Report from the Sixth WMO Workshop on the Impact of Various Observing System on NWP

Lars Peter Riishojgaard, WMO

Scientific Organizing Committee:

Erik Andersson, Co-Chair, ECMWF; Yoshiaki Sato, Co-Chair, JMA
Carla Cardinali, ECMWF; John Eyre, Met Office; Ron Gelaro, NASA
Jianjie Wang, CMA; Jochen Dibbern (DWD)
Thibaut Montmerle; Météo-France
Lars Peter Riishojgaard, WMO; Wenjian Zhang, WMO

WEATHER CLIMATE WATER
TEMPS CLIMAT EAU

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WMO Workshops on the Impact of Various Observing Systems on NWP

- 1st – Geneva, 1997
- 2nd – Toulouse, 2000
- 3rd – Alpbach, 2004
- 4th – Geneva, 2008
  - http://www.wmo.int/pages/prog/www/OSY/Reports/NWP-4_Geneva2008_index.html
- 5th – Sedona 2012
  - http://www.wmo.int/pages/prog/www/OSY/Reports/NWP-5_Sedona2012.html
- **6th – Shanghai, May 10-13 2016**
  - http://www.wmo.int/pages/prog/www/WIGOS-WIS/reports/6NWP_Shanghai2016/WMO6-Impact-workshop_Shanghai-May2016.html

Extremely important for WIGOS due to their role in the WMO Rolling Review of Requirements, WMO Impact Workshops bring together major NWP centers, research community and other stakeholders to discuss the contribution to forecast skill of various WIGOS/GOS elements; guidance to participants provided well in advance of Workshop

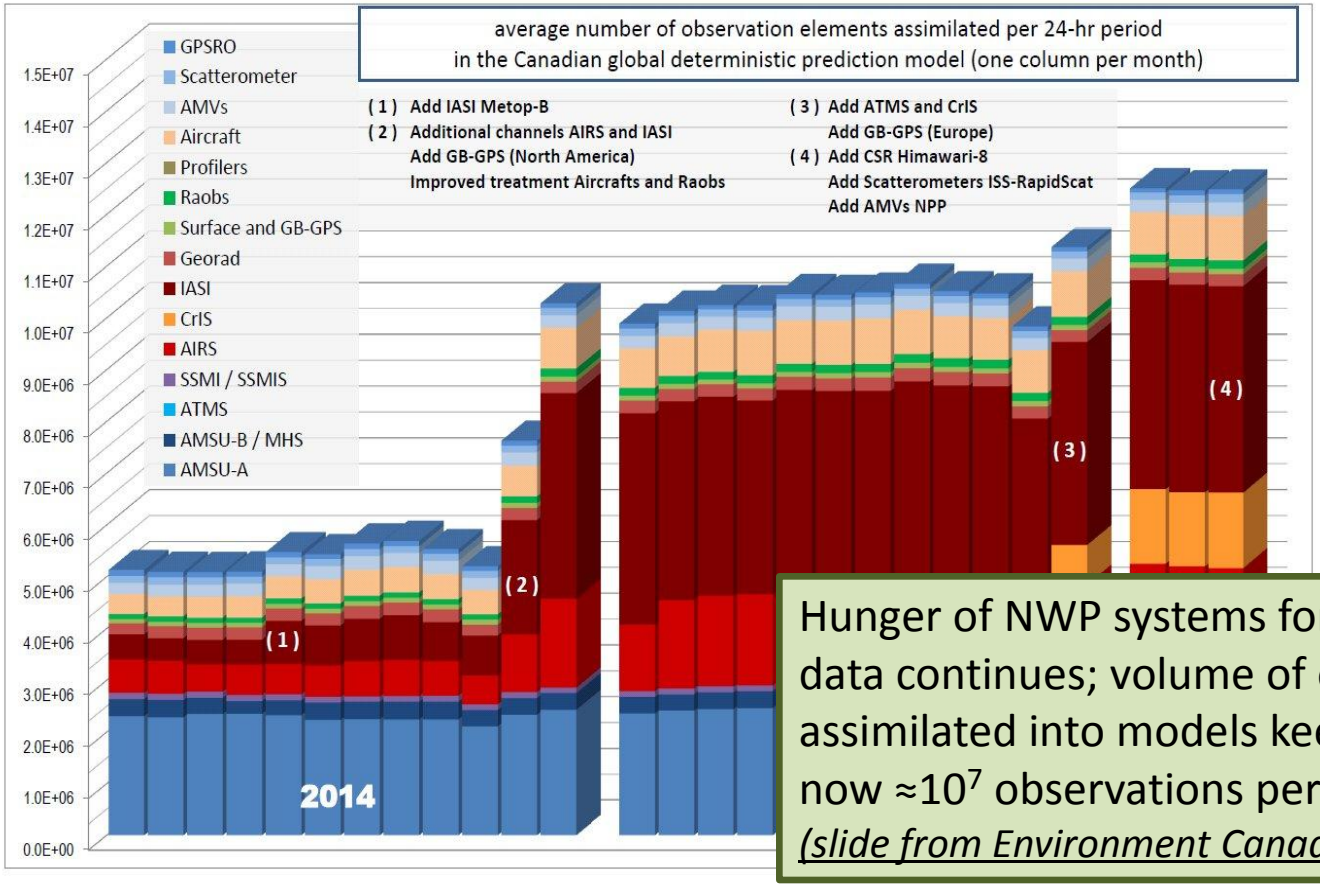
Science Questions for Shanghai

(distributed to participants 18 months ahead of the Workshop)

