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Unclassified

The New Mesoscale Eastern Range Lightning Information Network (MERLIN)

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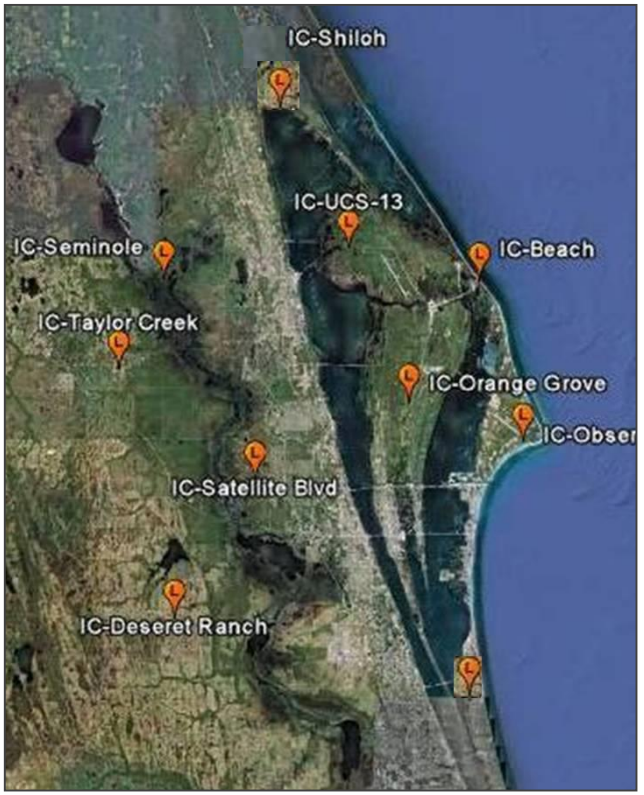
Meteorologists

45th Weather Squadron

No, not <u>that</u> Merlin!

OVERVIEW

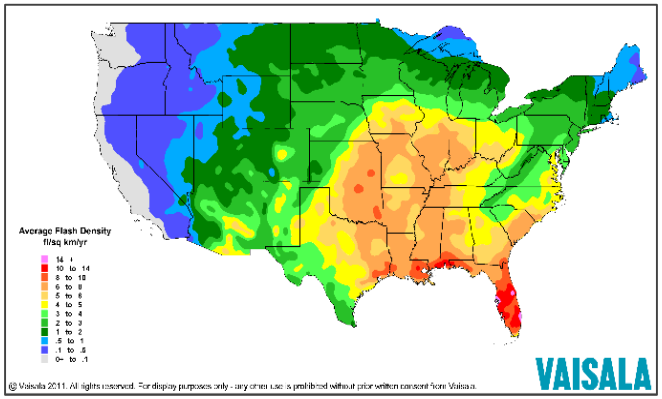
- **Motivation for New Lightning Detection System**
- **System Description of MERLIN**
- **Performance of MERLIN**
- **Future Work**
- **Summary**
- ***New Sensor Requirement (AMS request)***



Motivation for New Lightning Detection System

- **Main motivation for new lightning detection system**
  - **Current system is unsustainable**
  - **Vendor no longer manufactures those sensors**
- **Other benefits**
  - **Improved performance from new sensor design**
  - **More sensors for more robust performance**
  - **Integration of in-range NLDN sensors for extended range and more robust performance**

Motivation for New Lightning Detection System

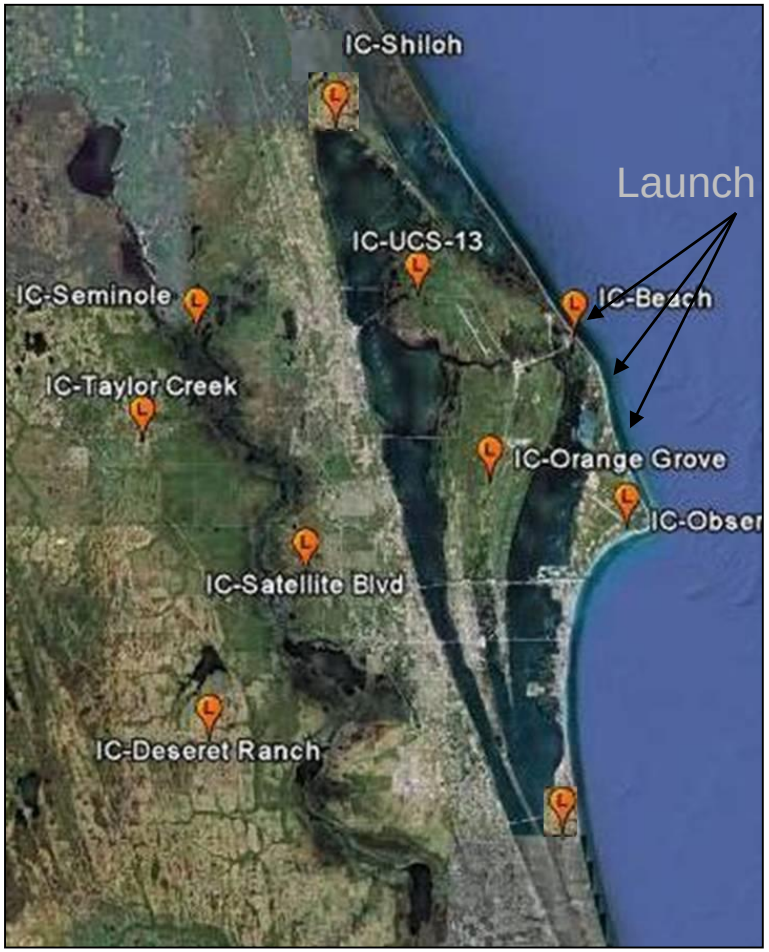


- **Importance of lightning detection to 45 WS**
  - **Located in ‘Lightning Alley’**
  - **Lightning watches and warnings**
  - **Evaluate Lightning Launch Commit Criteria**
  - **Daily Lightning Reports**
    - **Help customers assess risk of induced current damage from nearby return strokes to electronics in satellite payloads, space launch vehicles, test equipment, and facilities**
  - **Climatology for mission planning and risk assessment**
  - **Forecast tool development**
  - **Incident investigation**

