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


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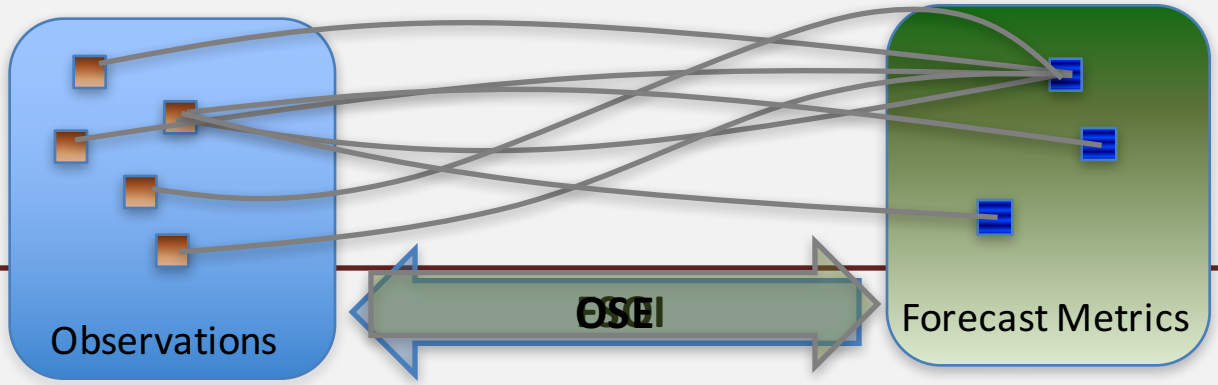
# FSOI Comparison Study Motivation

- Several NWP centers compute FSOI routinely to monitor/understand/tune their DA system. Opportunity to compare impacts in systems with different DA methods and different mix of assimilated observations.
- Impact of AMVs and other wind observation data.
- Satellite vs. in-situ data, TLM/ADJ vs ensemble DA.
- Are relative impact of various observation types comparable?
- Can we learn from similarities/differences to improve NWP systems and DA procedures?

- NWP Centers that participated: NRL, GMAO, EMC, Met Office, JMA

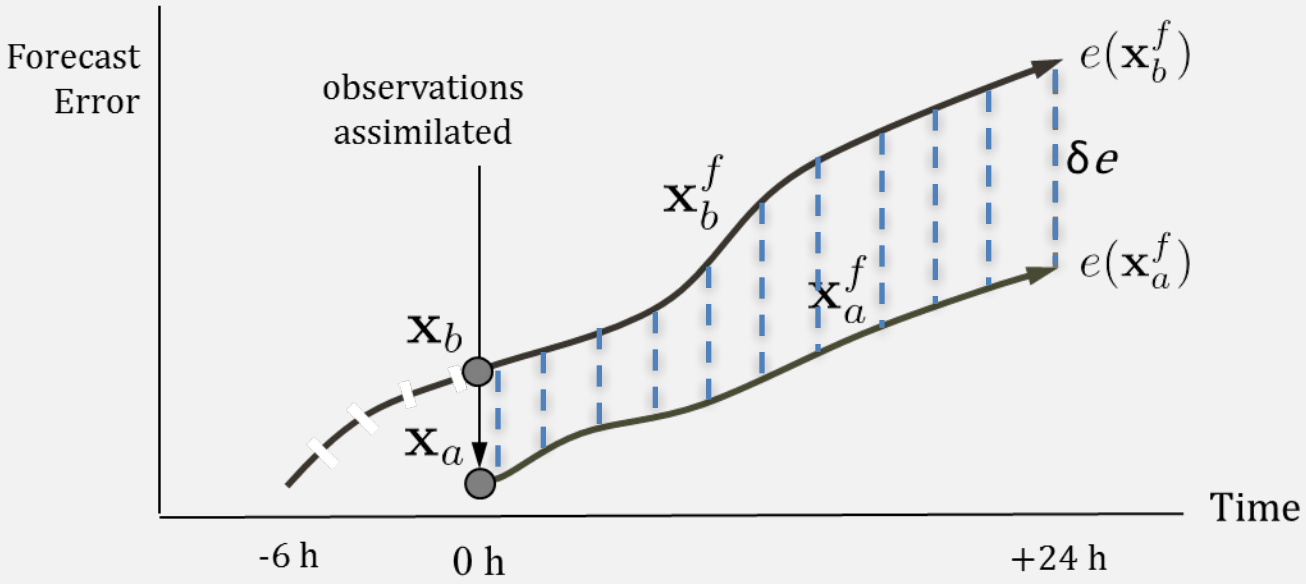
# FSOI vs. data-denial (OSE) experiments

- FSOI quantifies impact of all assimilated observations on a selected forecast metric … shows if any observation [or set of observations] decreases or increases forecast error …
- OSE shows impact of one selected change to the observation system on all aspects of forecast … not able to partition impact of various observation types



# Forecast Sensitivity – Observation Impact (FSOI)

Langland and Baker (Tellus, 2004)




