22 12:00(UTC)



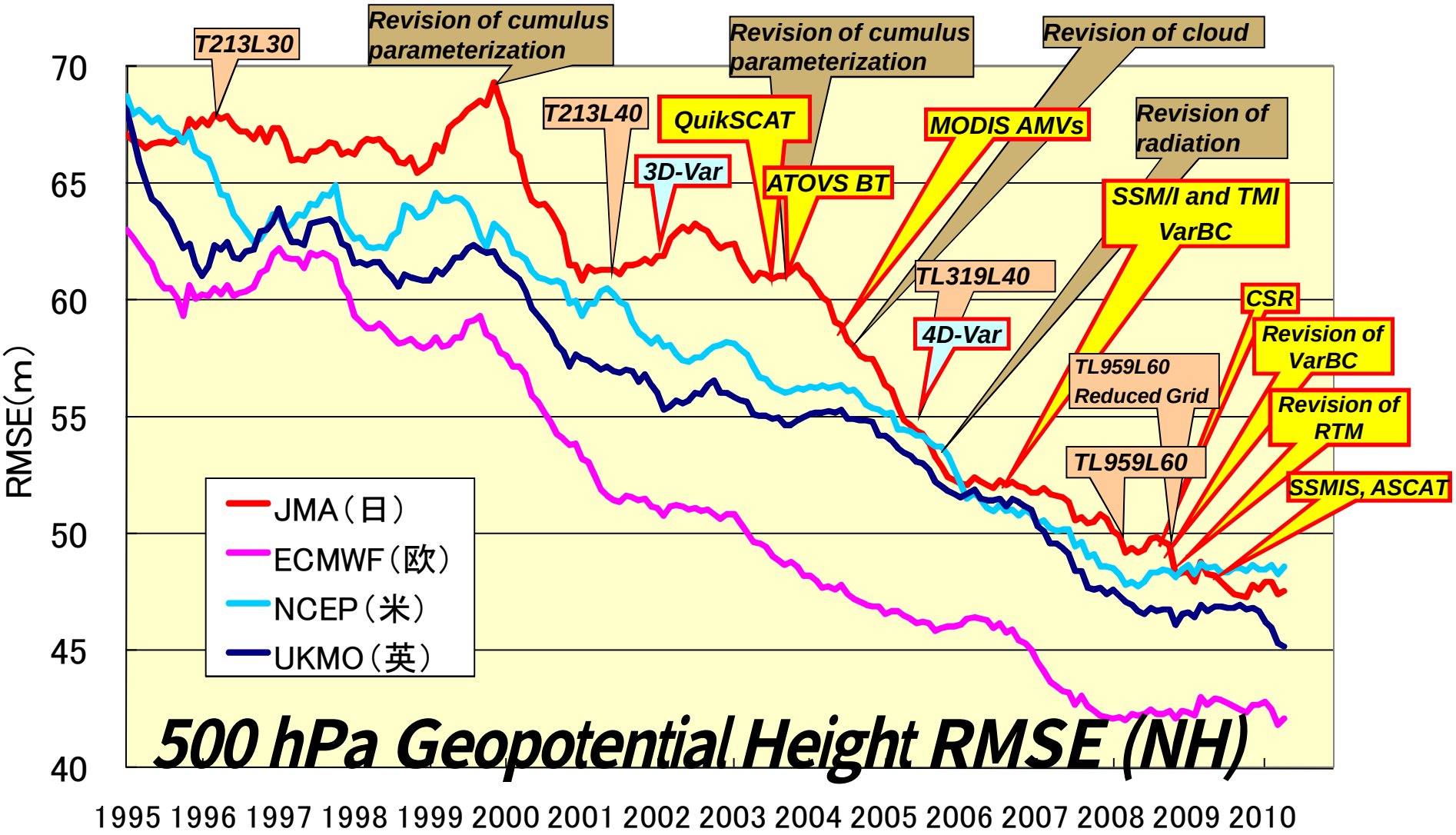
NOAA-15 NOAA-16 NOAA-18 NOAA-19 METOP-2
AMSU-B(●): 423 AMSU-B(●): 0 MHS(●): 1027 MHS(●): 1616 MHS(●): 2112
NOUSE[●]: 5154 NOUSE[●]: 5310 NOUSE[●]: 2419 NOUSE[●]: 2425 NOUSE[●]: 5010
ALL: 5577 ALL: 5310 ALL: 3448 ALL: 4041 ALL: 7123

GPS RADIO OCCULTATION 2010/06/22 12:00(UTC)



METOP-2
GRAS(●): 2484
NOUSE[●]: 30089
ALL: 32573

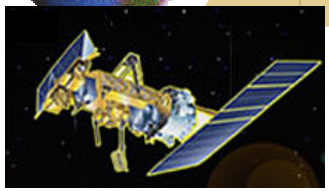
DA is important for NWP

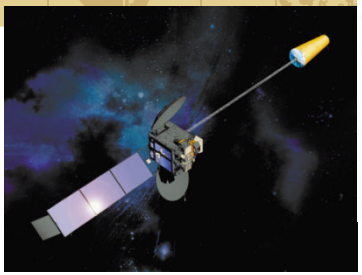


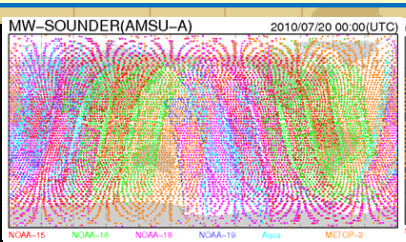
Courtesy of Y. Sato (JMA)

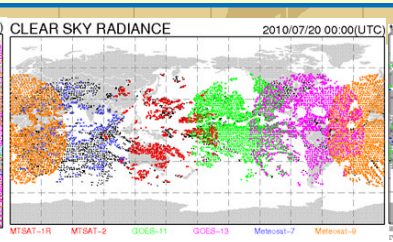
MRI Research Projects on Data Assimilation

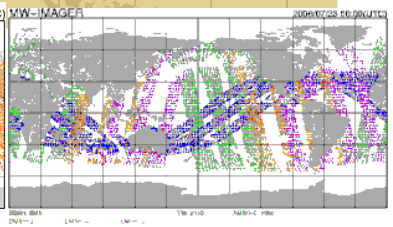
Study on sophistication of global data assimilation