- **S1Marine**: Surface pressure over ocean
- **S2AMDAR**: Coverage of AMDAR
- **S3Radar**: Radar observations *(impact)*
- **S4Strat**: In situ observations of the stratosphere *(requirements)*
- **S5PBL**: Observations of the PBL for regional and high resolution NWP *(requirements)*
- **S6SatLand**: Satellite sounding over land and ice *(methodology and impact)*
- **S7Sounders**: Impact of multiple satellite sounders *(orbital spacing, question of redundancy)*
- **S8AMVs**: Atmospheric Motion Vectors *(impact and product generation)*
- **S9UA**: Regional upper-air network design studies *(including radiosonde launch schedules)*
- **S10AdjEns**: Application of adjoint and ensemble methods *(impact assessment methodology)*
- **S11Ocean**: Impact in ocean coupled assimilation *(no such studies presented)*
- **S12Land**: Impact in land coupled assimilation
- **S13** Time frequency What is the required time frequency of observations?
- **S14** Atmospheric composition *(impact and observational data requirements)*
- **S15** OSSEs Observing system simulation experiments *(future satellite systems, orbit configuration scenarios, etc)*

A FEW SAMPLE RESULTS FROM SHANGHAI

Daily data volumes (assimilated)



13 M/day

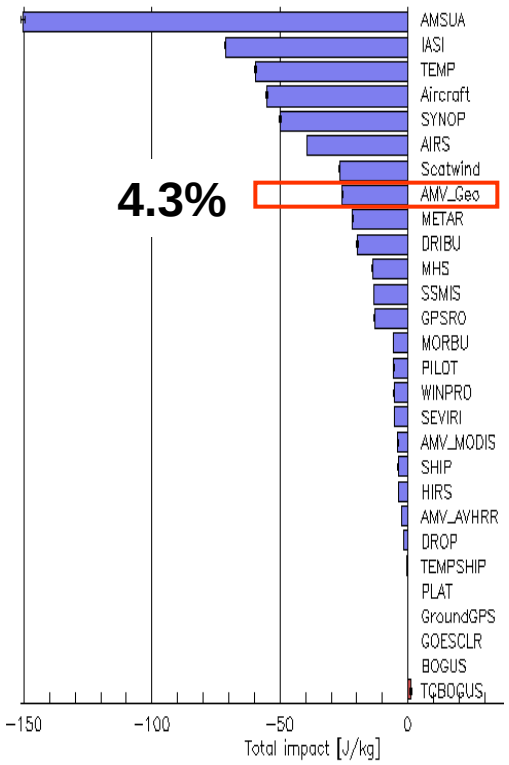
Hunger of NWP systems for observational data continues; volume of observations assimilated into models keeps increasing; now ≈10^7 observations per day
(slide from Environment Canada)

AMSU-A: NOAA 15-18-19, METOP A/B, AQUA; AIRS & IASI A/B: 142 channels each, CrIS: 103 channels.

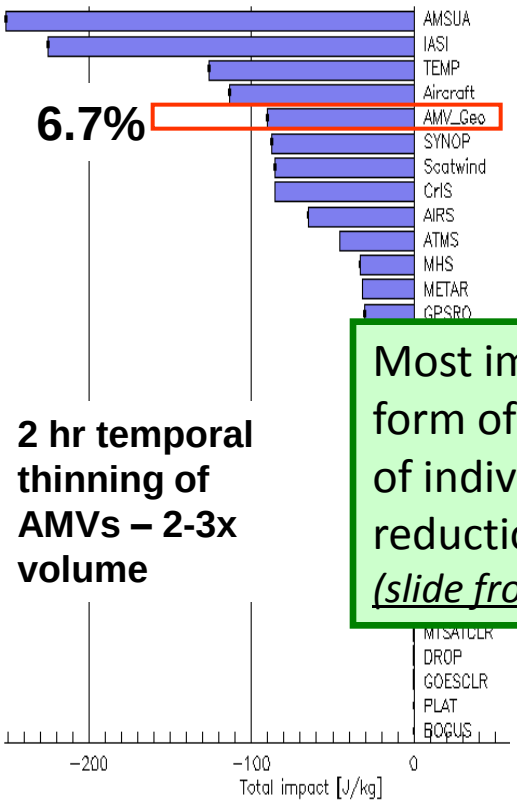
Impact on 24h forecast error (FSOI)

