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


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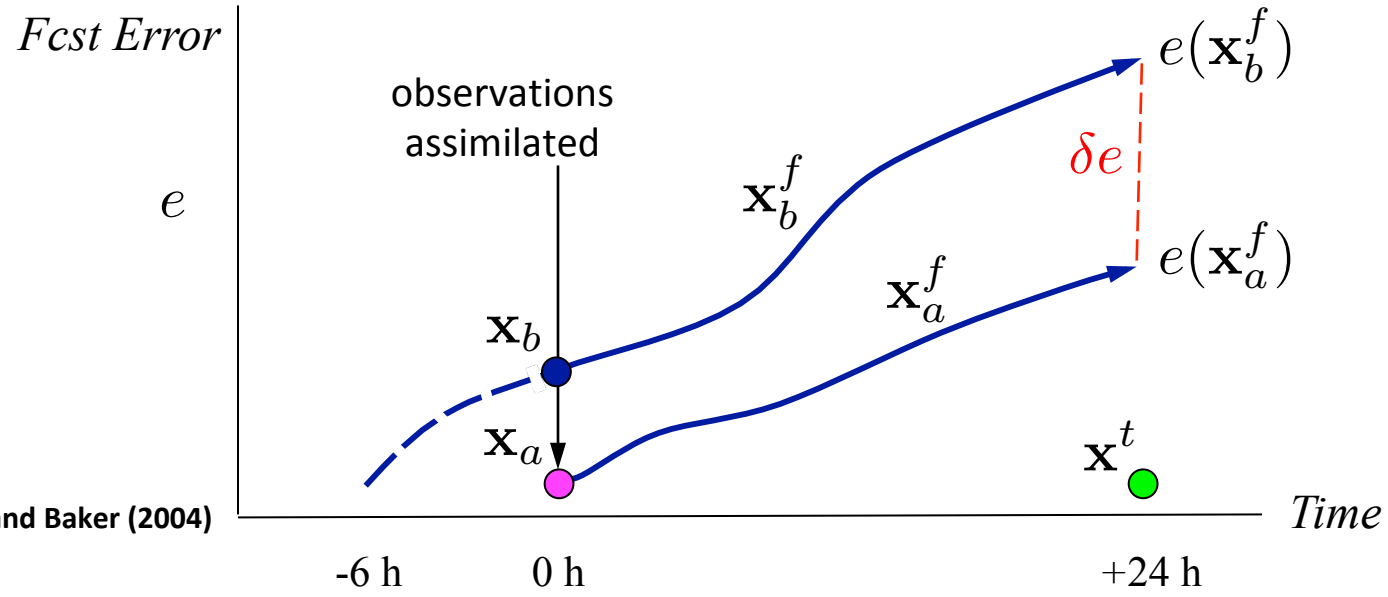
# Forecast Sensitivity – Observation Impact (FSOI)




Langland and Baker (2004)

**Adjoint-derived (single outer-loop) observation impact**

$$\delta e \approx \mathbf{d}^T \mathbf{K}^T \left[ \mathbf{M_b}^T e(x_b^f) + \mathbf{M_a}^T e(x_a^f) \right]$$

Langland and Baker (2004)

**Ensemble-derived observation impact**

$$\delta e \approx \mathbf{d}^T \mathbf{R}^{-1} \mathbf{L} \mathbf{H} \mathbf{X}_a^0 \mathbf{X}_a^{fT} \left[ e(x_b^f) + e(x_a^f) \right]$$

Ota et al. (2013)

# Motivation

- Several NWP centers are computing FSOI routinely to monitor/understand/tune their DA system.

- Are relative impact of various observation types comparable?
- Can we learn from similarities/differences to improve NWP systems?

- Multiple NWP Centers contributed to this study
  NRL, NASA/GMAO, NOAA/EMC, UK Met Office, Météo France, JMA

# Motivation (cont.)

- Multi-staged and multi-faceted set of experiments. Participants free to contribute commensurate with interests and capability.

- Initially a narrowly defined FSOI experiment—much in the mold of the previous THORPEX inter-comparison (*Gelaro et al. 2010*)

- **Original aspects**
  - Broader participation of NWP centers (Adjoint & Ensemble-based)
  - Latest global NWP systems
  - Operational (not baseline) observing network

- **Approach**
  - centrally collect FSOI output without aggregation of the data
  - Convert into common data structure
  - Flexibility to stratify information

# Experimental Design

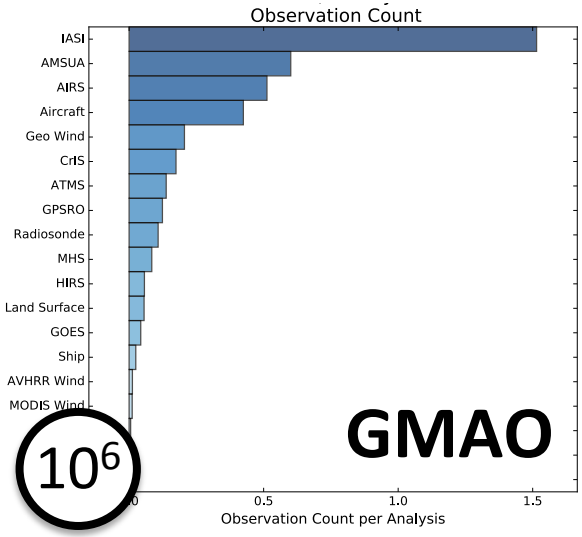
- **Time period**: 3-month DJF 2014-15 (JJA 2014) 00, 06, 12, 18UTC cycles
- **Verification**:  24h forecast against self analysis
- **Metric**: global total dry (moist) energy (surface-100hPa)
- **Adjoint**: dry (plus moist physics, as available)
- **Ensemble**: flow-following localization