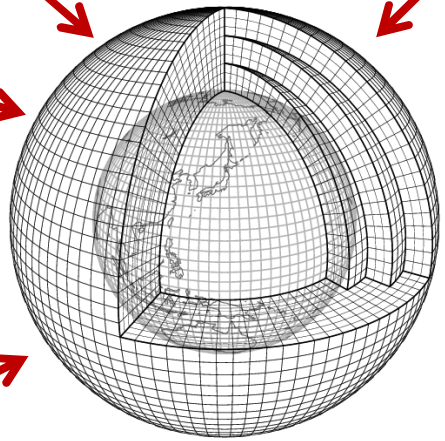






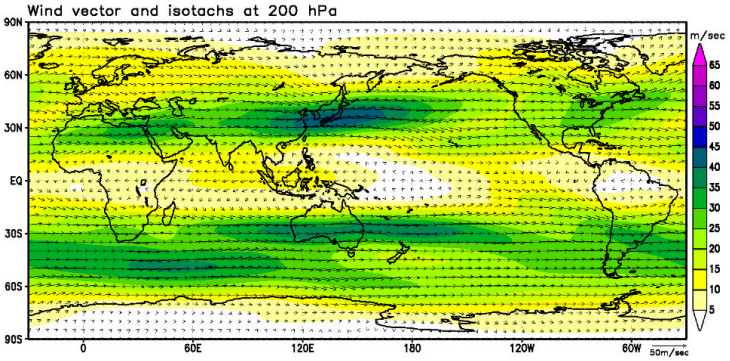




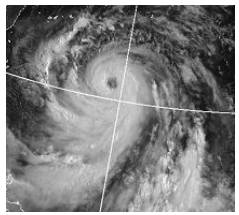


データ同化手法の高度化
衛星データ同化技術の高度化

高精度の解析値

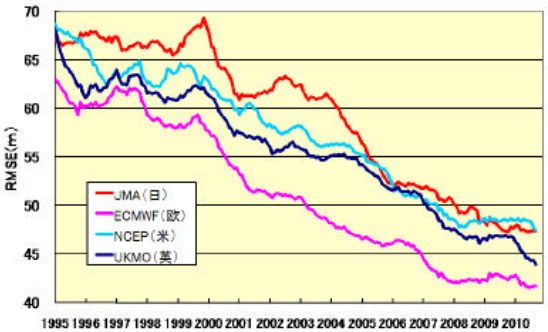


熱帯・台風
環境場の
精度向上



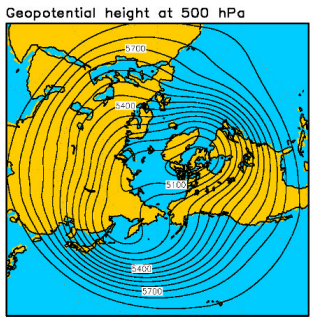
高精度の
第一推定値
（予報値）

図6-3 2010年9月までの北半球500hPa高度予報誤差（120時間予報）



全球予報の
成績改善

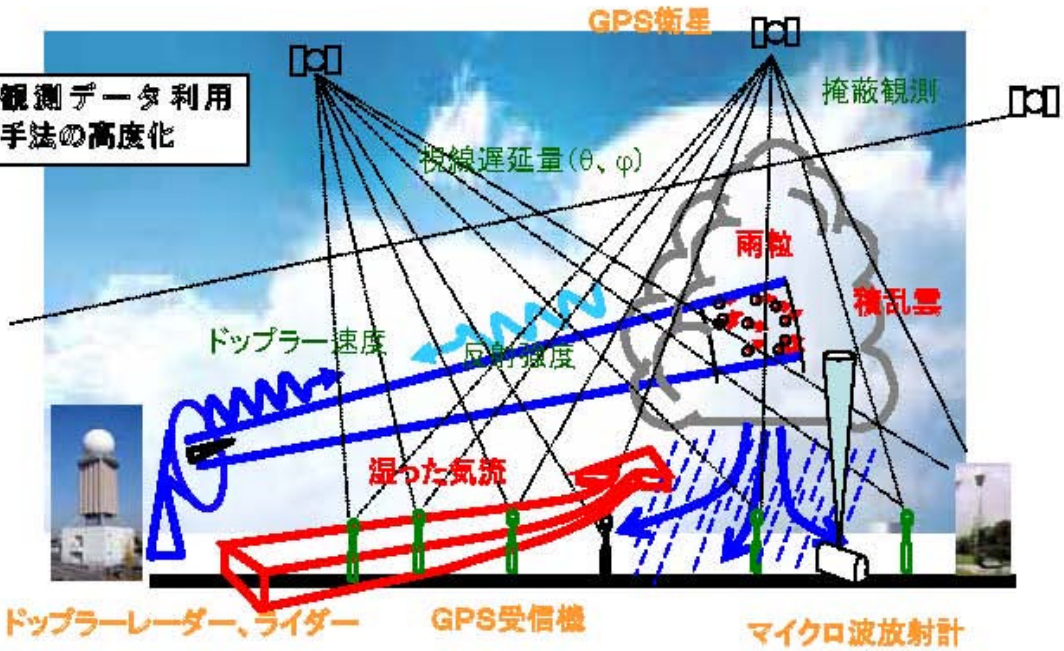
大規模
環境場の
精度向上

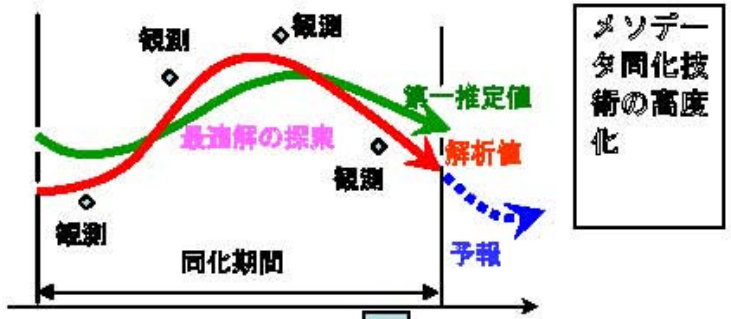


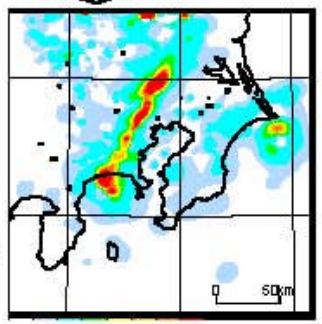
Study on meso-scale data assimiation and ensemble forecast