Increasing FSOI as more AMV data assimilated

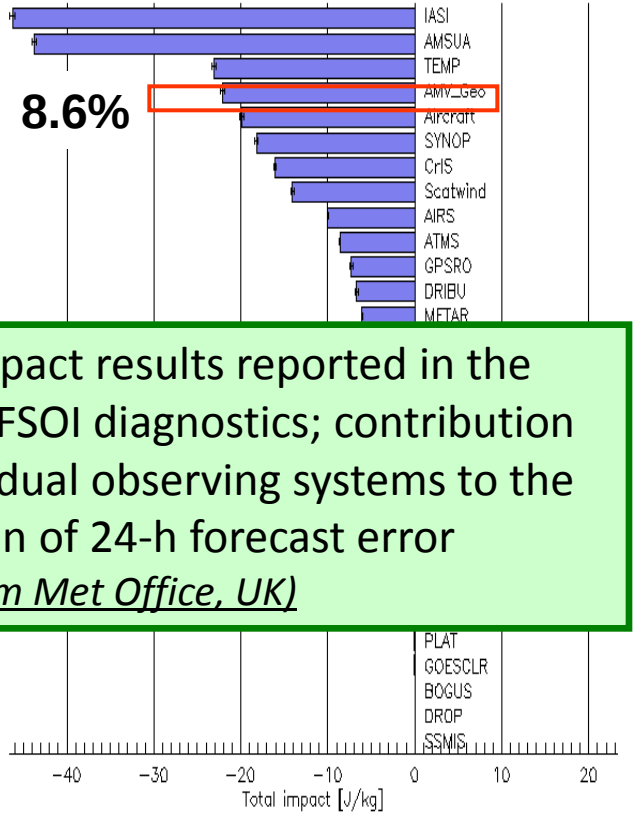
Jan-Mar 2012



Apr-July 2013



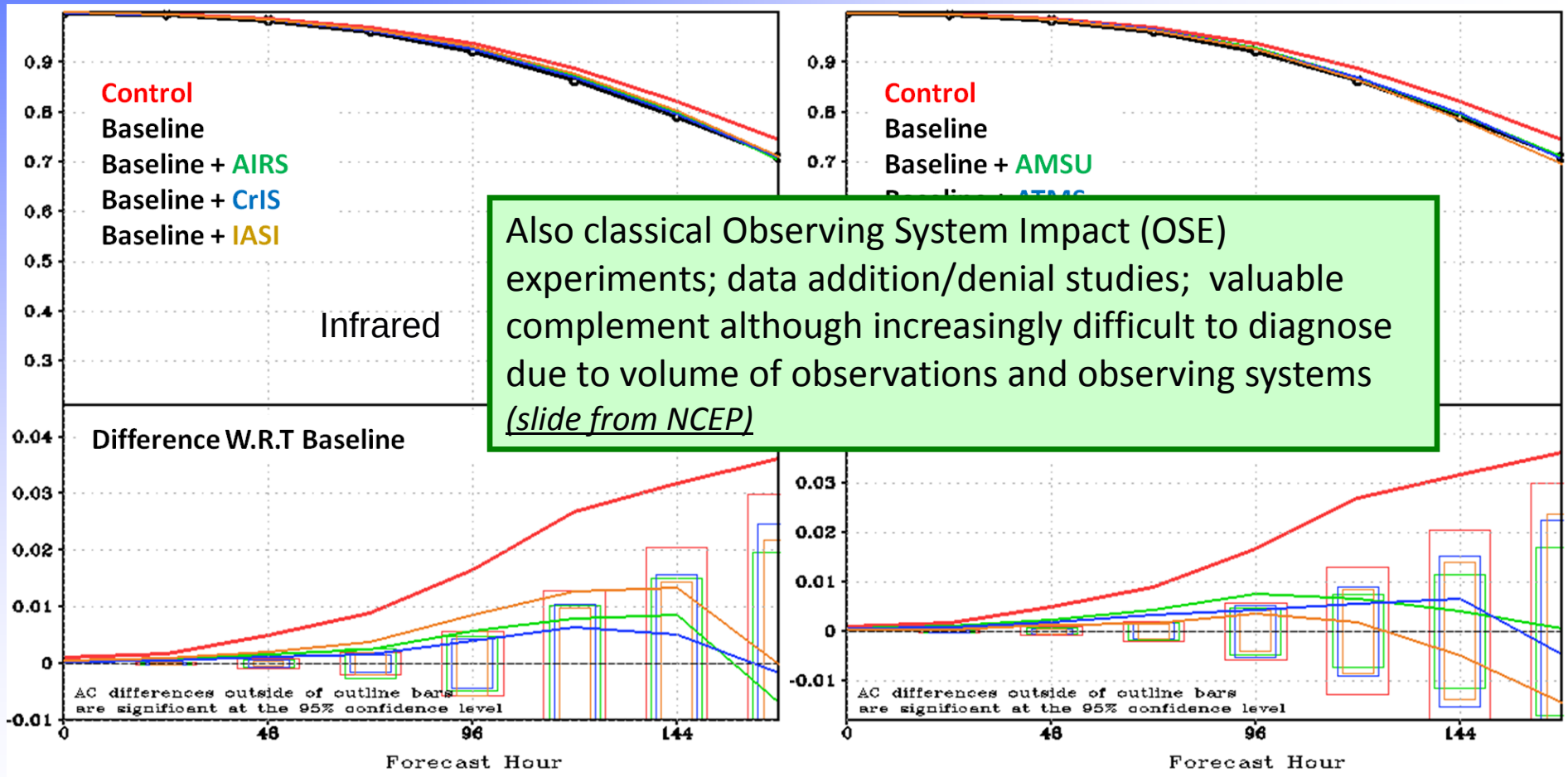
May 2014



Most impact results reported in the form of FSOI diagnostics; contribution of individual observing systems to the reduction of 24-h forecast error *(slide from Met Office, UK)*

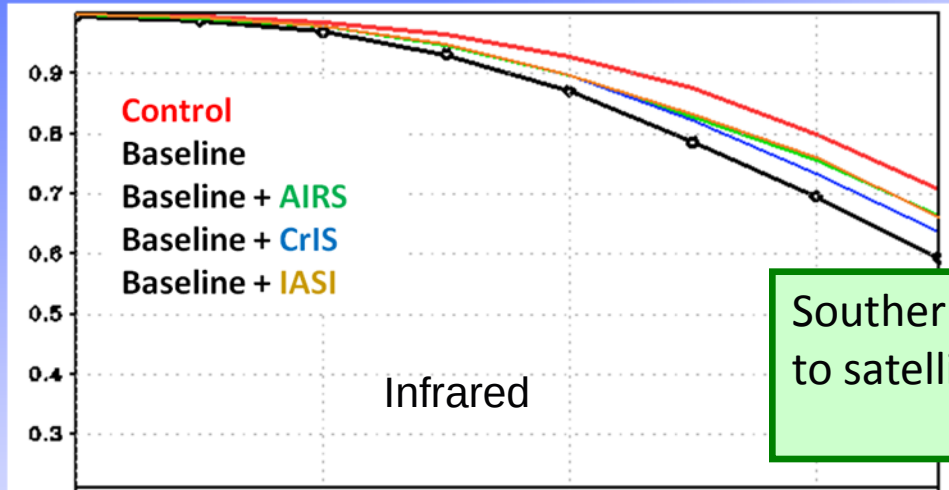
Contributions to the total observation impact on a moist 24-hour forecast-error energy-norm, surface-150 hPa (Richard Marriott and James Cotton)