NAVGEM ADJOINT NAVGEM ADJOINT

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

$$\delta e \approx d^T K^T [M_b^T e(x_b^f) + M_a^T e(x_a^f)]$$

Innovation vector

**Ensemble-derived observation impact**

$$\delta e \approx d^T R^{-1} L(HX_a^0) X_a^{fT} [e(x_b^f) + e(x_a^f)]$$

# Experimental Design

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

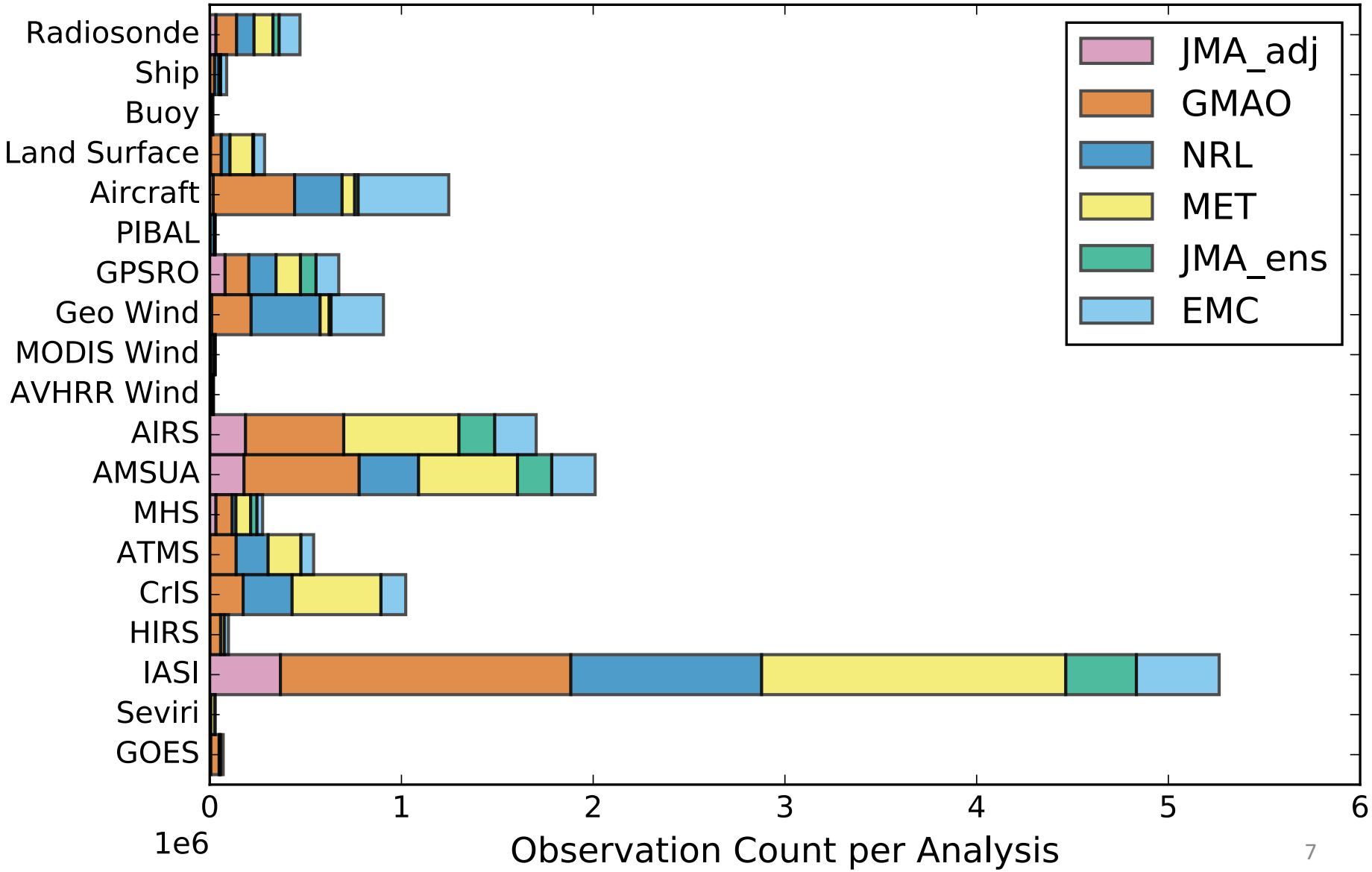
**Results shown here are preliminary**

[only global summary plots of impact at 00UTC will be shown]