課題

様式（計画Ｂ－１） 研究の概要説明図（ポンチ絵）（各サブ課題の連携、研究計画、各課題の成果がはっきりわかるように）

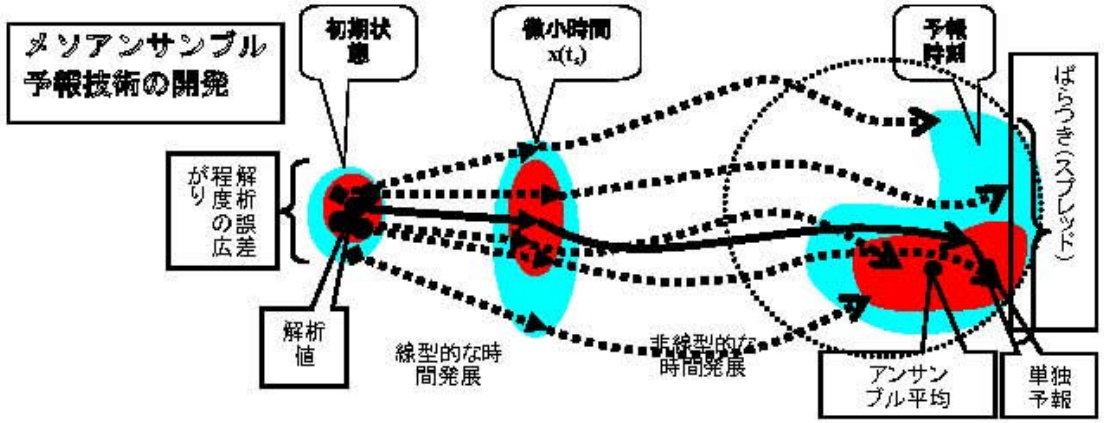


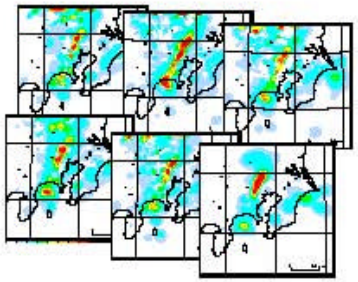




アンサンブル予報に基づく予報誤差の同化手法への利用

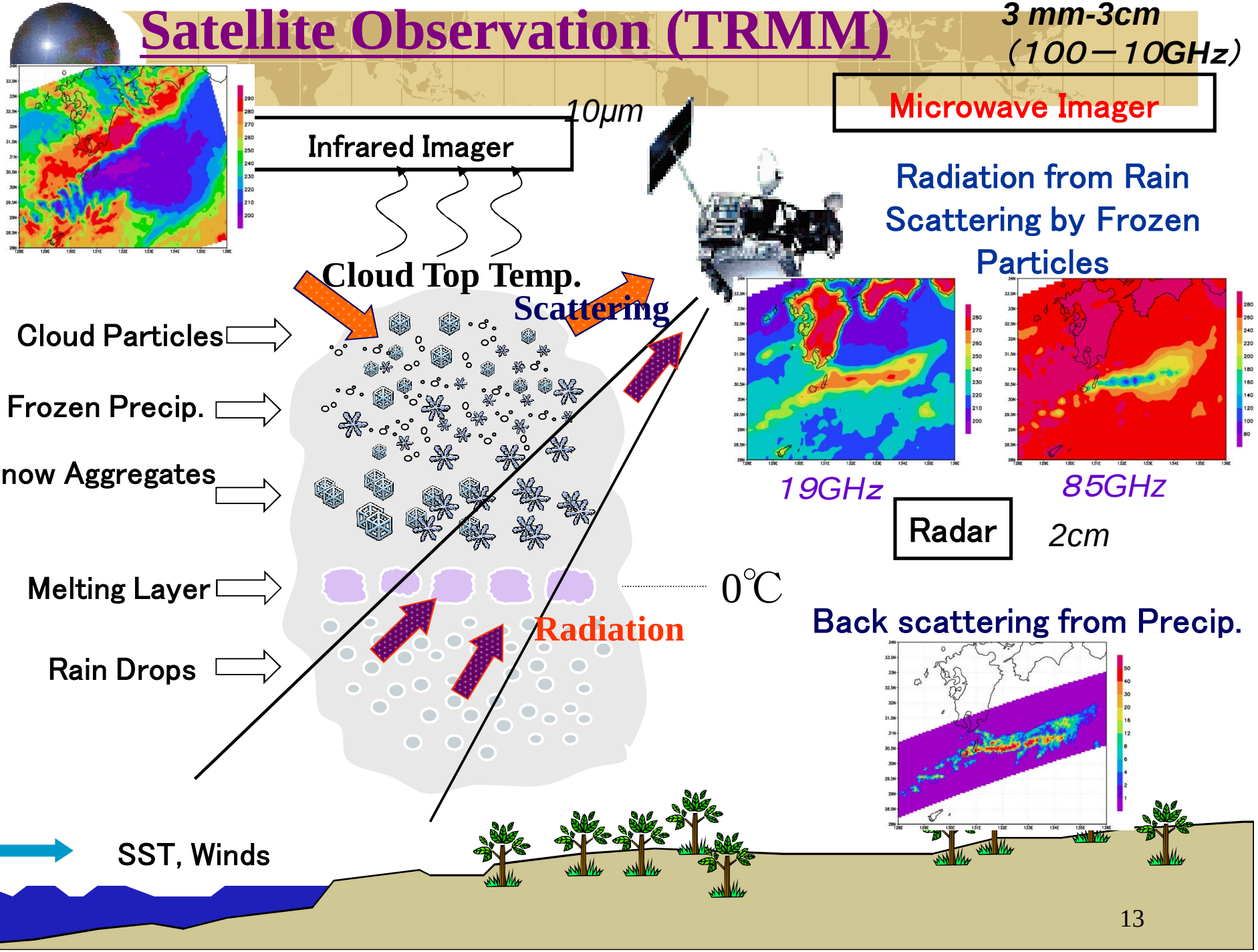
市町村単位での降水の短時間予測の精度向上





複数シナリオの提供、短期量的予測に信頼度や確率情報を付加

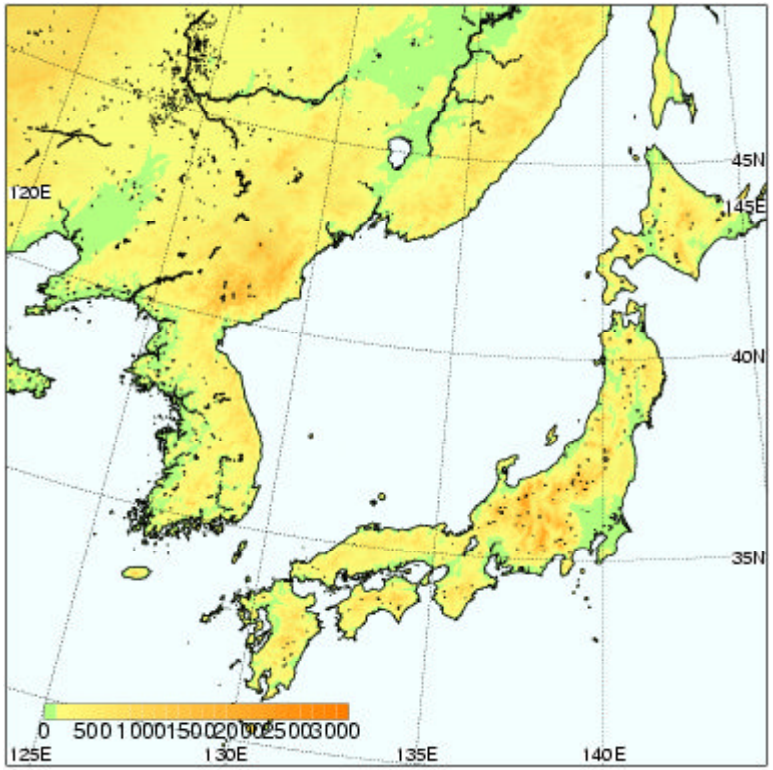
Satellite Observation (TRMM)



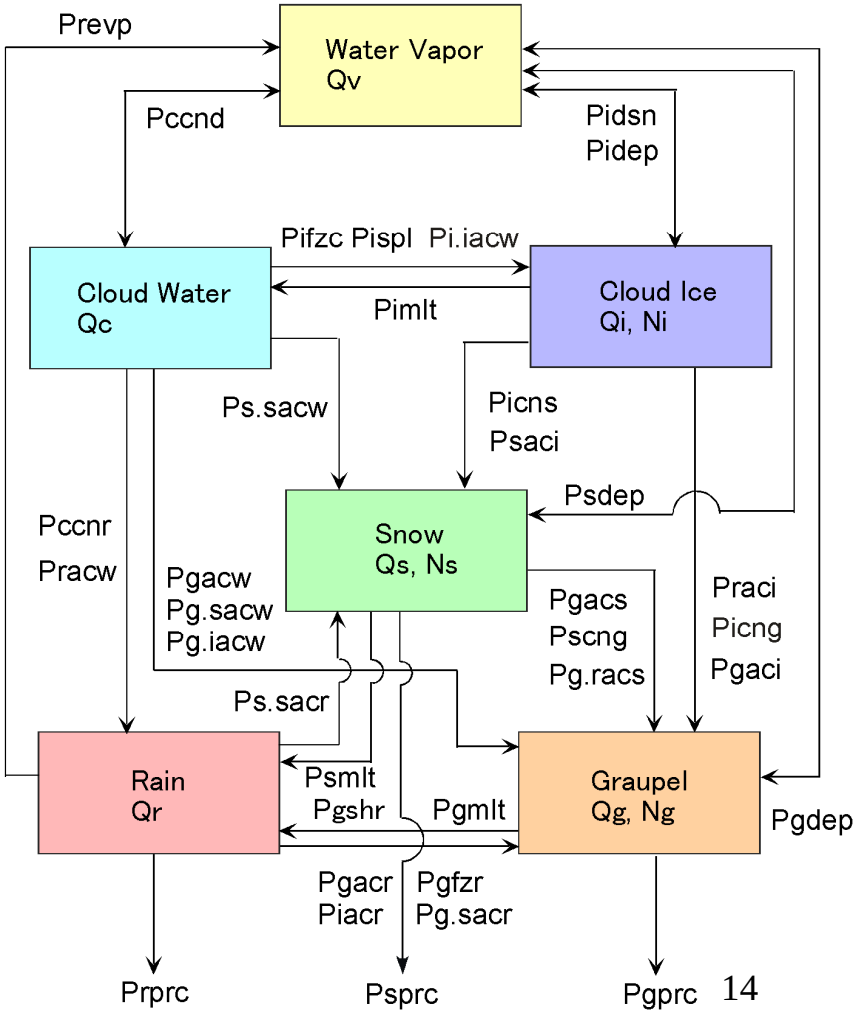
Cloud-Resolving Model used

JMANHM (Saito et al,2001)

