Multifrequency Point Source detection with Fully-Convolutional Networks: Performance in realistic microwave sky simulations (Casas, J.M., González-Nuevo, J., Bonavera, L. et al. Submitted A&A)

Debating the potential of Machine Learning in astronomical surveys

José Manuel Casas González
Departamento de Física, Universidad de Oviedo,
Instituto de Ciencias y Tecnologías Espaciales de Asturias (ICTEA)

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Point Source detection

- Point Sources are contaminants to the recovery of CMB signal at small scales.
- Future CMB experiments will have a higher angular resolution than *Planck*.

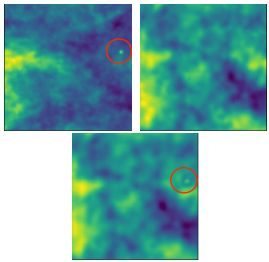


Figure 1: Patches of microwave sky (top left), CMB signal (top right) and recovered CMB signal (bottom)

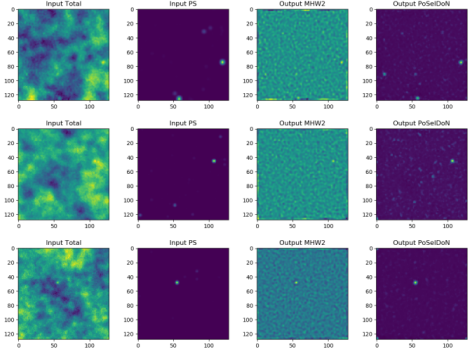
PICO
PROBE OF INFLATION AND COSMIC ORIGINS

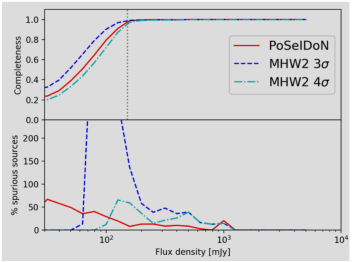
CMB-S4
Next Generation CMB Experiment

SIMONS OBSERVATORY

Figure 2: Future CMB experiments

Traditional methods are based on filters such the Mexican Hat Wavelet 2 (MHW2, González-Nuevo, 2006).





PoSelDoN & MHW2 performance comparisson (Bonavera et al. 2021)

The issue of multifrequency Point Source detection

- Component separation methods are not well suited for the detection of extragalactic compact sources.
- PS emit with an enormous variety of astrophysical mechanisms.
- PS detection methods can not define a common spectral behaviour for all of the sources
- The catalogues of extragalactic sources are extracted from CMB maps separately, one frequency channel at a time.
- A valuable fraction of the information that multiwavelength experiments can offer is wasted through the extraction of the catalogues.

Simulations

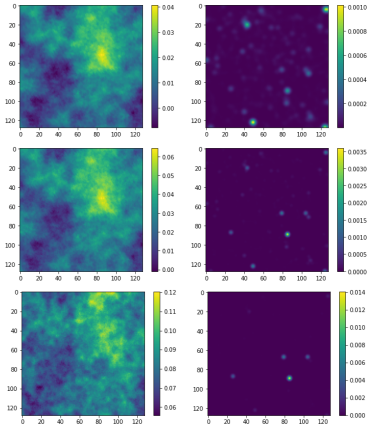


Figure 3: Simulated patches in Jy at 143, 217 and 353 GHz from top to bottom at $b > 30$ degrees of latitude

50.000 train, 5.000 test & 5.000 validation simulations with the next components:

- Radio, Infrared Late Type and Spheroidal Galaxies (Cosmic Infrared Background).
- CMB signal.
- Galactic emission.
- Thermal Sunyaev-Zeldovich.
- Instrumental noise.

Trained during 500 Epochs with AdaGrad optimizer, Mean Squared Error loss funcion, Batch Size of 32, Learning Rate of 0.05 & Leaky ReLU in all the layers.