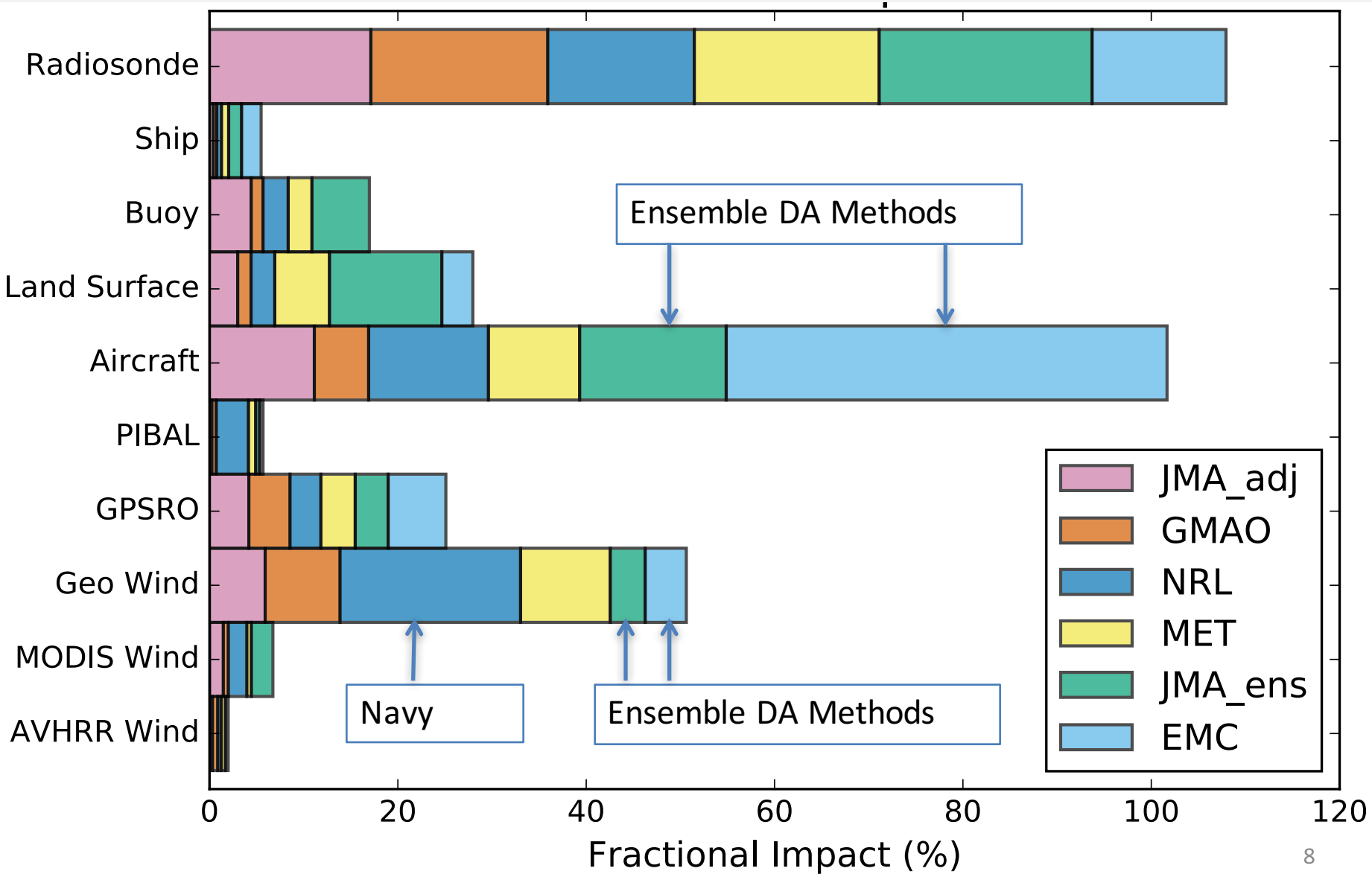
# Participating NWP Centers

| NWP Centers | NRL | GMAO | Met Office | JMA Adjoint | JMA Ensemble | EMC |
|---|---|---|---|---|---|---|
| **Analysis System** | 4DVar In Observation Space | Hybrid 3DVar | 4DVar | 4DVar | LETKF re-centered via 4DVar | EnKF re-centered via 4DEnVar |
| **FSOI Technique** | Adjoint | Adjoint | Adjoint | Adjoint | Ensemble | Ensemble |
| **Experiment Resolution** | Model: T425L60<br>Adjoint: T119L60 | Model: 25km<br>DA: 50km<br>Ens: 100km | Model: N320 (40km)<br>Adjoint: N216 (60km) | Model: TL959L100<br>Adjoint: TL319L100 | Ensemble: (x50) TL319L100 | Ensemble: (x80) T254 |
| **Specific Considerations** | Super-obbing for AMVs | QC = channel selection + dynamical observation error | ~30% cycles discarded due to spurious impacts | | | Additional thinning of observations except for aircraft data |