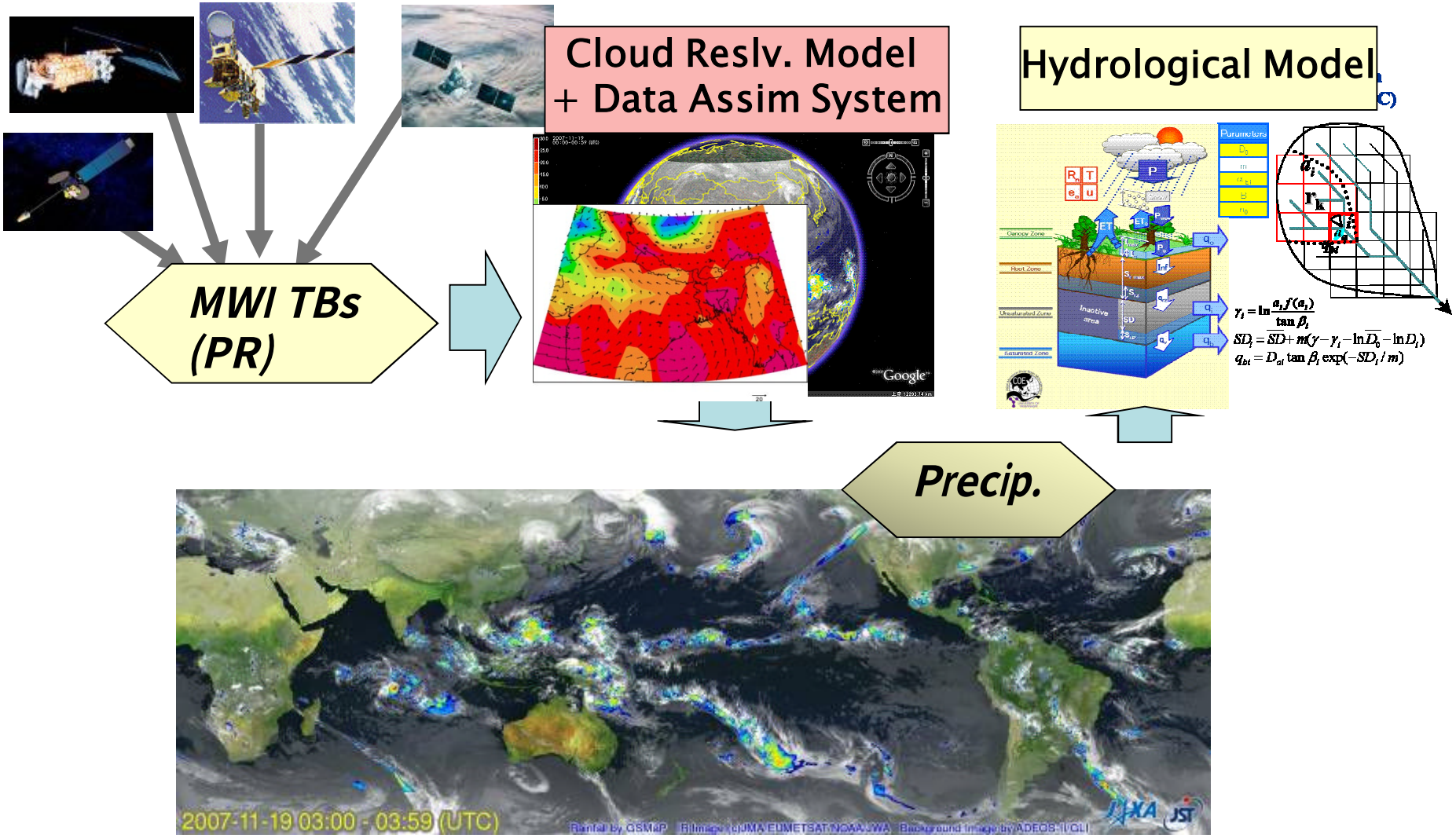
- **Resolution: 5 km**
- **Grids: 400 x 400 x 38**
- **Time interval: 15 s**



Explicitly forecasts 6 species of water substances



Goal: Data assimilation of MWI TBs into CRMs



Importance of Upper-Air Sonde Observation to Data Assimilation & Reanalysis

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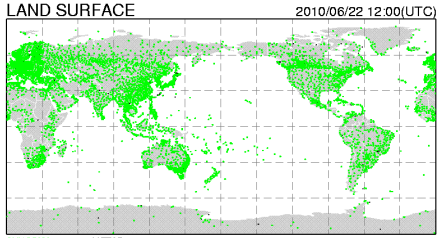

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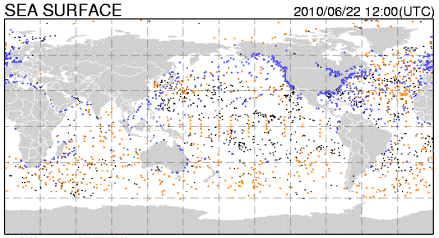

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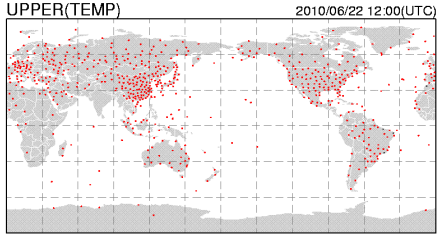

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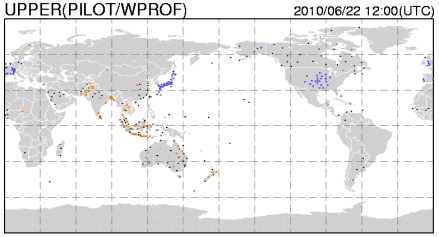

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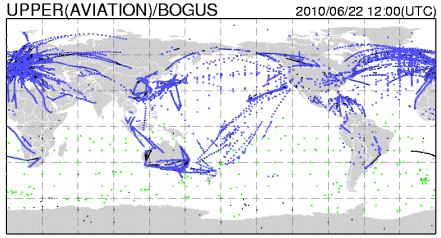
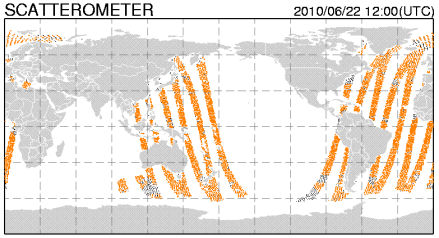
ALL: 266 ALL: 1828

UPPER(AVIATION)/BOGUS 2010/06/22 12:00(UTC)



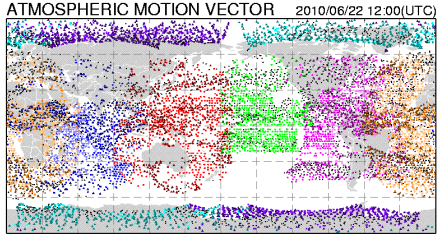
TYBOGUS(●): 0 YHTC PACOB(●): 241 AVIATION(●): 4840
NOUSE[●]: 0 NOUSE[▼]: 0 NOUSE[●]: 74 NOUSE[●]: 25846
ALL: 0 ALL: 0 ALL: 315 ALL: 30686

SCATTEROMETER 2010/06/22 12:00(UTC)



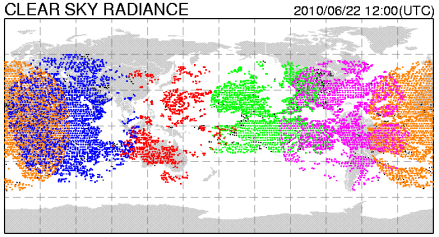
METOP-2
ASCAT(●): 4687
NOUSE[●]: 1033
ALL: 5720