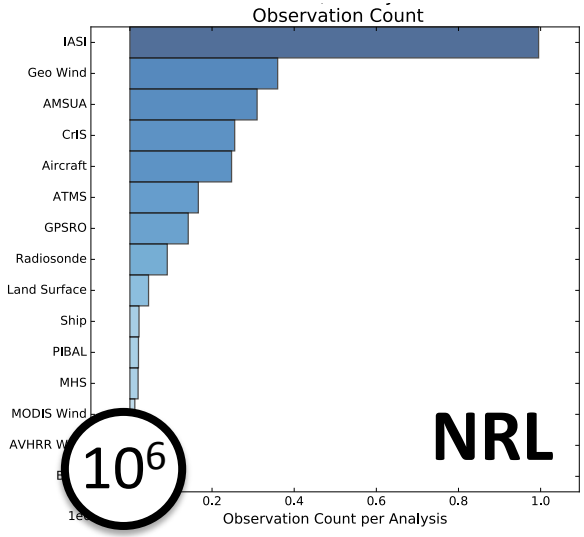
# Participating NWP Centers

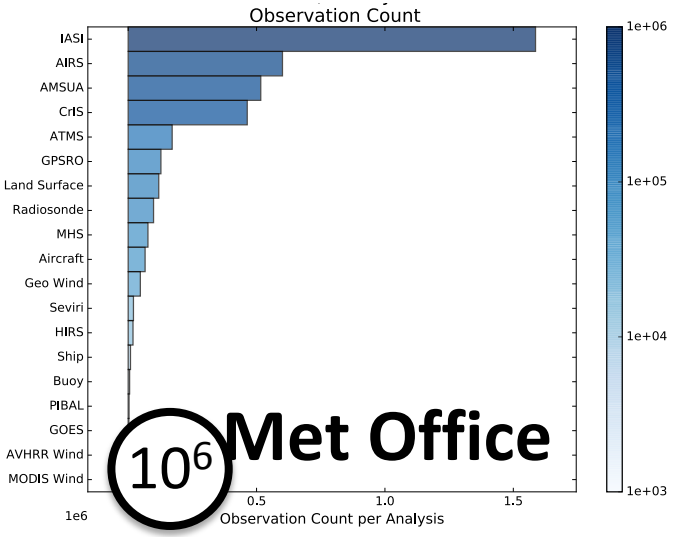
| NWP Centers | NRL | GMAO | Met Office | Météo France | JMA Adjoint | JMA Ensemble | EMC |
|---|---|---|---|---|---|---|---|
| **Analysis System** | 3DVar In Observation Space | Hybrid 3DVar | 4DVar | 4DVar | 4DVar | LETKF re-centered via 4DVar | EnKF re-centered via 4DEnVar |
| **FSOI Technique** | **Adjoint** | **Adjoint** | **Adjoint** | **Adjoint** | **Adjoint** | **Ensemble** | **Ensemble** |
| **Experiment Resolution** | T119L60 | Model: 25km<br>DA: 50km<br>Ens: 100km | Model N320 (40km)<br>Adjoint N216 (60km) | Model: 17km<br>DA: 40km<br>Adjoint: 120km | Model: TL959L100<br>Adjoint: TL319L100 | Ensemble (x50) TL319L100 | T670 Control / T254 Ensemble (x80) |
| **Specific Information** | | QC = channel selection + dynamical | ~30% cycles discarded due to spurious | | | | Additional thinning of observations especially |

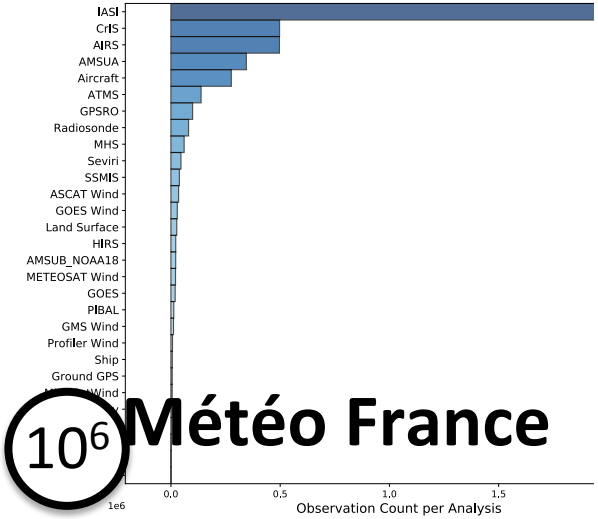
| COMMON | GMAO | NRL | UK Met Office | Météo France | JMA | EMC |
|---|---|---|---|---|---|---|
| | TCBogus | TCBogus | TCBogus | | TYBOGUS | TCBogus |
| Radiosonde | Radiosonde | Radiosonde | Radiosonde | Radiosonde | RADIOSONDE | Radiosonde |
| Dropsonde | Dropsonde | Dropsonde | Dropsonde | | | |
| Marine | Ship<br>Moored_Buoy<br>Drifting_Buoy | Ship<br>Moored_Buoy<br>Drifting_Buoy | Ship<br>Moored_Buoy<br>Drifting_Buoy<br>Platform_Buoy | SHIP<br>Drifting_Buoy | SHIP<br>BUOY | Mobile_Marine_Surface<br>Moored_Buoy |
| Land | Land_Surface<br>METAR | Land_Surface | SYNOP<br>METAR | SYNOP<br>RADOME | SYNOP | Land_Surface |
| Aircraft | AIREP<br>ASDAR<br>MDCARS | AIREP<br>AMDAR<br>MDCARS<br>MIL_ACARS | Aircraft | AIREP<br>AMDAR<br>ACARS | AIRCRAFT | Aircraft |
| GPSRO | GPSRO | GPSRO | GPSRO | GPSRO | GNSSRO | GPSRO |
| AVHRR Wind | AVHRR_Wind | AVHRR_Wind | AVHRR_Wind | AVHRR_NOAA15<br>AVHRR_NOAA16<br>AVHRR_NOAA18<br>AVHRR_NOAA19 | AMV-AVHRR | |
| MODIS Wind | MODIS_Wind | MODIS_Wind | MODIS_Wind | MODIS_TERRA<br>MODIS_AQUA | AMV-MODIS | |
| ASCAT Wind | ASCAT_Wind | ASCAT_Wind | ASCAT_Wind | ASCAT_Wind | SCATWIND? | ASCAT_Wind |
| NEXRAD Wind | NEXRAD_Wind | | | NEXRAD_Wind | | NEXRAD_Wind |
| Profiler Wind | Profiler_Wind | | Profiler_Wind | Profiler_Wind | PROFILER | Profiler_Wind |
| PIBAL | PIBAL | PIBAL | PILOT | PIBAL | PILOT | PIBAL |
| GEO Wind | Geo_Wind | Sat_Wind | Geo_Wind | Sat_Wind | AMV-GEOSTAT | Sat_Wind |
| LEO-GEO | | LEO-GEO | LEO-GEO | | AMV-LEOGEO | |
| AIRS Aqua | AIRS_AQUA | | AIRS_Aqua | AIRS_AQUA | AIRS_Aqua | AIRS281SUBSET_AQUA |
| AMSUA | AMSUA_AQUA<br>AMSUA_METOP-A<br>AMSUA_METOP-B<br>AMSUA_N15<br>AMSUA_N18<br>AMSUA_N19 | AMSUA_METOP-A<br>AMSUA_METOP-B<br>AMSUA_N15<br>AMSUA_N18<br>AMSUA_N19 | AMSUA_METOP-A<br>AMSUA_METOP-B<br>AMSUA_N15<br>AMSUA_N18<br>AMSUA_N19 | AMSUA_AQUA<br>AMSUA_METOP-A<br>AMSUA_METOP-B<br>AMSUA_N15<br>AMSUA_N18<br>AMSUA_N19 | AMSUA_Aqua<br>AMSUA_Metop-A<br>AMSUA_Metop-B<br>AMSUA_NOAA15<br>AMSUA_NOAA18<br>AMSUA_NOAA19 | AMSUA_AQUA<br>AMSUA_METOP-A<br>AMSUA_METOP-B<br>AMSUA_N15<br>AMSUA_N18<br>AMSUA_N19 |
| AMSUB | AMSUB_N18 | AMSUB_N18 | AMSUB_N18 | AMSUB_N18 | AMSUB_N18 | AMSUB_N18 |
| MHS | MHS_METOP-A<br>MHS_METOP-B<br>MHS_N18 | MHS_METOP-A<br>MHS_METOP-B<br>MHS_N18<br>MHS_N19 | MHS_METOP-A<br>MHS_METOP-B<br>MHS_N18<br>MHS_N19 | MHS_METOP-A<br><br>MHS_N18<br>MHS_N19 | MHS_Metop-A<br>MHS_Metop-B<br>MHS_NOAA18<br>MHS_NOAA19 | MHS_METOP-A<br><br>MHS_N18<br>MHS_N19 |