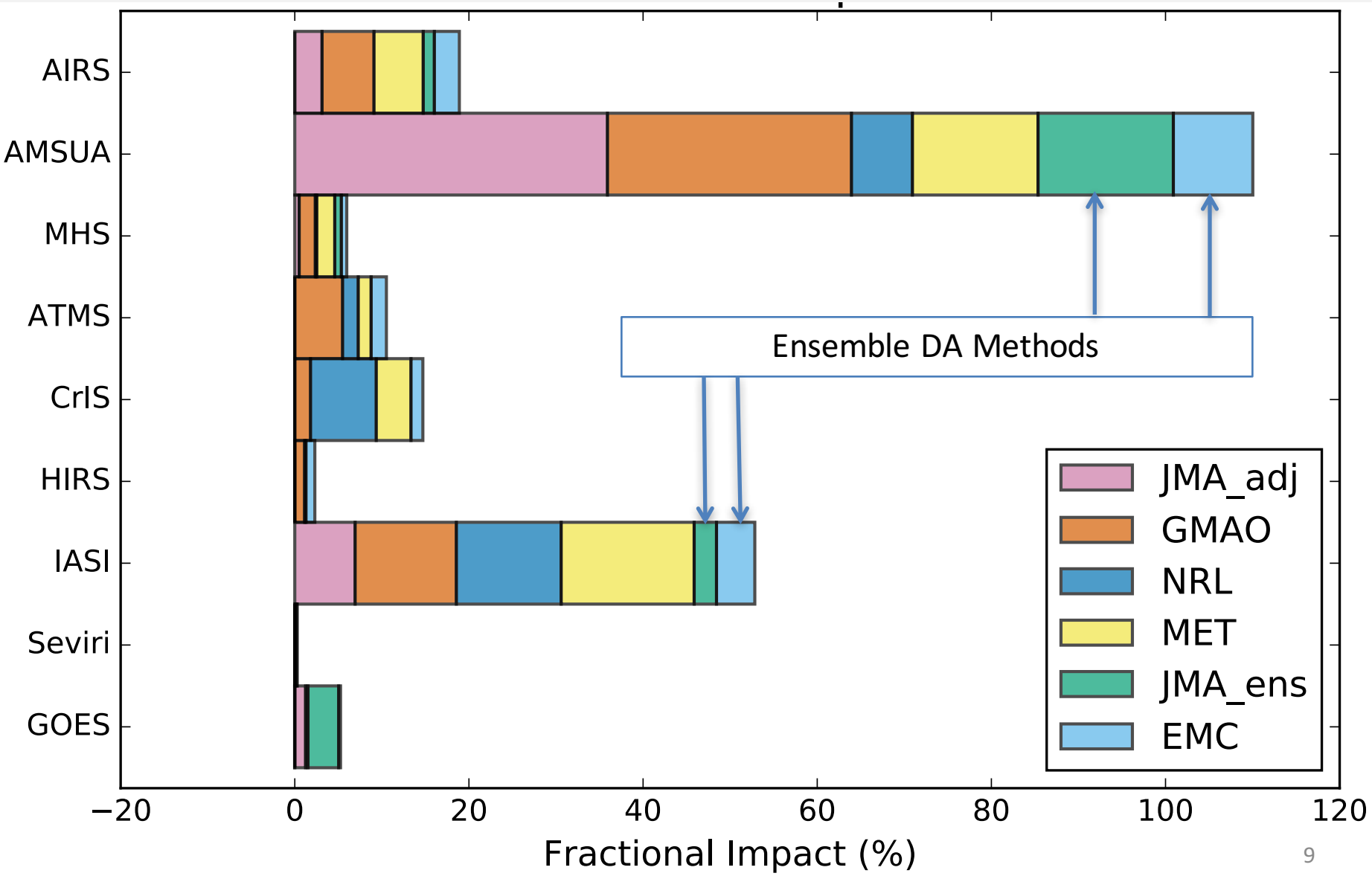
# Observation Count at 00UTC



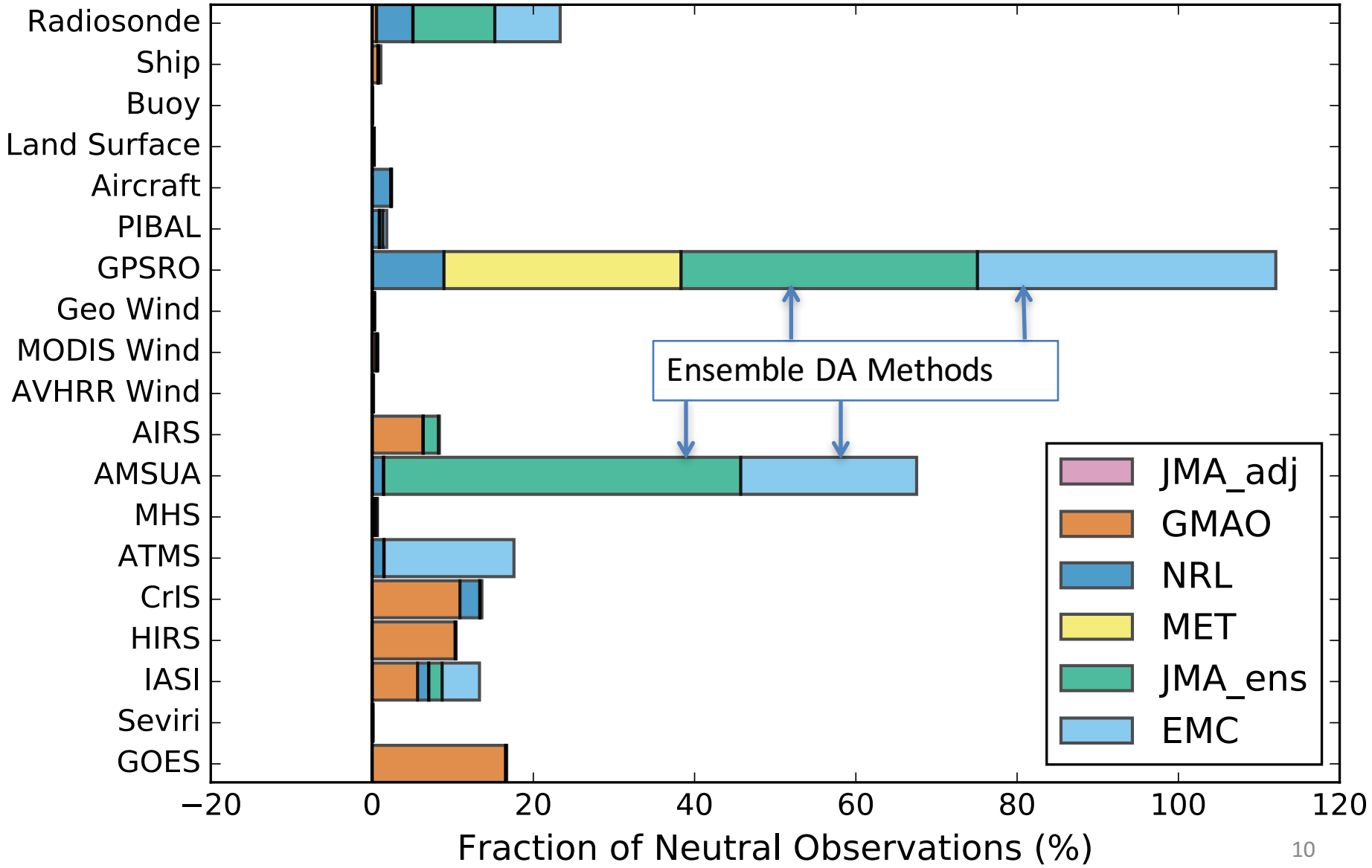
# Fractional Ob-Impact



# Fractional Ob Impact: Satellite Radiances



# Fraction of Neutral Impact-Observations



# FSOI Inter-comparison Summary

- Largest AMV impacts in Navy Global system
- Smallest AMV impacts in EMC & JMA ensemble-DA systems
- Impacts depend on amount of AMV and other observation data that is assimilated