ATMOSPHERIC MOTION VECTOR 2010/06/22 12:00(UTC)



MTSAT-1 GOSE-11 GOSE-13 Metecast-7 Metecast-9 Terra Aqua
IR(●): 573 IR(●): 643 IR(●): 428 IR(●): 232 IR(●): 343 IR(●): 467 IR(●): 285
VS(▼): 0 VS(▼): 0 VS(▼): 199 VS(▼): 248 VS(▼): 891
WV(▲): 419 WV(▲): 73 WV(▲): 357 WV(▲): 316 WV(▲): 571 WV(▲): 784 WV(▲): 791
NOUSE[●]: 234 NOUSE[●]: 558 NOUSE[●]: 1021 NOUSE[●]: 381 NOUSE[●]: 1082 NOUSE[●]: 605 NOUSE[●]: 528

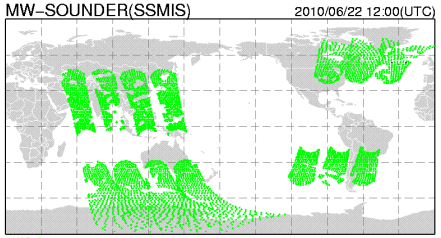
CLEAR SKY RADIANCE 2010/06/22 12:00(UTC)



MTSAT-1 GOES-11 GOES-13 Metecast-7 Metecast-9
IMAGER(●): 1117 IMAGER(●): 2091 IMAGER(●): 3069 MVIR(●): 4335 SEVIR(●): 5853
NOUSE[●]: 65 NOUSE[●]: 177 NOUSE[●]: 190 NOUSE[●]: 240 NOUSE[●]: 274
ALL: 1182 ALL: 2268 ALL: 3259 ALL: 4575 ALL: 5927

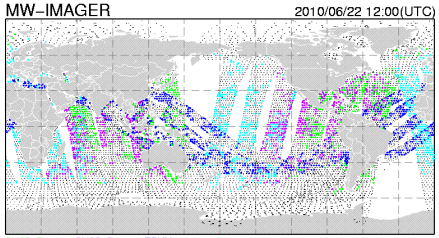
JMA GLOBAL ANALYSIS – DATA COVERAGE MAP – 2 (Da12ps): 2010/06/22 12:00(UTC)

MW-SOUNDER(SSMIS) 2010/06/22 12:00(UTC)



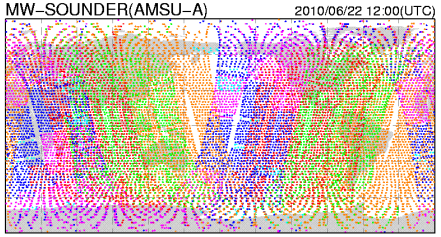
DMSP-F16
SSMIS(●): 4812
NOUSE[●]: 2
ALL: 4814

MW-IMAGER 2010/06/22 12:00(UTC)



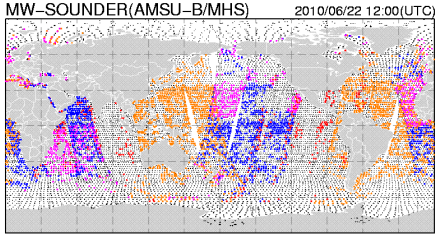
DMSP-F16 DMSP-F17 TRMM Aqua
SSMIS(●): 741 SSMIS(●): 900 TM(●): 884 AMSR-E(●): 855
NOUSE[●]: 2931 NOUSE[●]: 2847 NOUSE[●]: 1426 NOUSE[●]: 3264
ALL: 3672 ALL: 3747 ALL: 2310 ALL: 4119

MW-SOUNDER(AMSU-A) 2010/06/22 12:00(UTC)



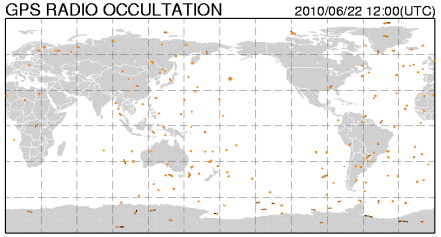
NOAA-15 NOAA-16 NOAA-18 NOAA-19 Aqua METOP-2
AMSU-A(●): 4212 AMSU-A(●): 4044 AMSU-A(●): 2868 AMSU-A(●): 2898 AMSU-A(●): 264 AMSU-A(●): 505

MW-SOUNDER(AMSU-B/MHS) 2010/06/22 12:00(UTC)



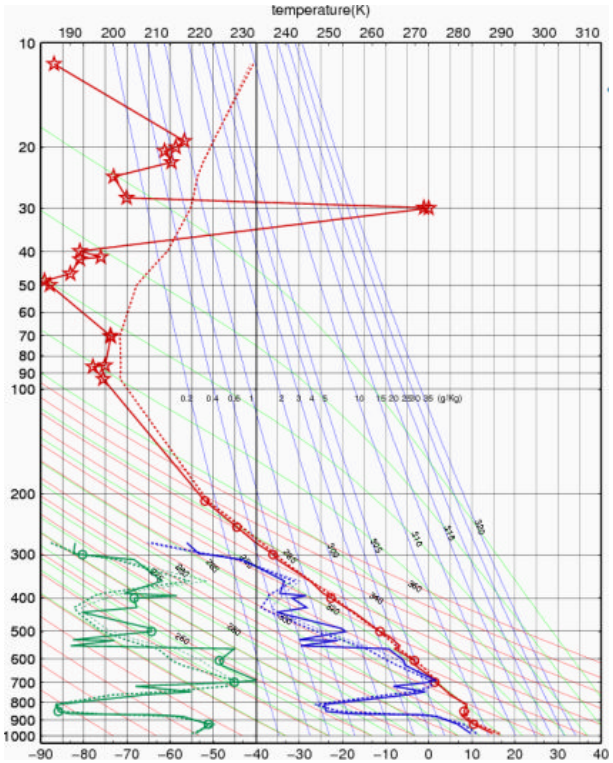
NOAA-15 NOAA-16 NOAA-18 NOAA-19 METOP-2
AMSU-B(●): 423 AMSU-B(●): 0 MHS(●): 1027 MHS(●): 1616 MHS(●): 2112
NOUSE[●]: 5154 NOUSE[●]: 5310 NOUSE[●]: 2419 NOUSE[●]: 2425 NOUSE[●]: 5010
ALL: 5577 ALL: 5310 ALL: 3448 ALL: 4041 ALL: 7123

GPS RADIO OCCULTATION 2010/06/22 12:00(UTC)