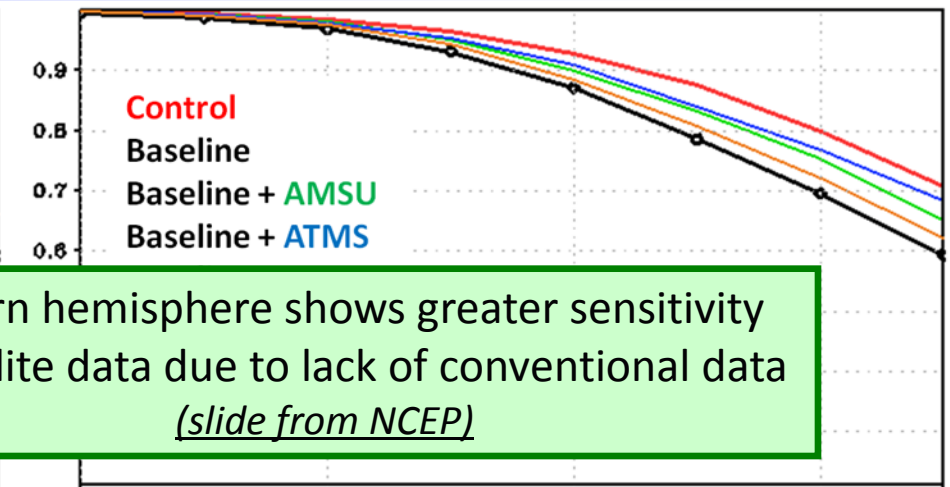
500 hPa Northern Hemisphere AC scores for 20140101 – 20140131 00Z



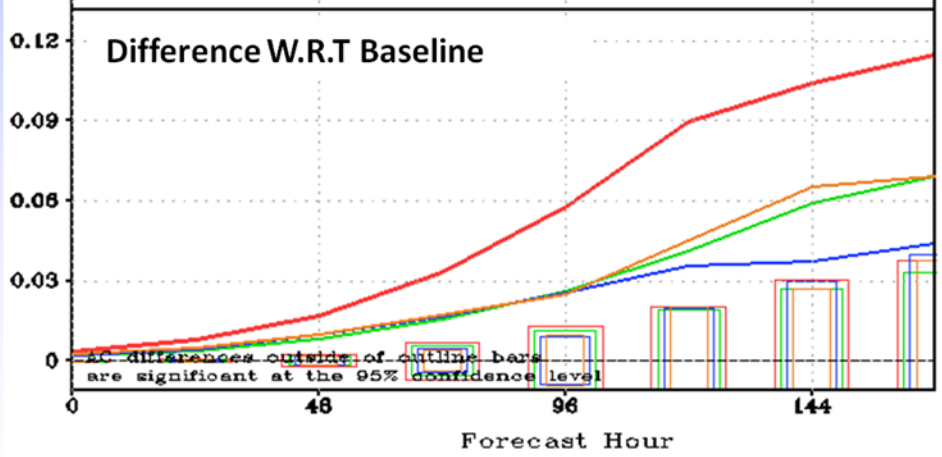
Also classical Observing System Impact (OSE) experiments; data addition/denial studies; valuable complement although increasingly difficult to diagnose due to volume of observations and observing systems *(slide from NCEP)*

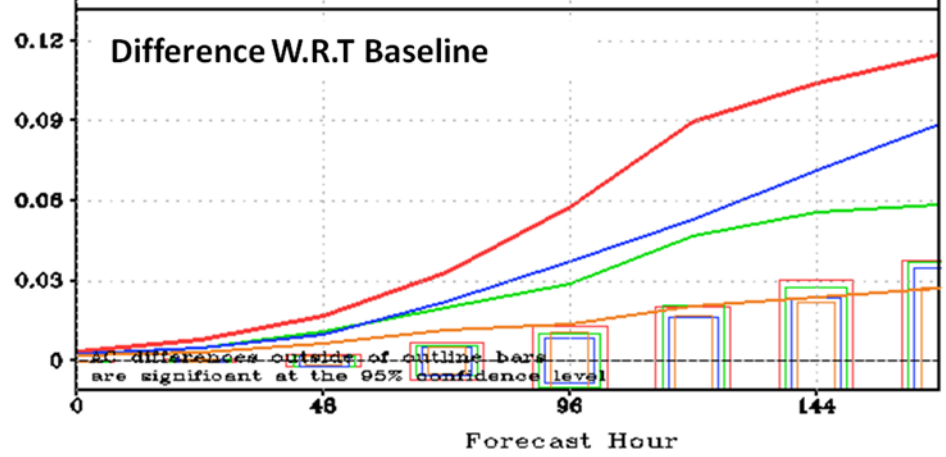
500 hPa Southern Hemisphere AC scores for 20140101 – 20140131 00Z





Southern hemisphere shows greater sensitivity to satellite data due to lack of conventional data *(slide from NCEP)*





Observation fits – global

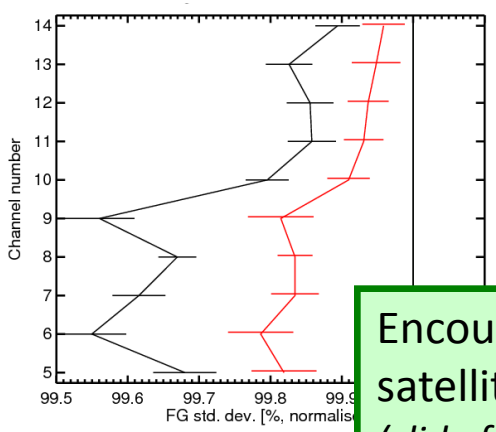
Normalised change in std. dev. of FG dep.