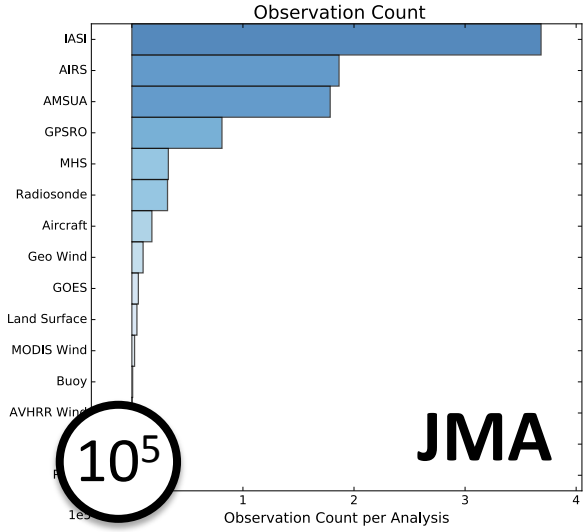
# Observation Counts

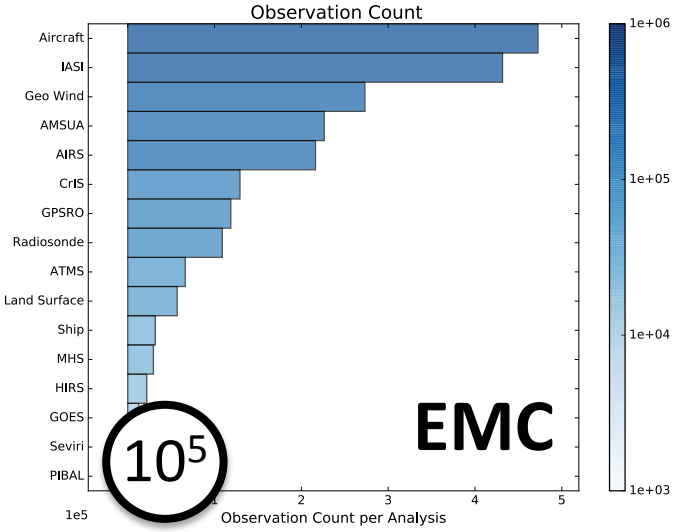


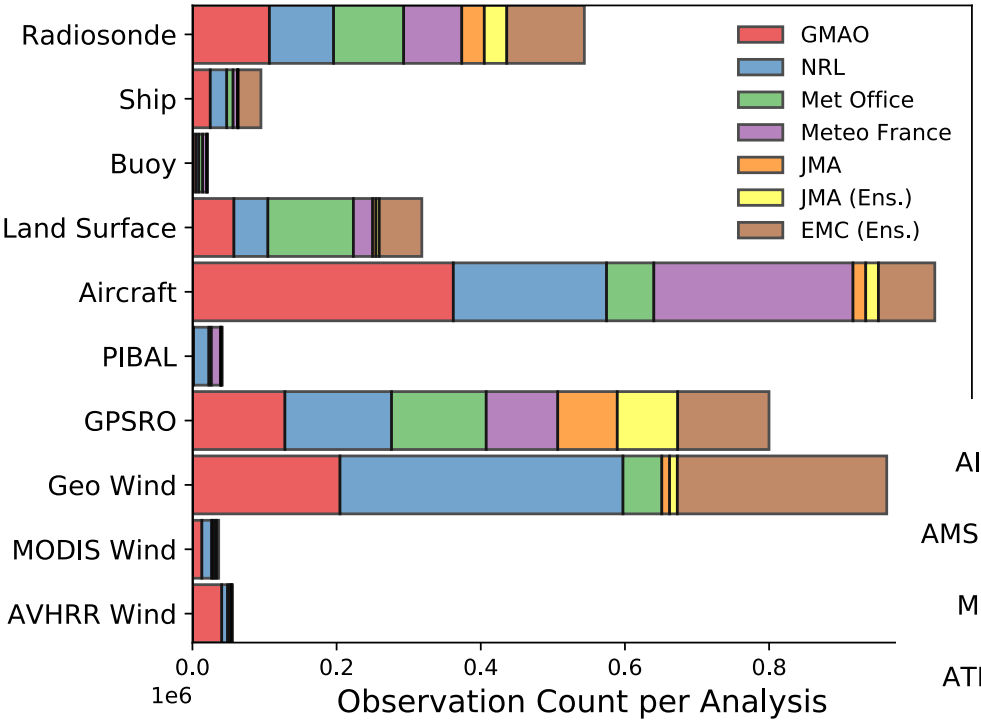



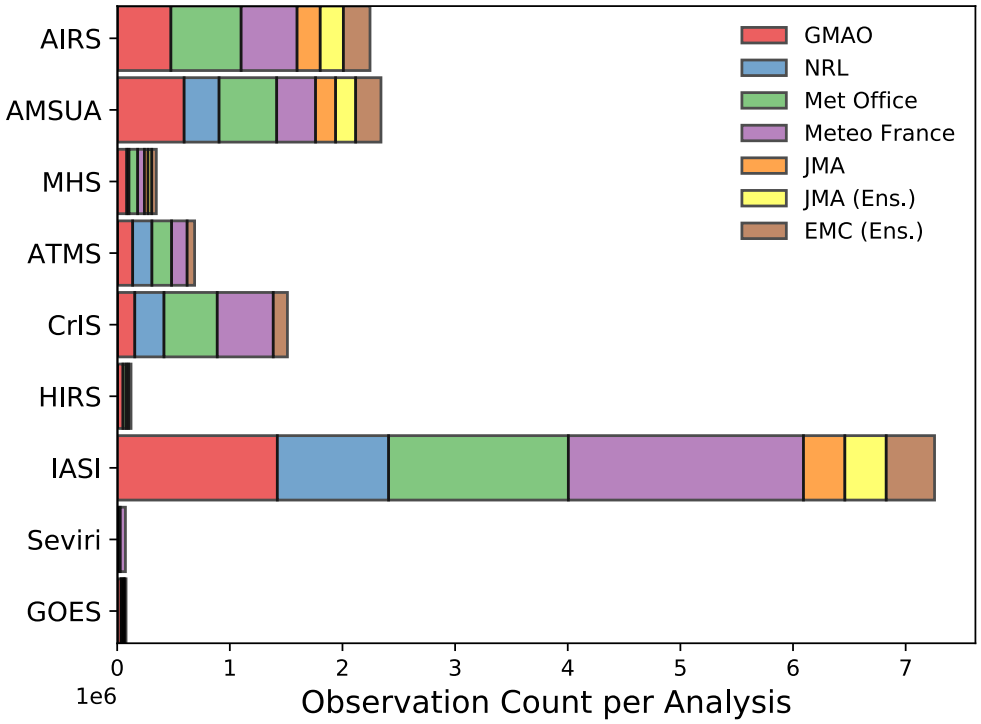



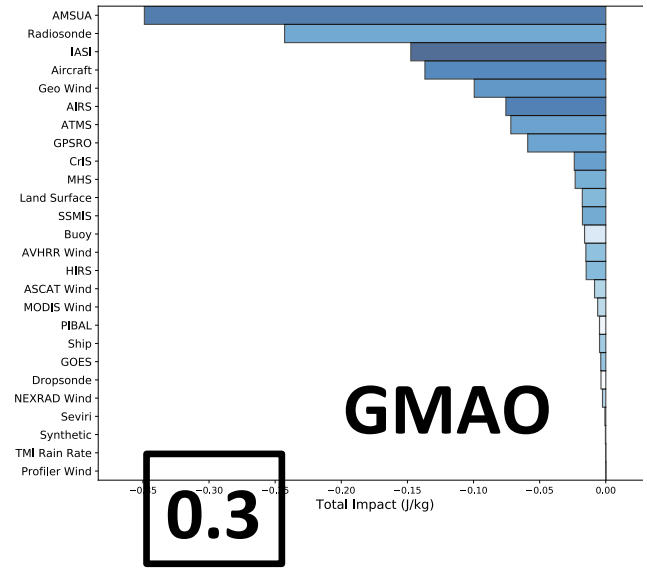



# Observation Counts



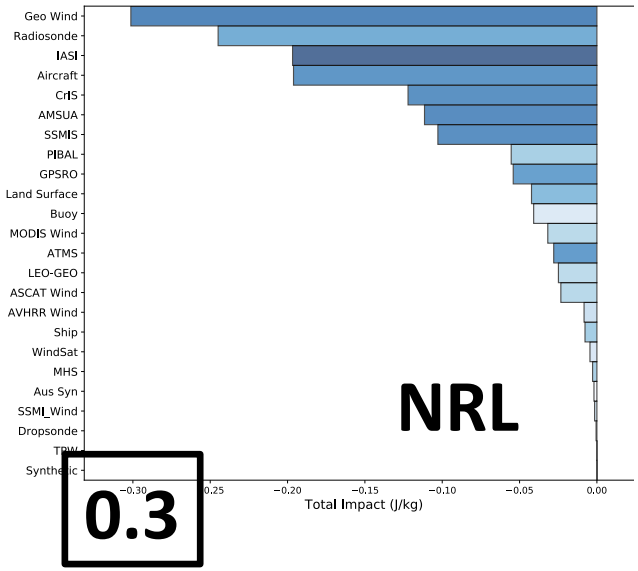



# Total Impact (J/kg): Adjoint-based



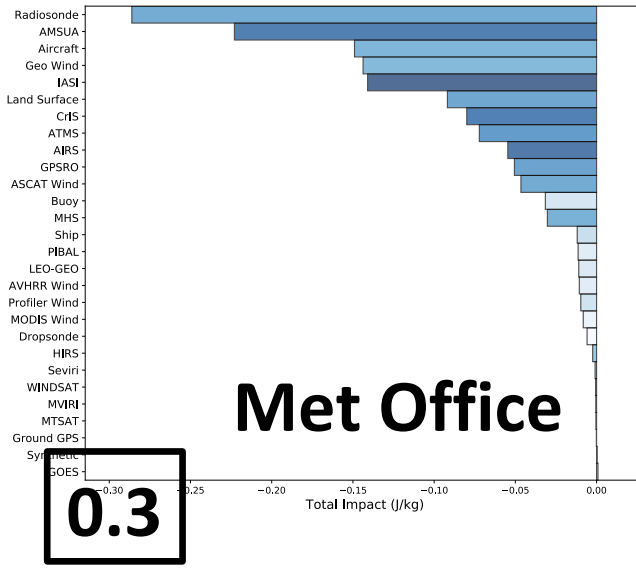