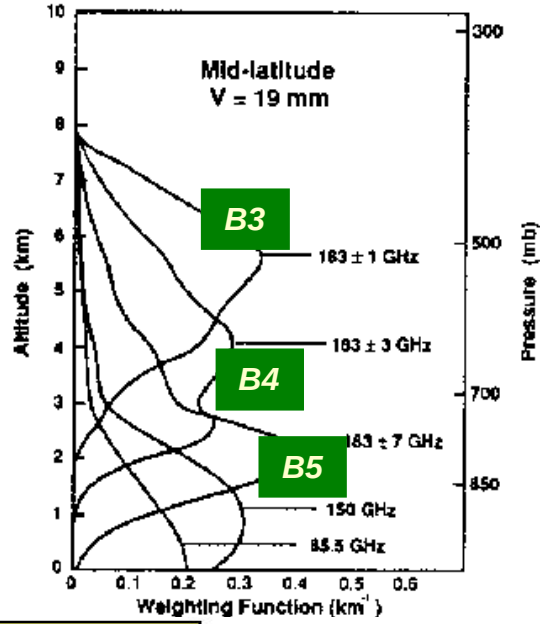


METOP-2
GRAS(●): 2484
NOUSE[●]: 30089
ALL: 32573

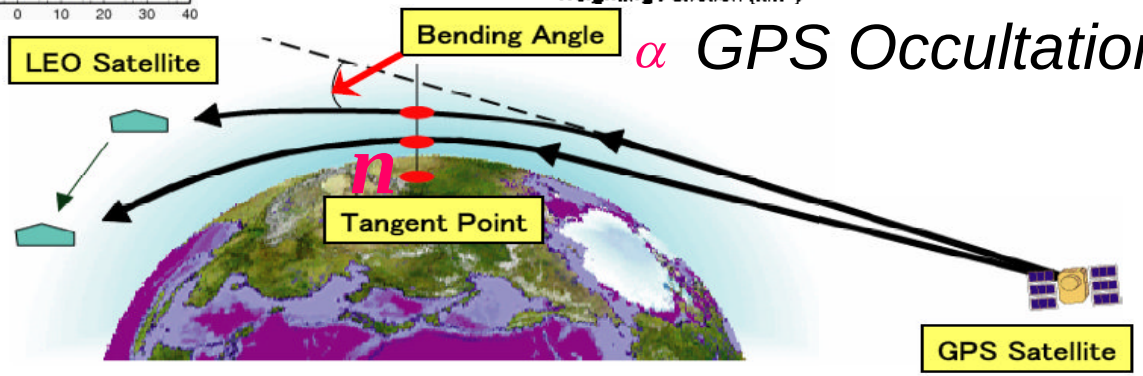
Complementary Property of Upper-Air Sonde Data to Satellite observation