All-sky microwave WV

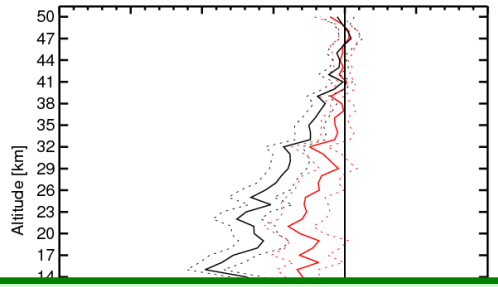
Clear-sky microwave WV

100% = control (no microwave WV)

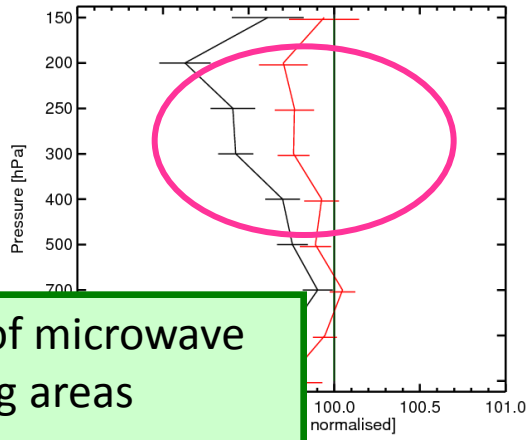
AMSU-A



GPSRO



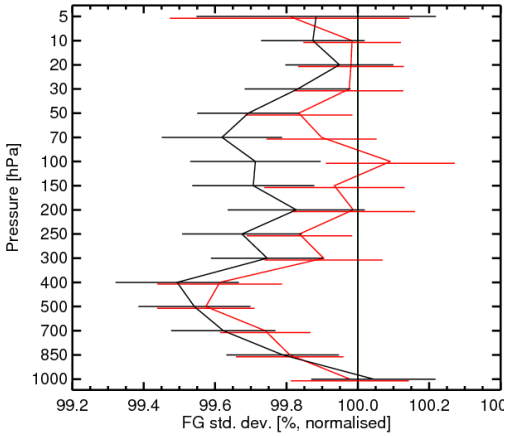
SATOB (AMVs)



Encouraging progress in the assimilation of microwave satellite data over cloudy and precipitating areas

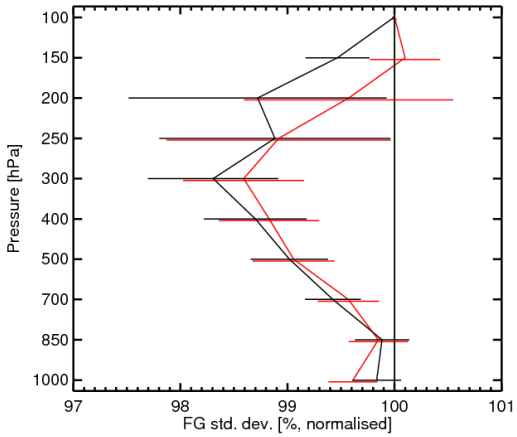
(slide from ECMWF)