GMAO

0.3



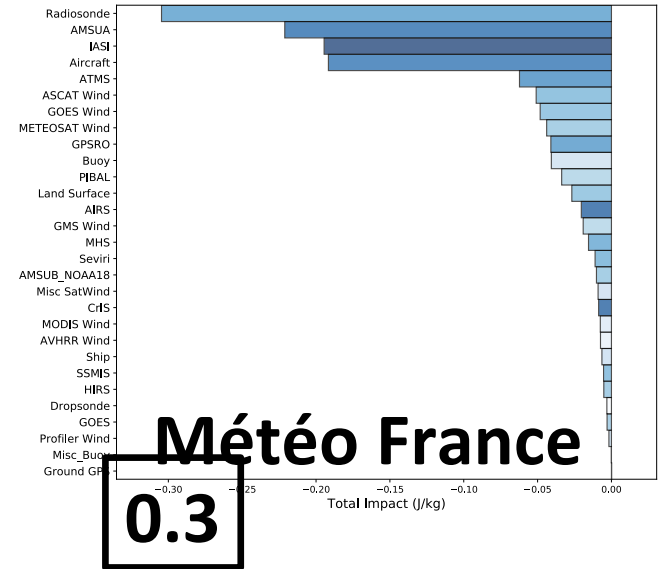

NRL

0.3



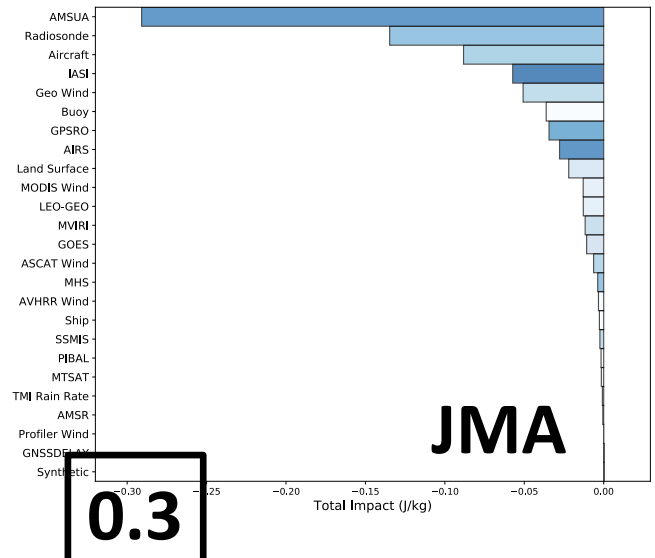

Met Office

0.3



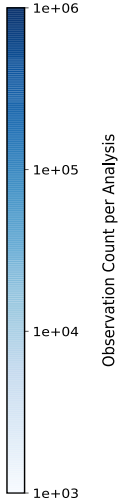

Météo France

0.3

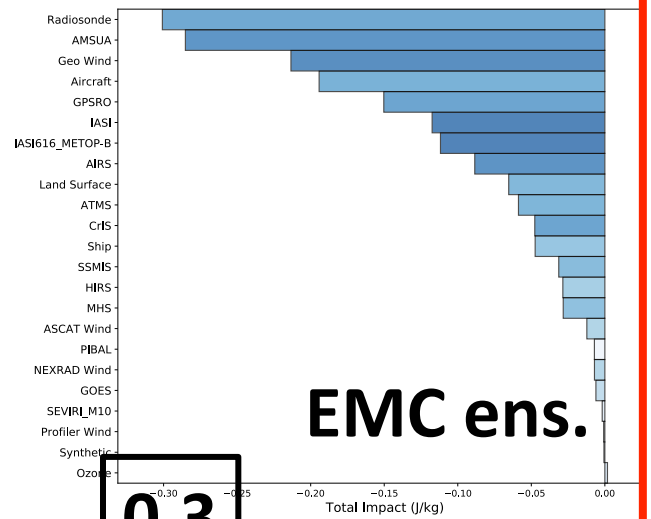



JMA

0.3

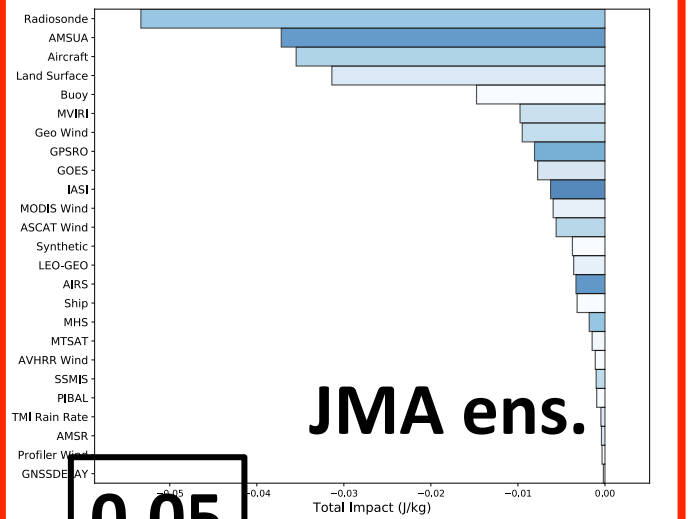


# Total Impact (J/kg): Ensemble-based



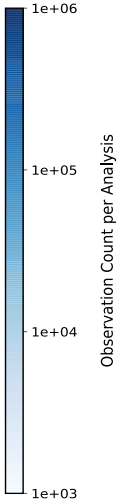

EMC ens.