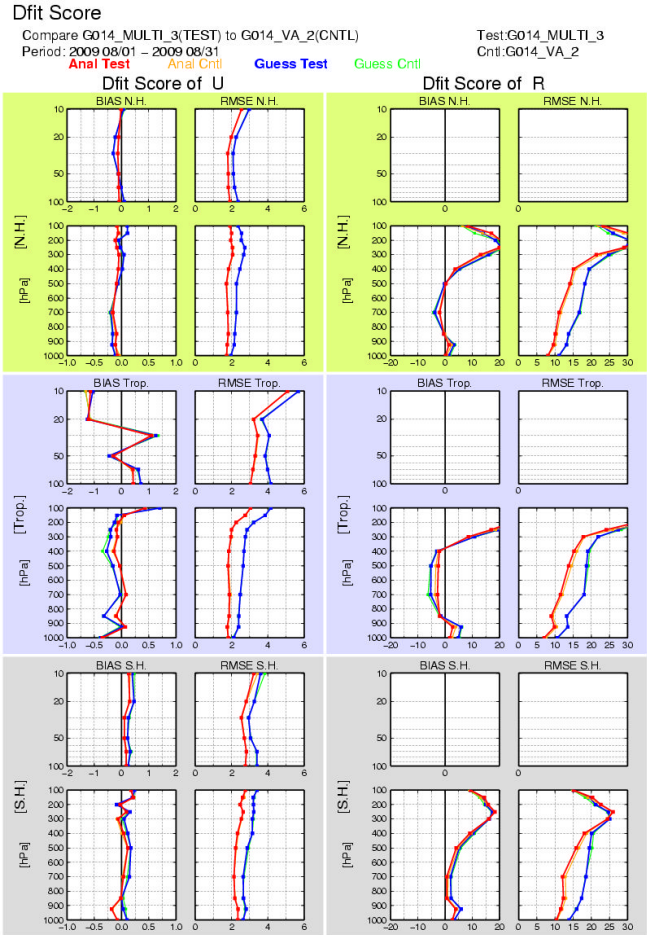
Weighting of AMSU-B

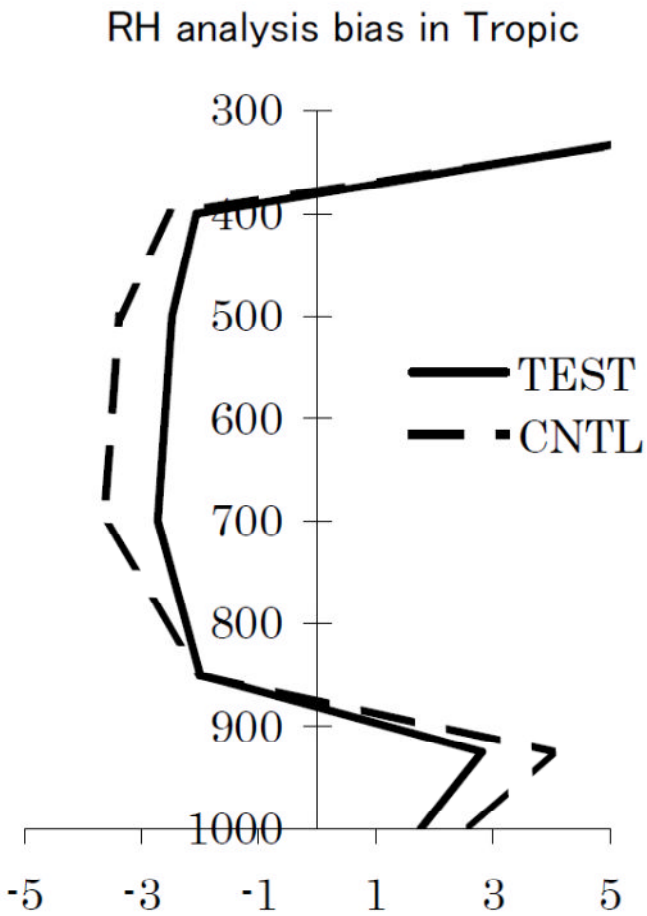


α GPS Occultation

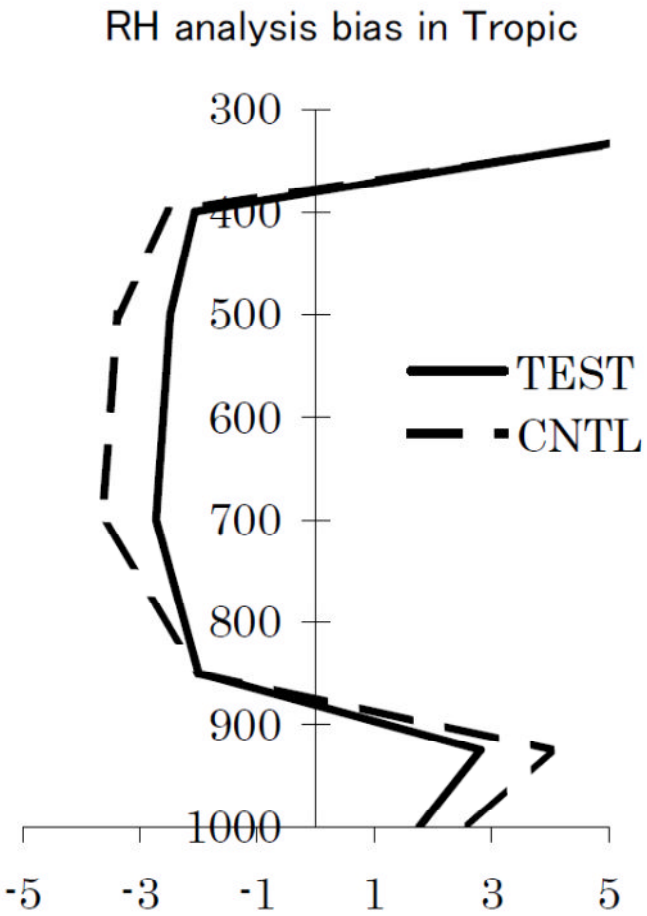


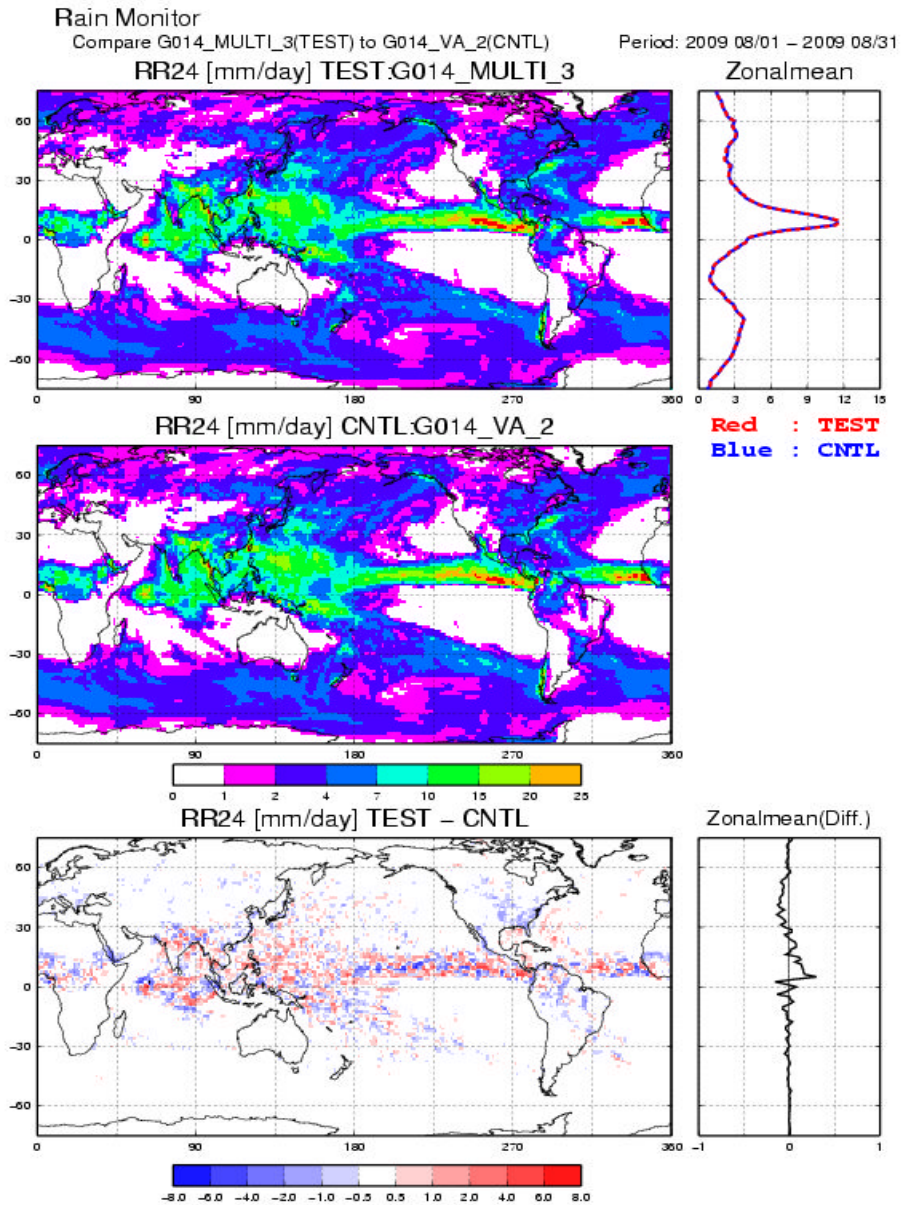
Radiosonde data as the validation data for checking the analyses of DA systems