- Thinning or super-ob procedures
- Assimilation method: TLM/ADJ vs. ensemble
- Ensemble methods appear less-accurate at quantifying sensitivity for observations with small individual impacts (e.g., satellite obs) …

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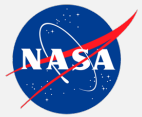
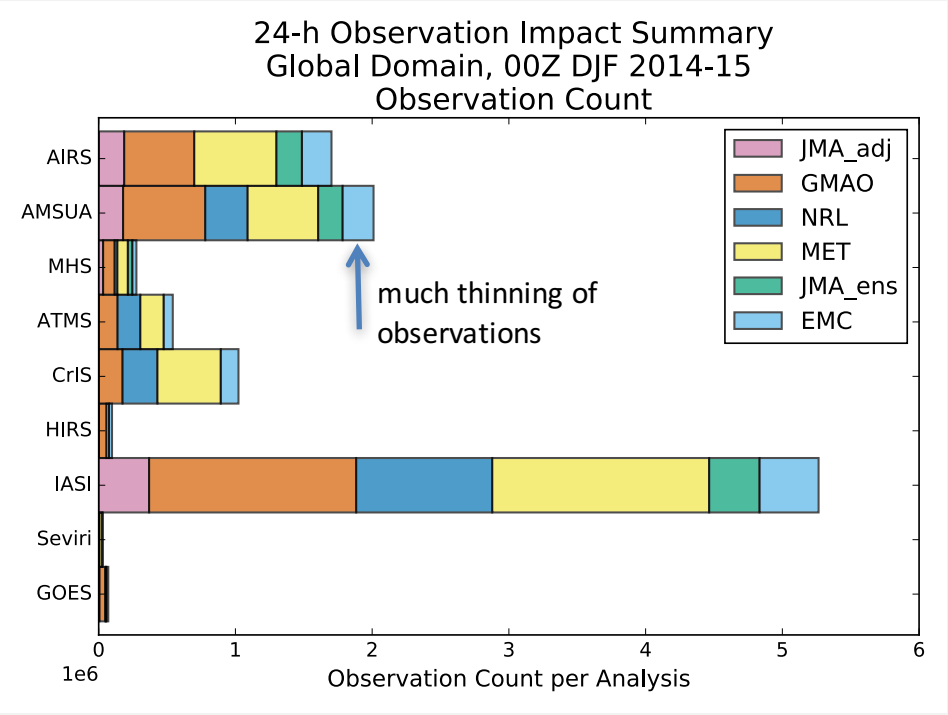
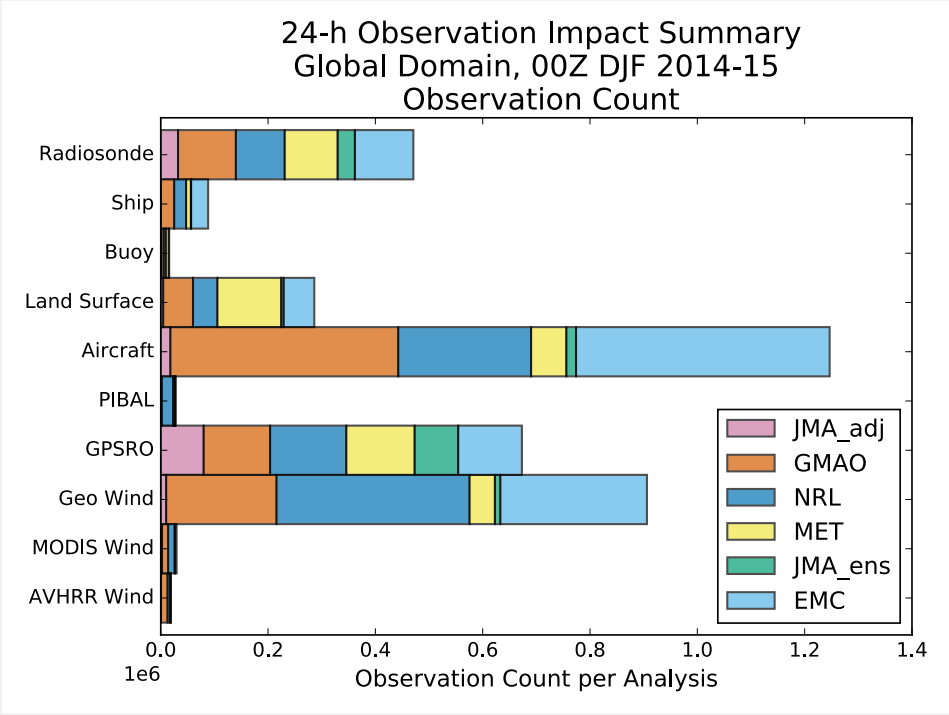
# Questions about the FSOI inter-comparison study?