Radiosonde T



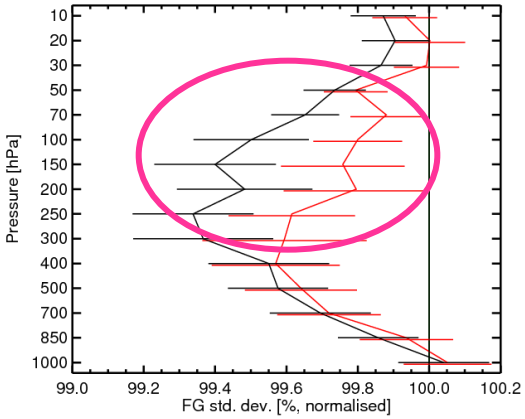
Improvement

Radiosonde q



Improvement

Conventional wind



Improvement

ECMWF

Mean daily precipitation pattern from June to August 2013~2014

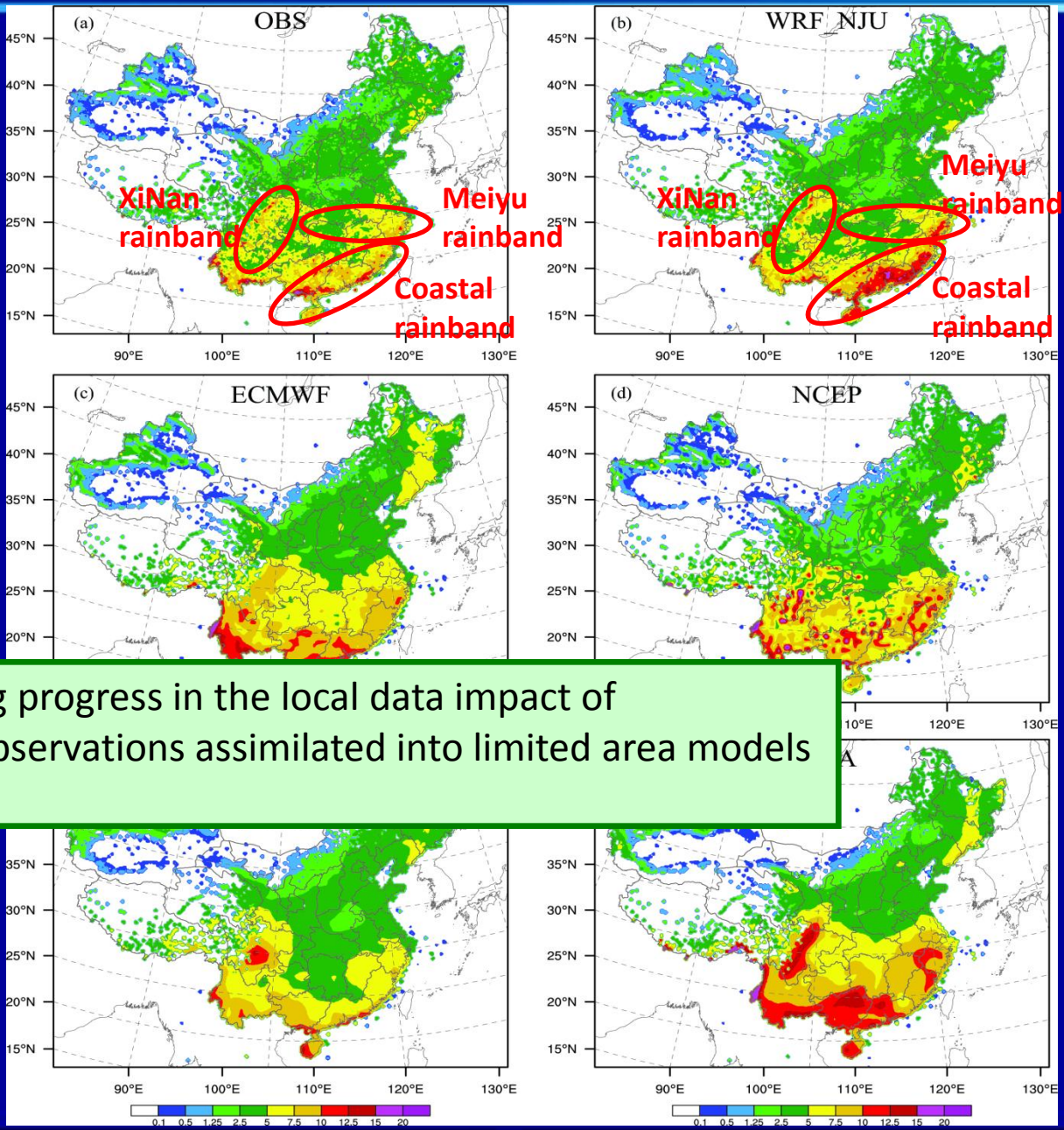
OBS

WRF_NJU

ECMWF

NCEP

CMA



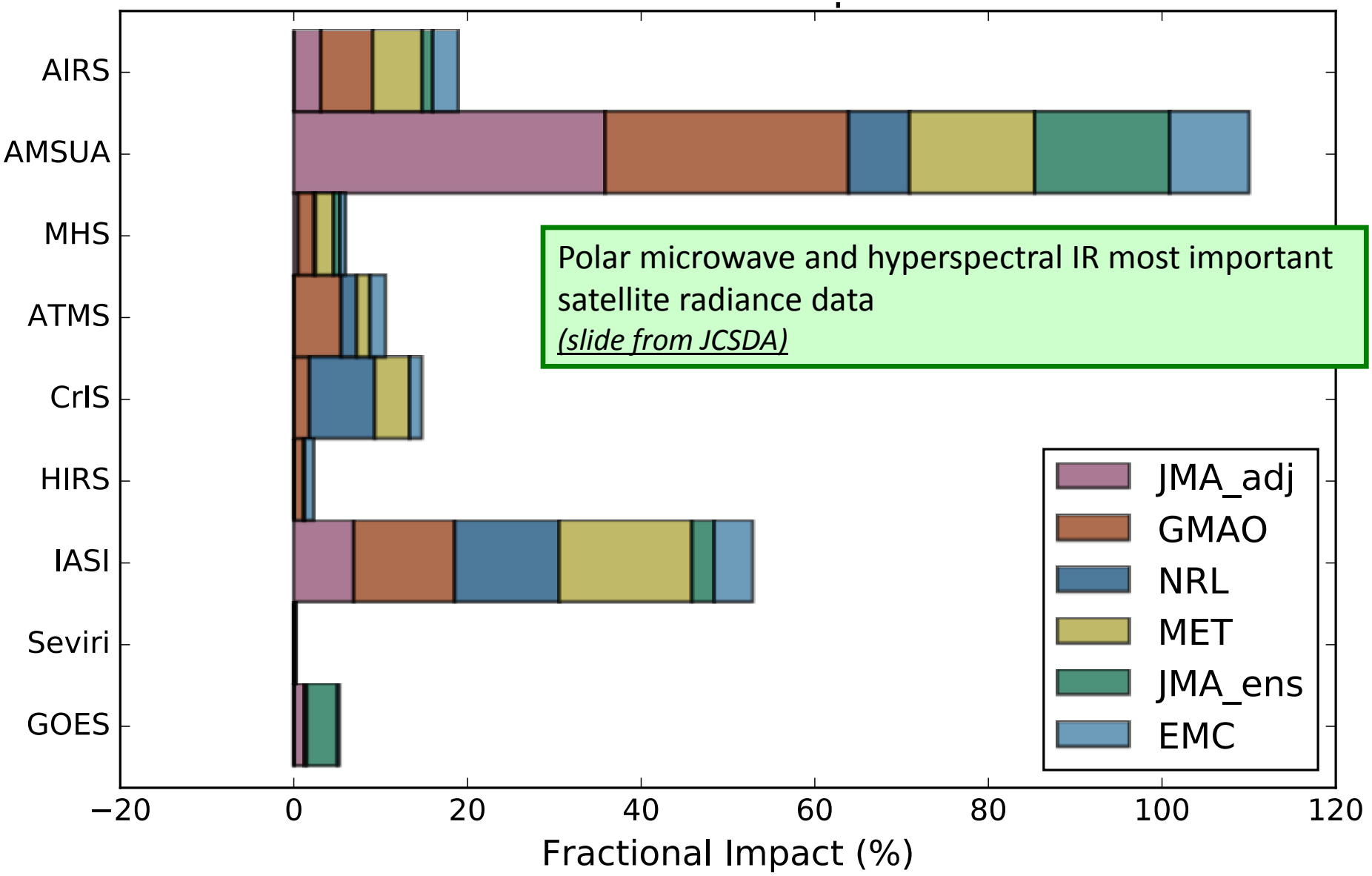
Very encouraging progress in the local data impact of (conventional) observations assimilated into limited area models *(slide from CMA)*