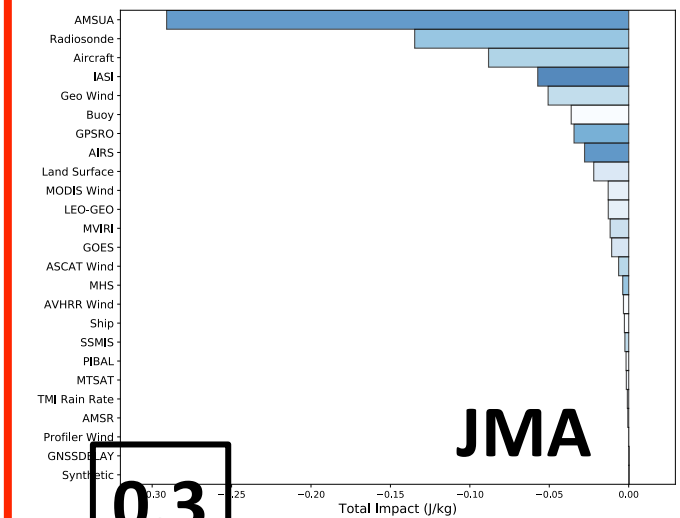
0.3




JMA ens.

0.05

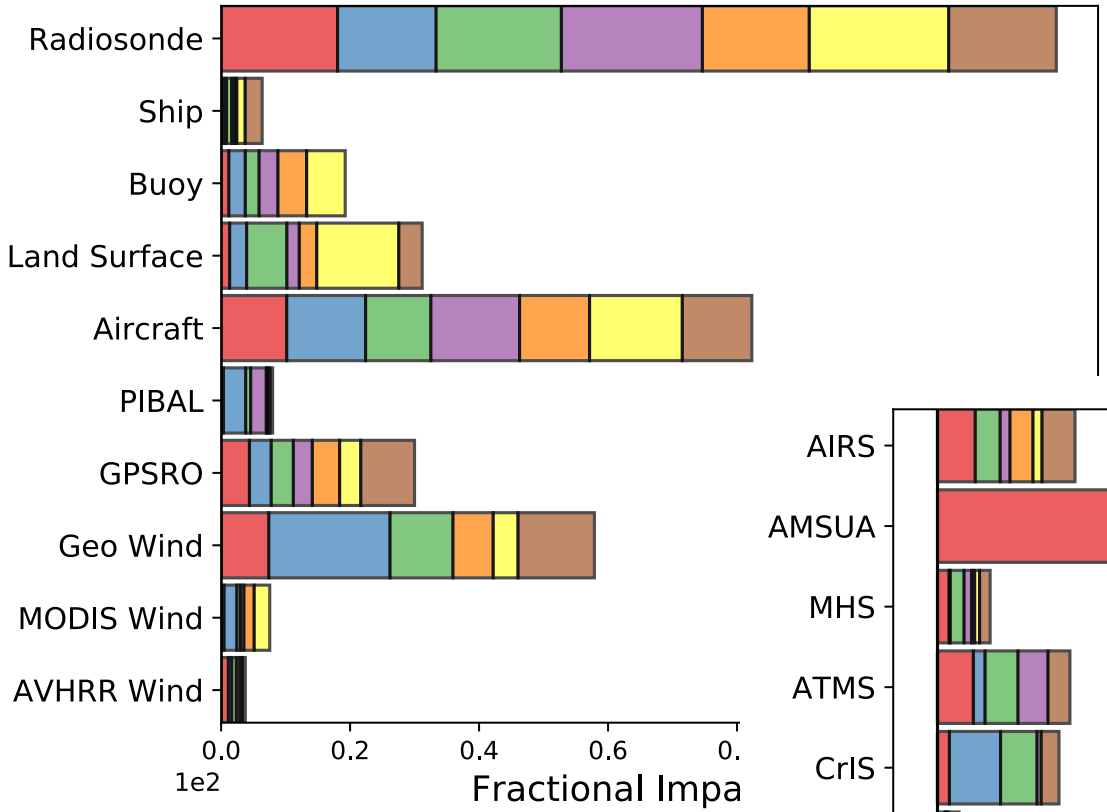


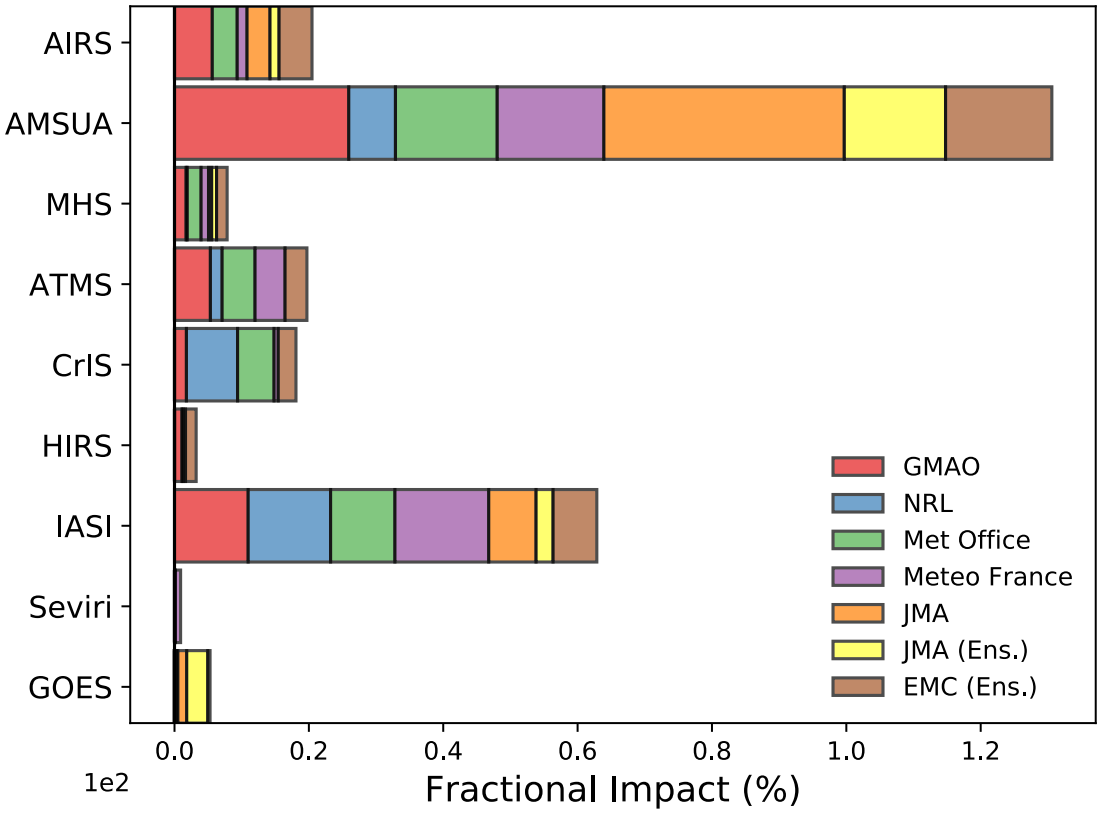




JMA

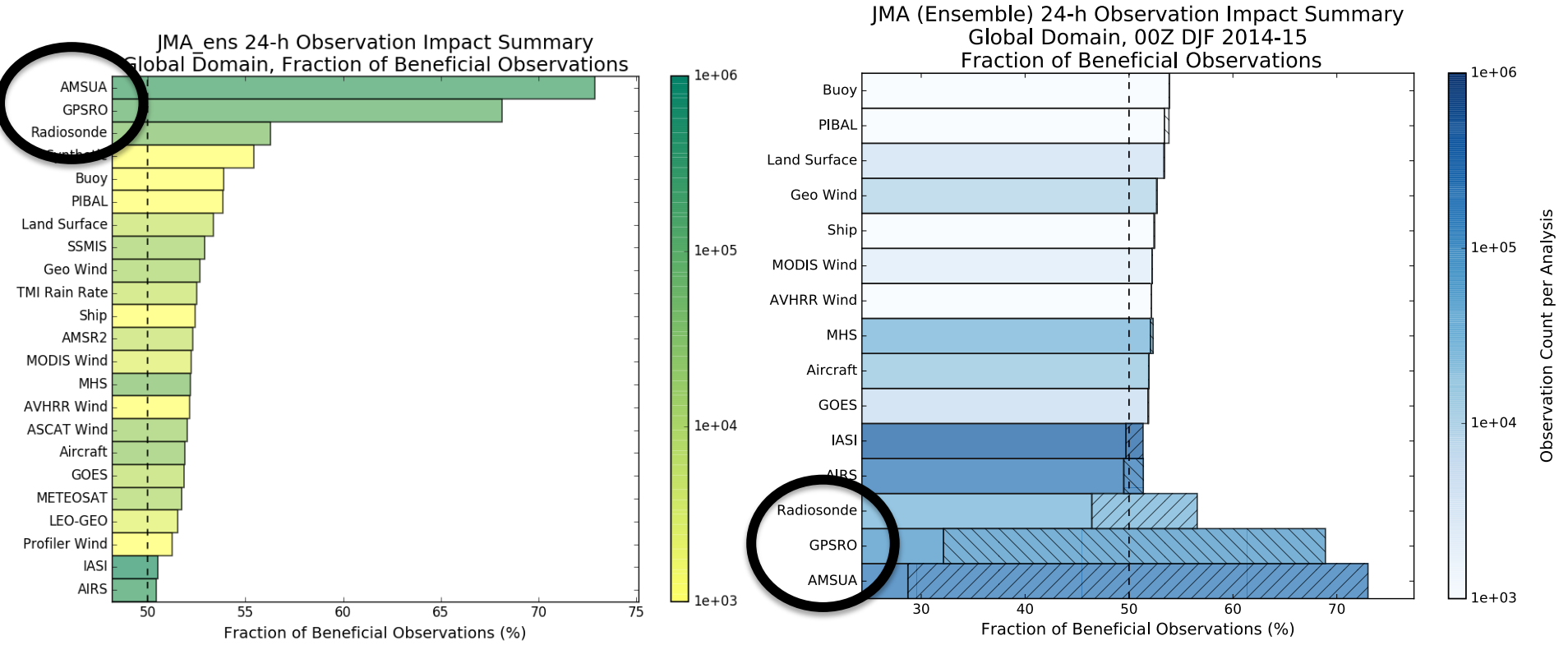
0.3

# Fractional Impact

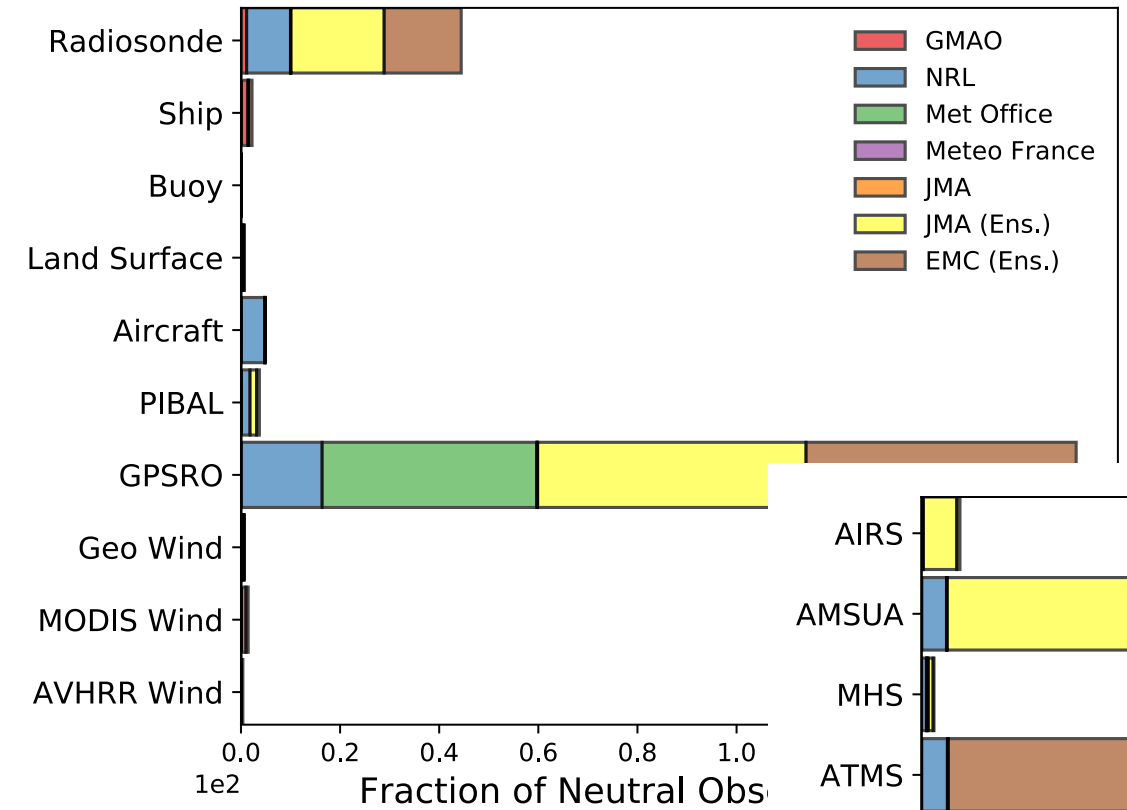


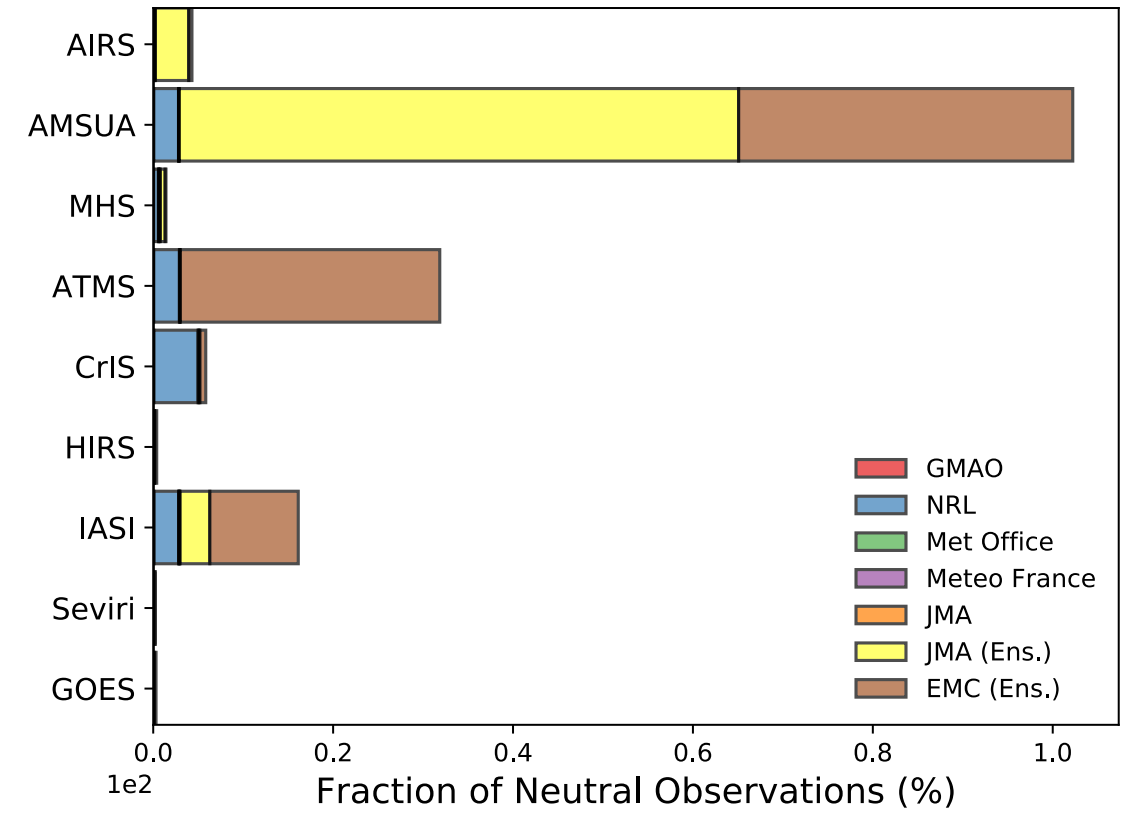



# Fraction of Beneficial Observations

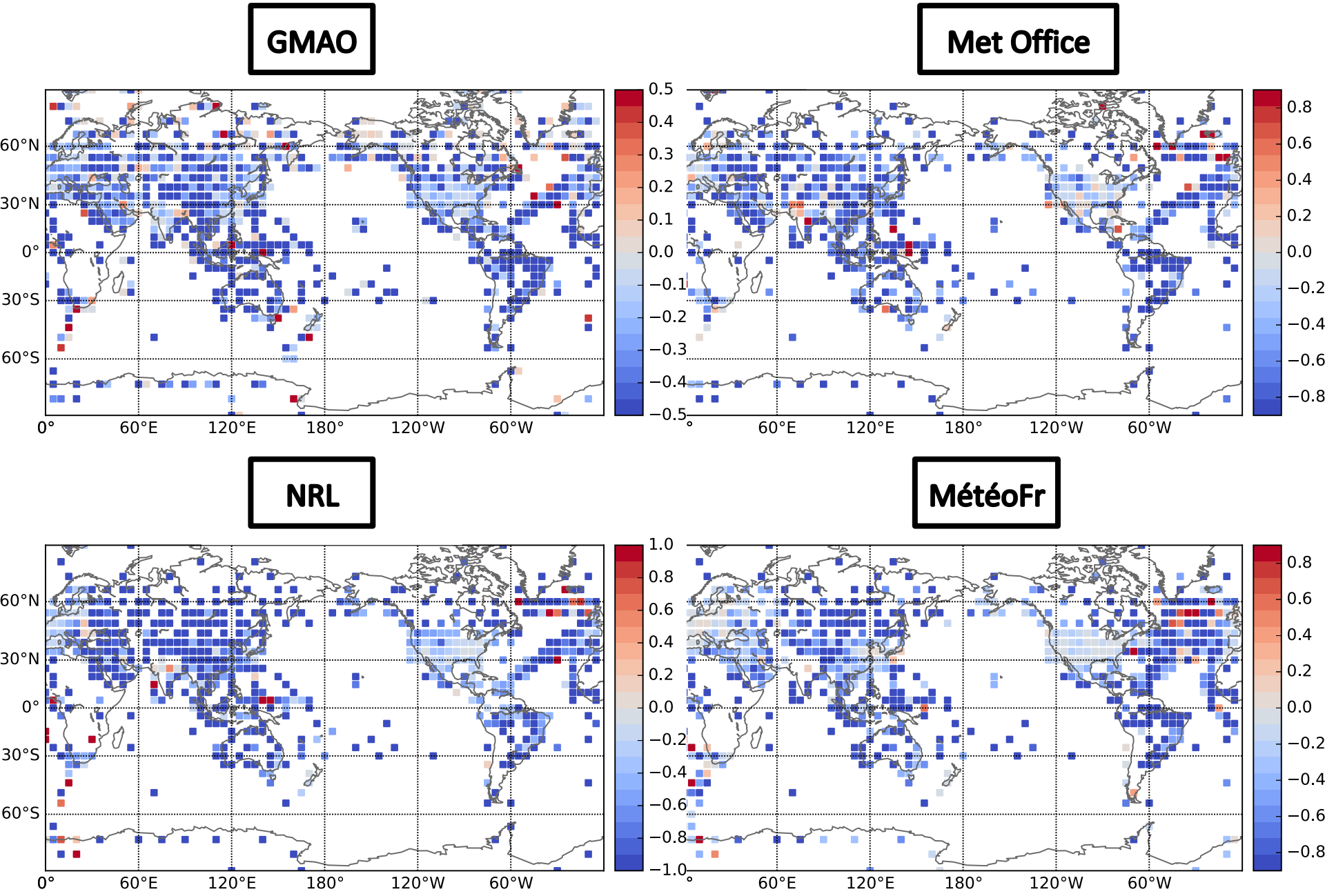