# Observation Impact at 00UTC: **Observation Count**

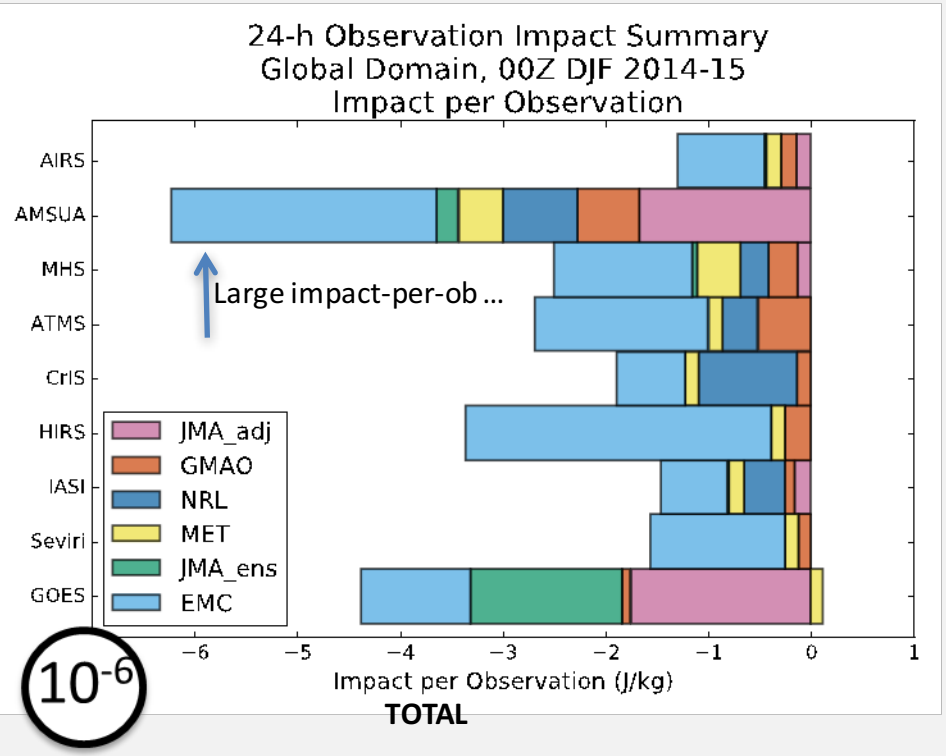


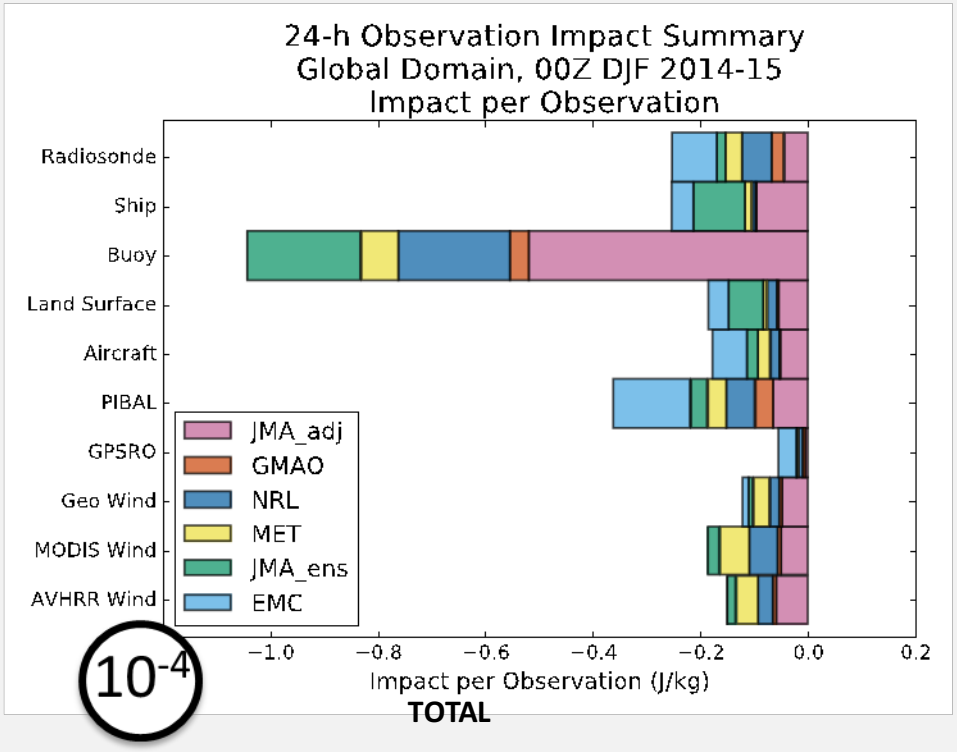

**Radiances**

**Other Observations**

# Observation Impact at 00UTC: **Impact per Observation**



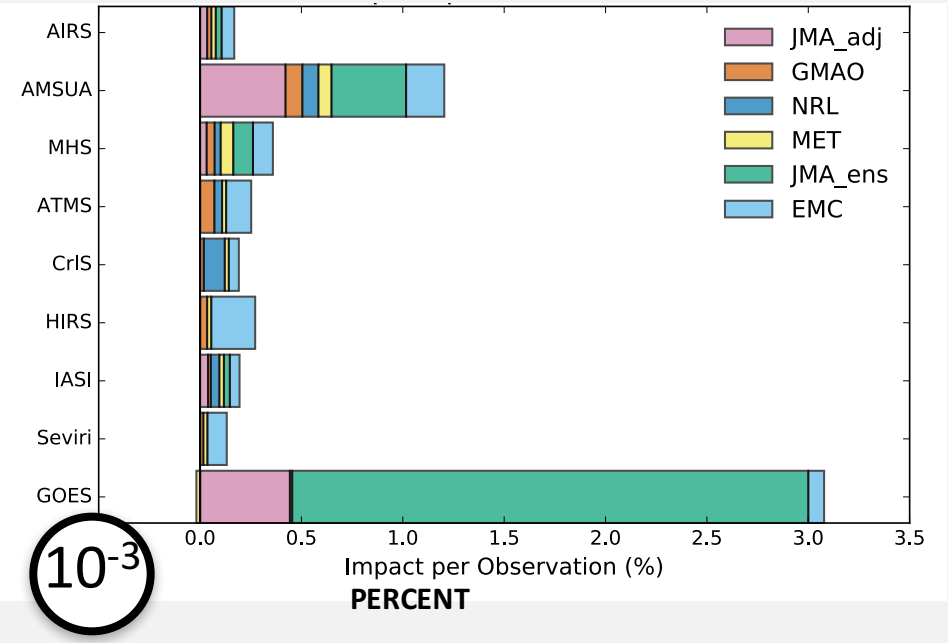

**Radiances**



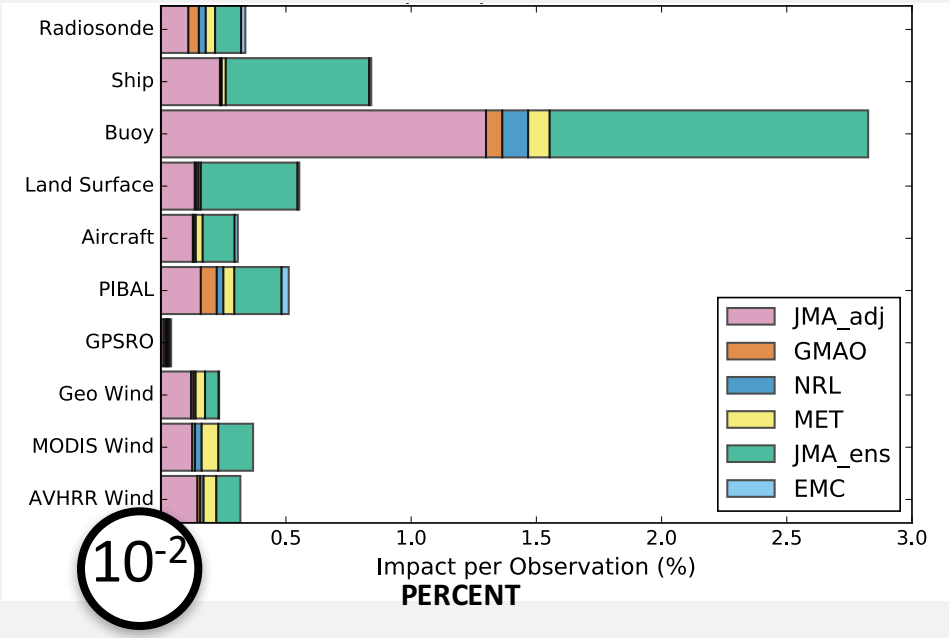