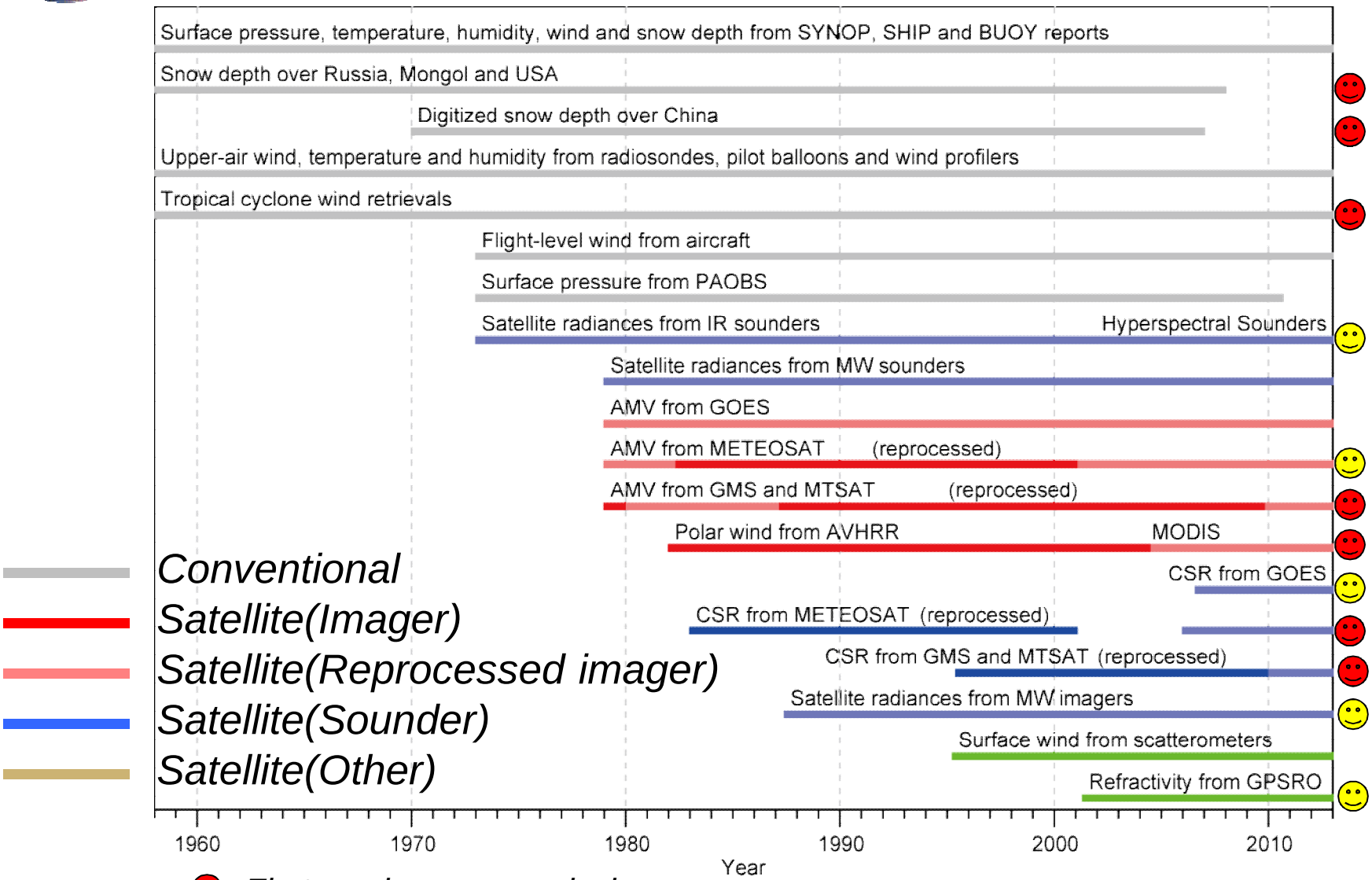


Thermodynamical profiles from sonde data is essential for NWP precip. schemes





Input data for Reanalysis :JRA-55



First use in any reanalysis

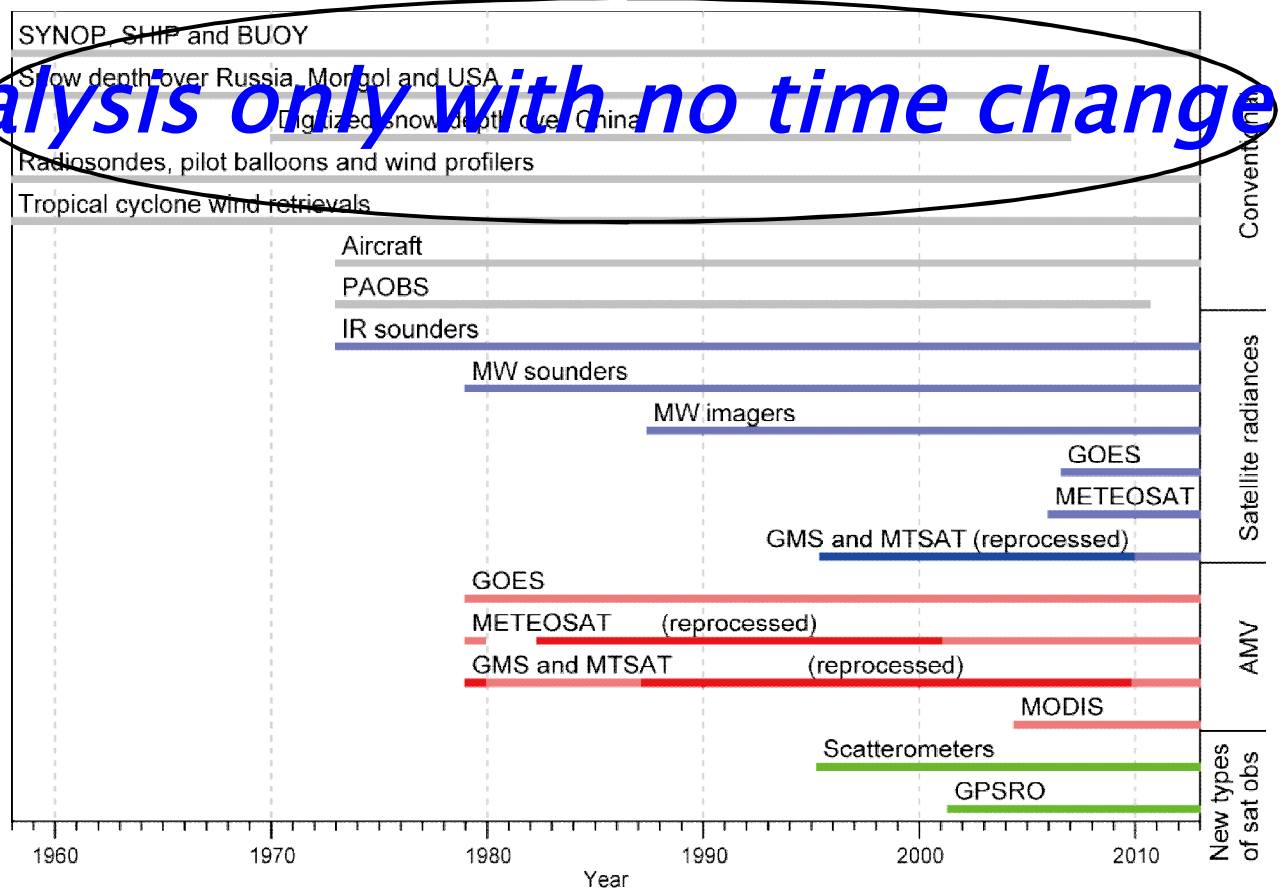
Utilized in JRA-55, but no use in JRA-25JRA-25/JCDAS

JRA-55C

Reanalysis for climate change research

- *S/N of conventional reanalysis is too large to study climate change.*
- *This is due to the dependency of reanalysis on observations (Satellite).*
- *Reanalysis specialized in climate change study.*
- *Only with no time change observations (SYNOPs, TEMPs)*

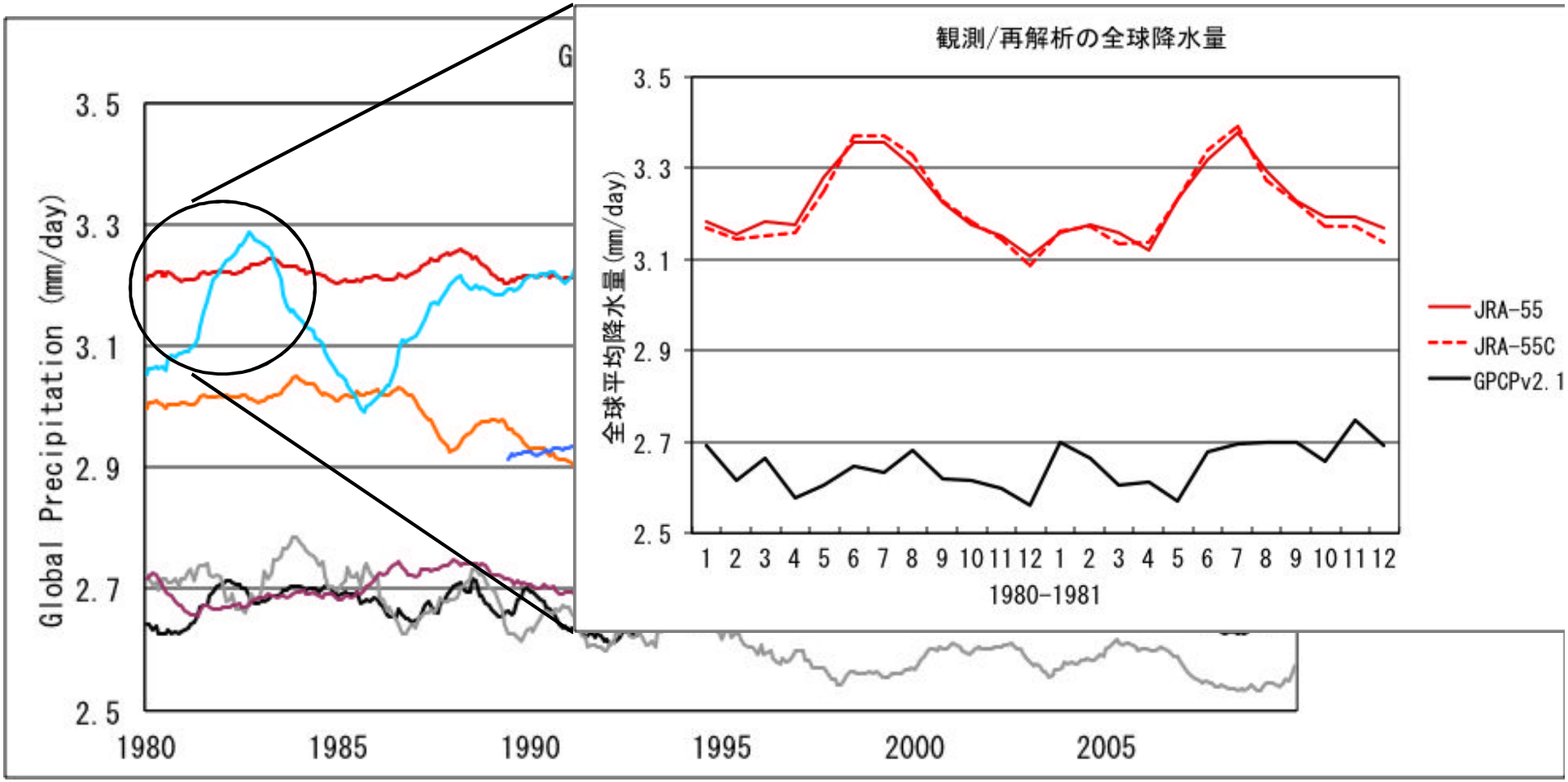
Reanalysis only with no time change Obs.



JRA-55C

Progress of the calculation

Global mean precipitation (12 month running mean)



Summary

- What is “Data Assimilation”?
- Importance of Data Assimilation to NWP systems
- MRI Research Projects on Data Assimilation
- Significance of Upper-Air Sonde Observation for Data Assimilation & Reanalysis