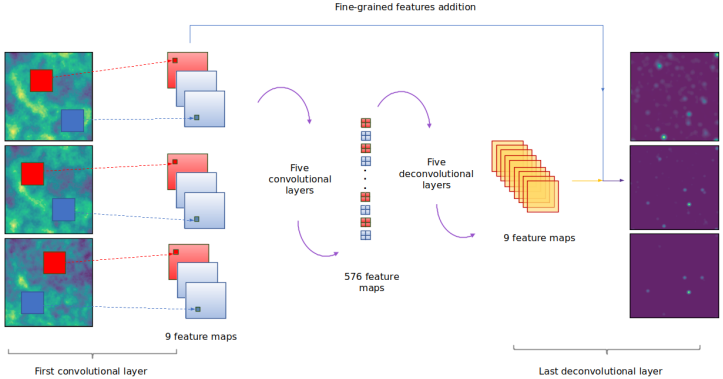


Figure 4: Architecture of MultiPoSeIDoN

Results - MTXF (Herranz et al. 2009) vs MultiPoSelDoN

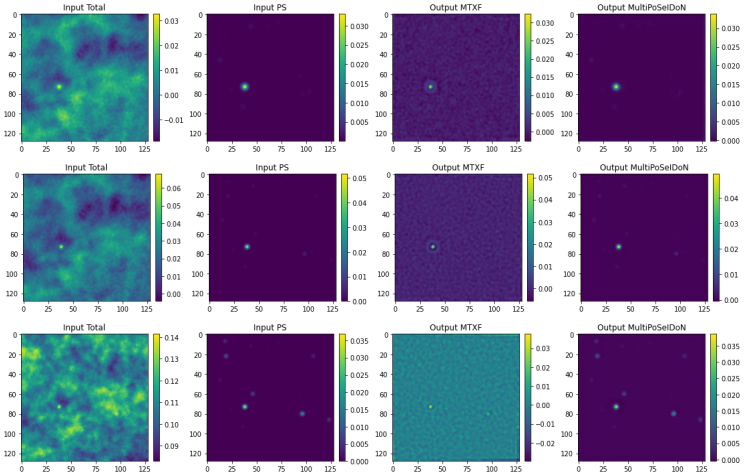


Figure 5: MTXF & MultiPoSelDoN output patches in Jy at 143, 217 and 353 GHz from top to bottom

Results - MTXF (Herranz et al. 2009) vs MultiPoSeIDoN

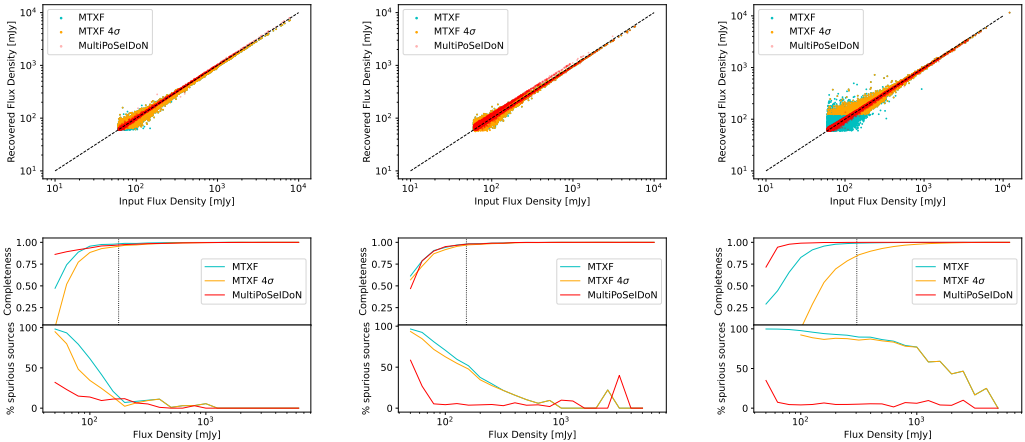


Figure 6: MultiPoSeIDoN & MTXF Photometry (top), Completeness and % of spurious sources (bottom) at 143, 217 and 353 GHz from left to right

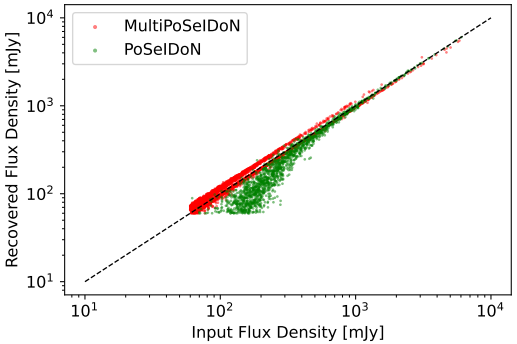


Figure 7: MultiPoSeIDoN & PoSeIDoN Photometry at 217 GHz

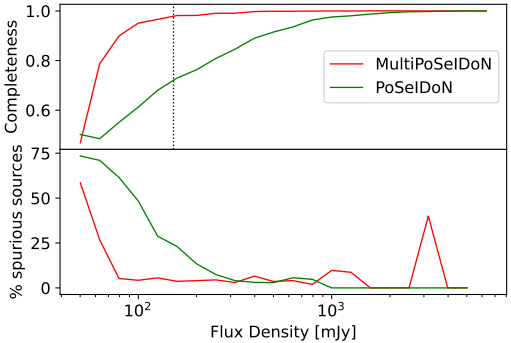


Figure 8: MultiPoSeIDoN & PoSeIDoN Completeness and % spurious sources at 217 GHz

Conclusions

- Multifrequency approaches based on NNs perform better than single-frequency ones.
- Multifrequency NNs have better performance than traditional methods.
- Lower computation time, border effects...

Future prospects

- Regions with higher Galactic emission.
- CMB Component separation.

Thank you for your attention.