**Other Observations**

# Observation Impact at 00UTC: **Impact per Observation**

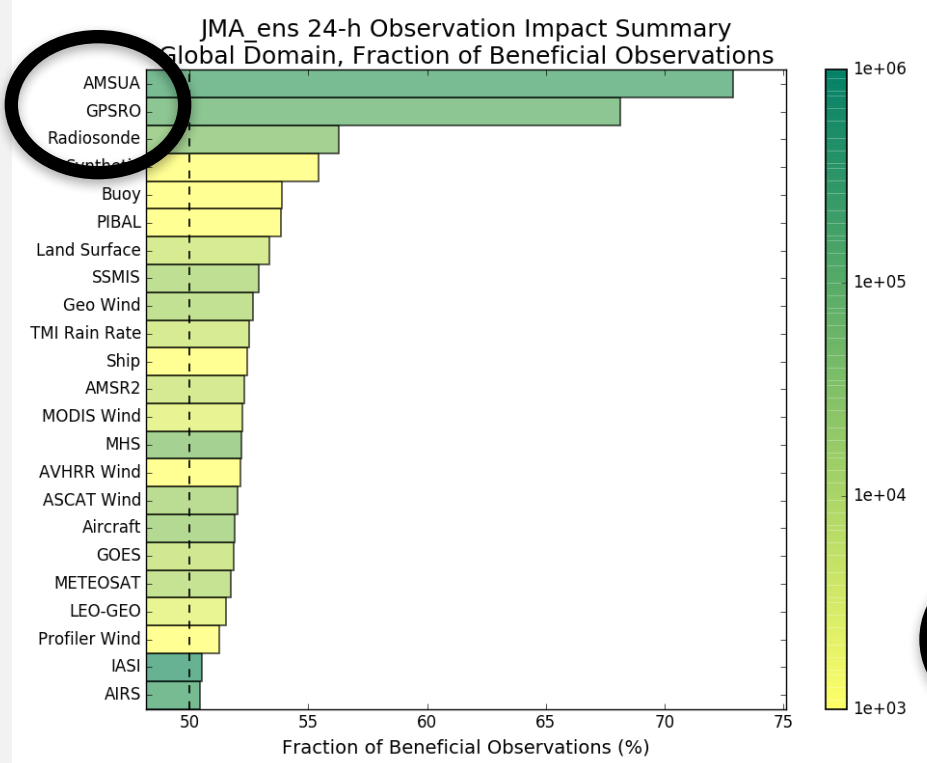
## Radiances

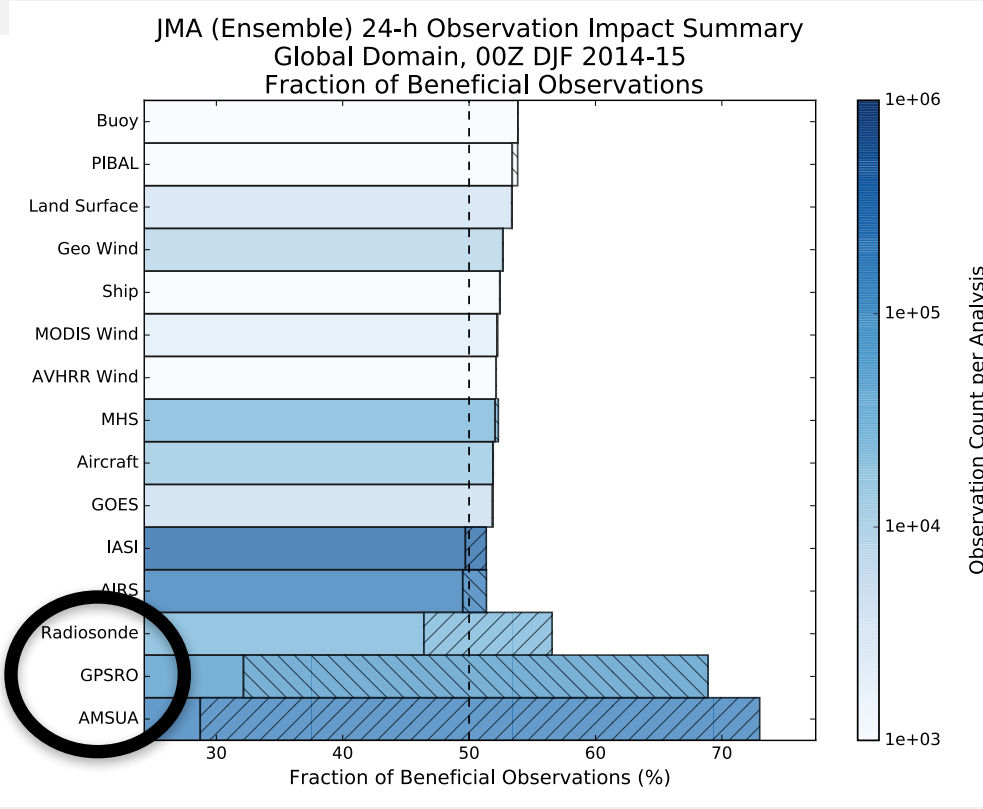



## Other Observations



# Observation Impact at 00UTC: **Fraction of Beneficial Observations**



# FSOI TLM/ADJ vs. Ensemble methods

Only ~20% of the forecast error metric projects onto ensemble structures, so observation sensitivity may be not well-represented with ensemble methods [Problems with ensemble localization, inflation factors and other issues]. Implications for FSOI with ensemble methods, and also for ensemble DA itself, such as 4dENS-Var, as opposed to 4DVAR with TLM/ADJ.

Observation impact with ensemble method is artificially changed by ensemble "inflation factors."