# Fraction of Neutral Observations

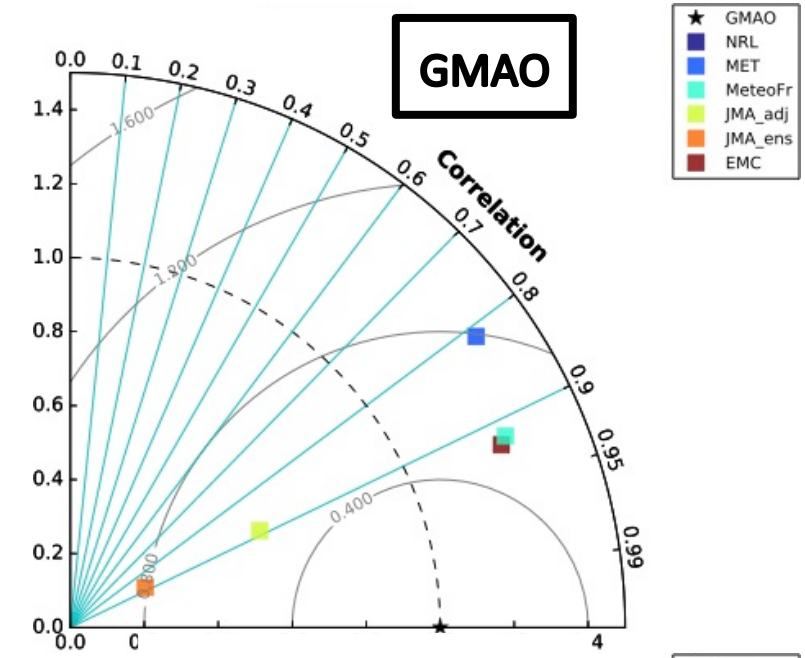


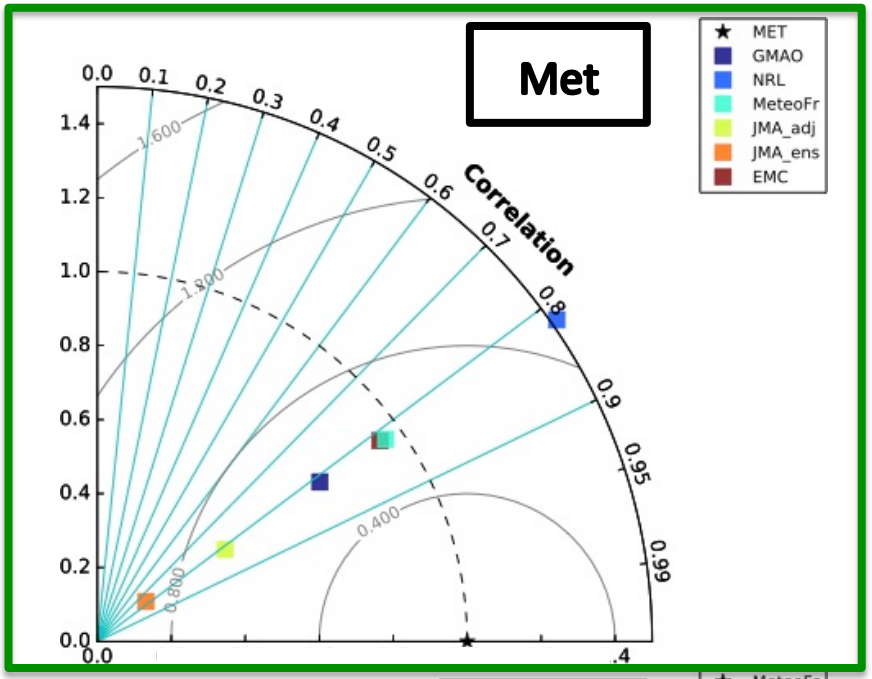



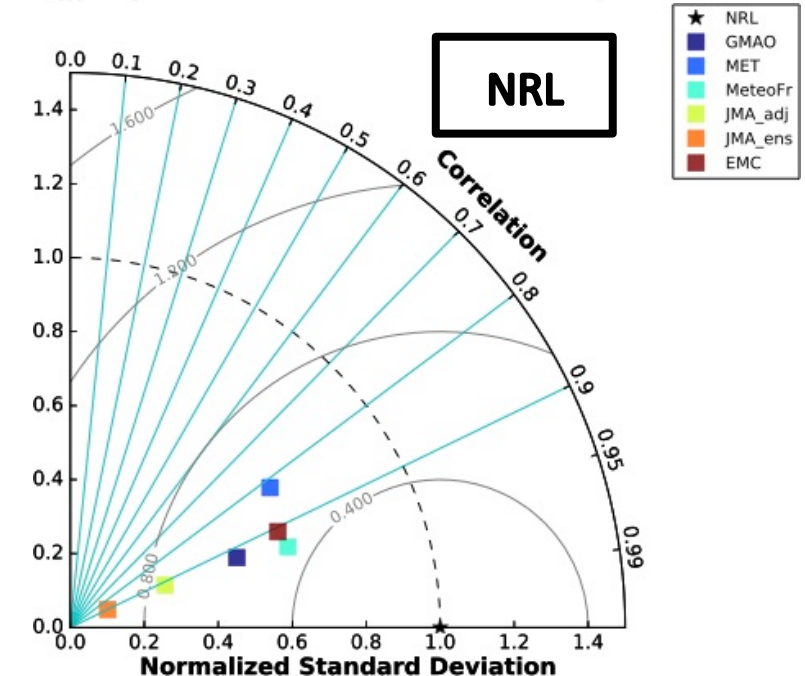
# Total Impact (J/g): Radiosonde

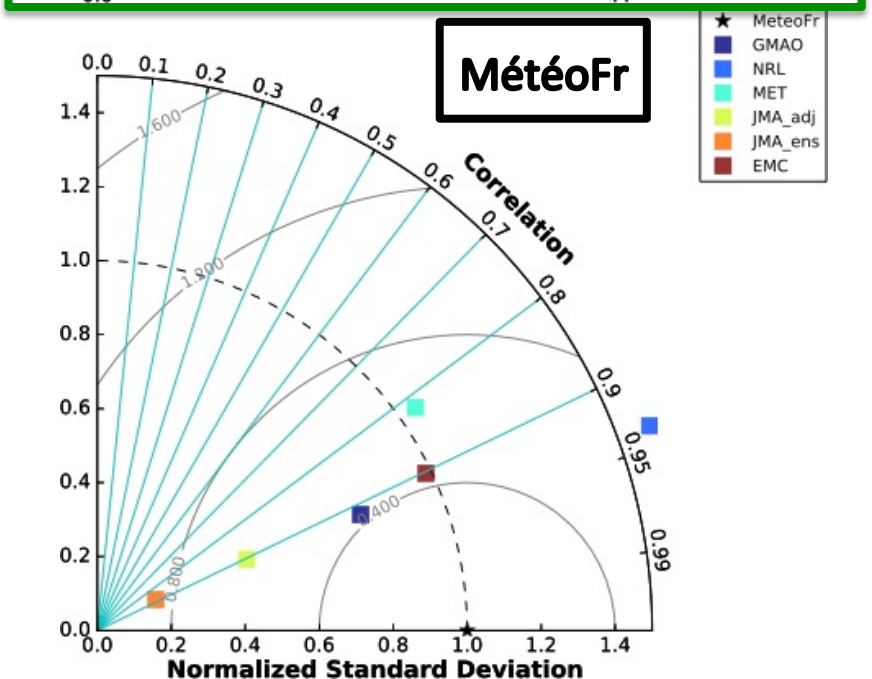


# Inter-agency Total Impact Correlations: Radiosonde



# Conclusion and Perspectives

- Confirmation of results from *Gelaro et al. (2010)*, noticeable additional impact from hyperspectral IR sounders
- Discrepancies between adjoint- and ensemble-based FSOI values. Further investigation needed.
- Many more composite plots can provide detailed analysis
  - Mean/variance maps (across centers)
  - Time/spatial correlations
- Ancillary interests not covered so far
  - investigation of different types of norms and verifications methods,
  - more participating NWP centers: global & regional NWP systems.
- Near-Real-Time multi-agency monitoring capability being built between NRL, GMAO and EMC
- Use machine learning on collected database to intelligently predict observation impact