Forecast Sensitivity - Observation Impact (FSOI) Inter-comparison Experiment

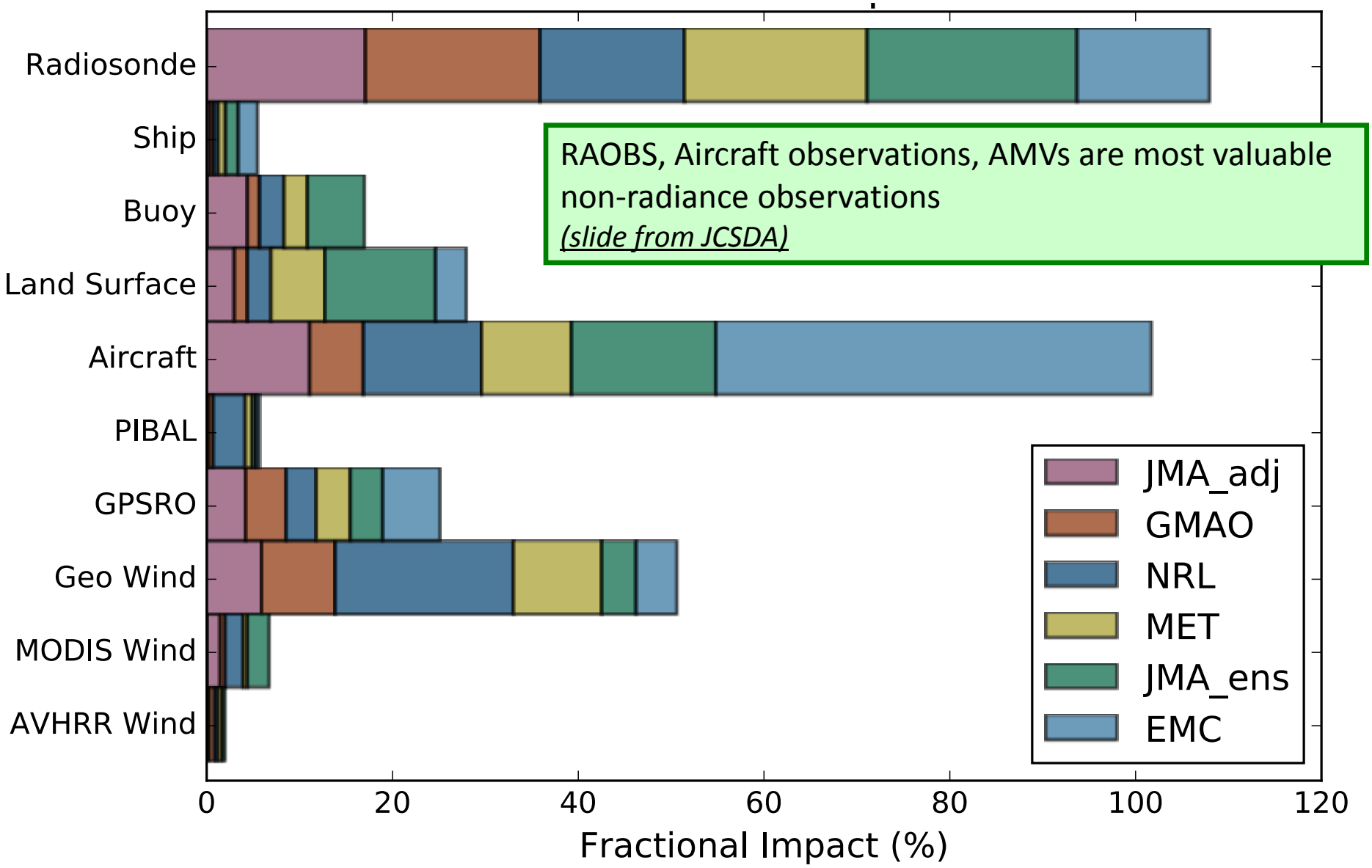
Tom Auligné, Joint Center for Satellite Data Assimilation (JCSDA)
Ron Gelaro, NASA, Global Modeling and Assimilation Office (GMAO)
Rahul Mahajan, David Groff, NOAA, National Weather Service (NWS)
Rolf Langland, Naval Res
Jianjun Liu, NOAA's Satel
James Cotton, Larry Mor
Yoichiro Ota, Japan Mete

Coordinated data impact studies by multiple NWP centers using same observing system classification and same diagnostics; direct result of OPAG-IOS guidance!
(slide from JCSDA)

Fractional Impact at 00UTC: **Satellite Radiances**



Fractional Impact at 00UTC: **Other Observations**



Key messages from Shanghai

- Less evidence of resilience/robustness/redundance of the overall Global Observing System than reported at the 5th Workshop in Sedona in 2012
  - Addition of observations almost always leads to improvements in skill
  - Addition of observations from secondary (operational back-up) satellites often leads to significant improvement in skill beyond the baseline achieved using the primary satellites
  - Positive impact now also of some sensors for which this was difficult to demonstrate in the past (e.g. scatterometers, wind profilers, MISR winds, …)
  - Regional/mesoscale/convective scale data assimilation and NWP has made significant progress in the direct use of observational data

Formal output from the 6th WMO Impact Workshop

- Final Report from the Workshop has now been published as a WIGOS Report, and it includes
  - Brief (10-page) Summary Report, ***including 23 formal recommendations***, mostly addressed to
    - WMO (Commission for Basic Systems)
    - Space agencies (CGMS)
    - Numerical Weather Prediction community
  - All oral presentations from the meeting
  - All poster presentations (many authors did not deliver these)

The summary and recommendations are available in CGMS-45-WMO-WP-02, full Workshop report at:

Sixth WMO Impact Workshop; Report and Presentations

Some satellite-related key points from the report

- *"In terms of the most important observing systems contributing to forecast skill of global NWP models, the top five system were, in no particular order,* ***microwave sounders (AMSU-A, ATMS), hyperspectral infrared sounders (AIRS, IASI, CrIS), radiosondes, aircraft data and atmospheric motion vectors (AMVs)****."*
- ***"So-called secondary (or back-up) satellites within a given orbital plane have a substantial impact on sk****ill – their data are thus not redundant with those provided by the primary satellites;"*
- ***"One area showing very significant improvement was the use of microwave radiances affected by cloud and precipitation, i.e. all-sky radiance assimilation****. This has been made possible by much improved modelling of radiative transfer in these situations, especially in the water vapor absorption band at 183 GHz."*
- ***"Several new satellite data types have entered operational assimilation during the past four years, all with positive impacts.*** *Among them are: MetOp-B (in addition to MetOp-A); CrIS and ATMS on Suomi-NPP; Megha-Tropiques/SAPHIR (microwave sounder in low-inclination orbit); ISS Rapidscat (scatterometer in low-inclination orbit); FY-3C/MWHS-2 183 and 118 GHz channels; GCOM-W/AMSR-2; GPM-core/GMI; LEO-GEO AMVs."*

Key points from the report (II)

- *"**The positive direct impact of GNSS-RO data on global NWP skill was confirmed**, as well as the indirect impact of these data through their contribution to bias correction of radiance data from other satellite sensors."*
- ***"The Workshop took note of the current development in the space sector regarding commercial data providers** proposing to put privately funded GNSS-RO constellations in space with an aim to sell these observations to national governments, and it was emphasized that unless the data are procured with a clear aim to continue respecting existing principles on international data sharing, these data will not be fully utilized,"*
- *" **Several presenters demonstrated that assimilating observations at increased temporal resolution improved short to medium range forecast skill**. This was assumed to be at least in part caused by a significant increase in the number of assimilated observations that are asynoptic in nature, e.g. satellite radiances, ground-based GPS, wind profiler data …"*

Key recommendations addressed to, or of relevance to, CGMS/Space Agencies

- ***Recommendation 2;*** *The constellation of scatterometers should be improved (better orbital spacing) in order to provide better spatial and temporal coverage. Generally the impact of adding observations in data void areas is significantly higher than the impact of adding additional data in areas where observations already exist.*
- ***Recommendation 3***; *NWP centers rely on high-quality level 1 data. Space agencies are encouraged to make every effort to improve the quality of their level-1 data, including via the Global Space-based Inter-Calibration System (GSICS)*
- ***Recommendation 4***; *Additional data impact studies for new AMV products (e.g. LEO-GEO winds, IR sounder winds, MISR winds) are strongly encouraged.*

Key recommendations (II)

- ***Recommendation 5***; *(first proposed by the IROWG and supported by this Workshop in slightly modified form); The deployment of an operational constellation of GNSS-RO satellites capable of providing at least 20,000 high quality soundings per day, at near-uniform global coverage and extending well into the lower troposphere is strongly recommended.*
- ***Recommendation 6***; *The CGMS space agencies operating GEO satellites are encouraged to continue the development and deployment of hyperspectral IR GEO sounders. Further studies of GEO MW sounders and imagers and their potential impacts are encouraged.*
- ***Recommendation 10***; *All data providers are encouraged to continue to share all observations internationally, especially those observations that are essential for numerical weather prediction, e.g. all GNSS-RO soundings.*

Next steps

- Relevant Recommendations to WMO have been incorporated in Work Programs of CBS Expert Teams and other parts of WMO working structure.
- CGMS is invited to consider the recommendations made to it by the 6th Impact Workshop and to refer them to its Working Groups for further action where appropriate.
- EC-69 invited CBS to plan for a 7th WMO Impact Workshop in 2020;
  - CGMS Science Working Groups and member space agencies are invited to propose science

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TEMPS CLIMAT EAU

Thank you

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