System Description of MERLIN

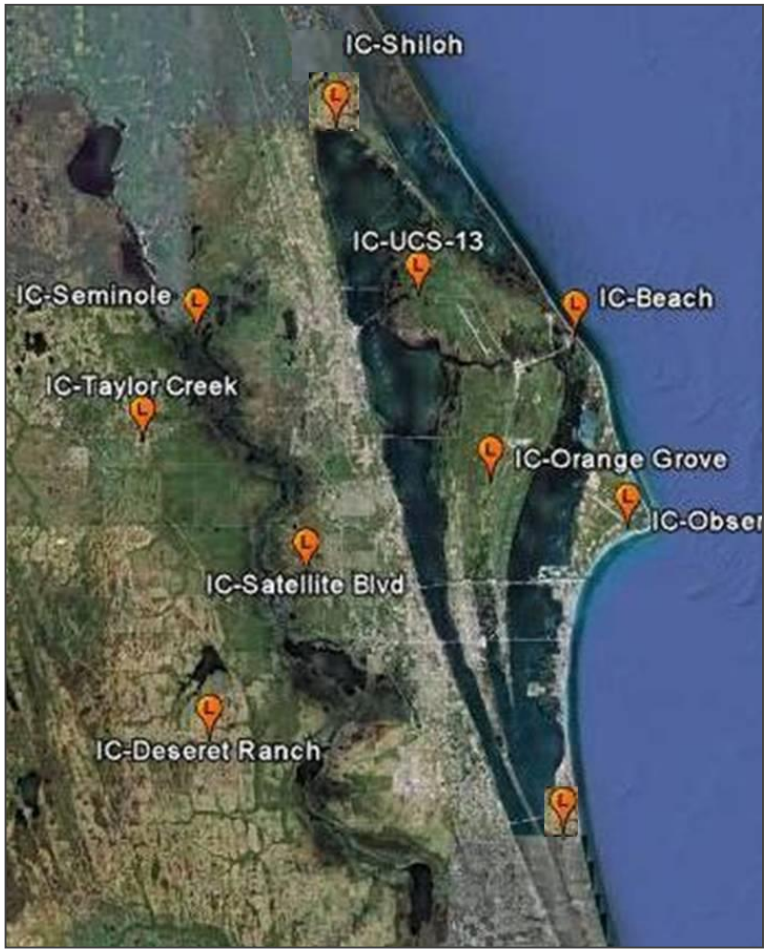
- **System Description – Sensors and Locations**

Total Lightning Sensor Model 200 (TLS-200)

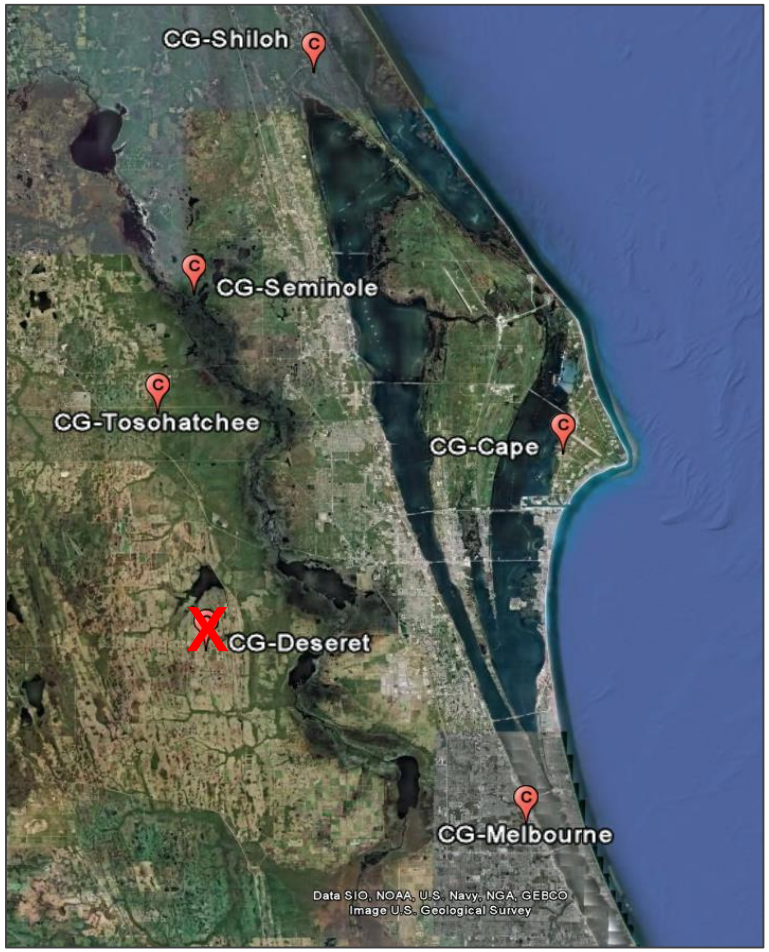


System Description of MERLIN

- **System Description – Comparison with CG-4DLSS**



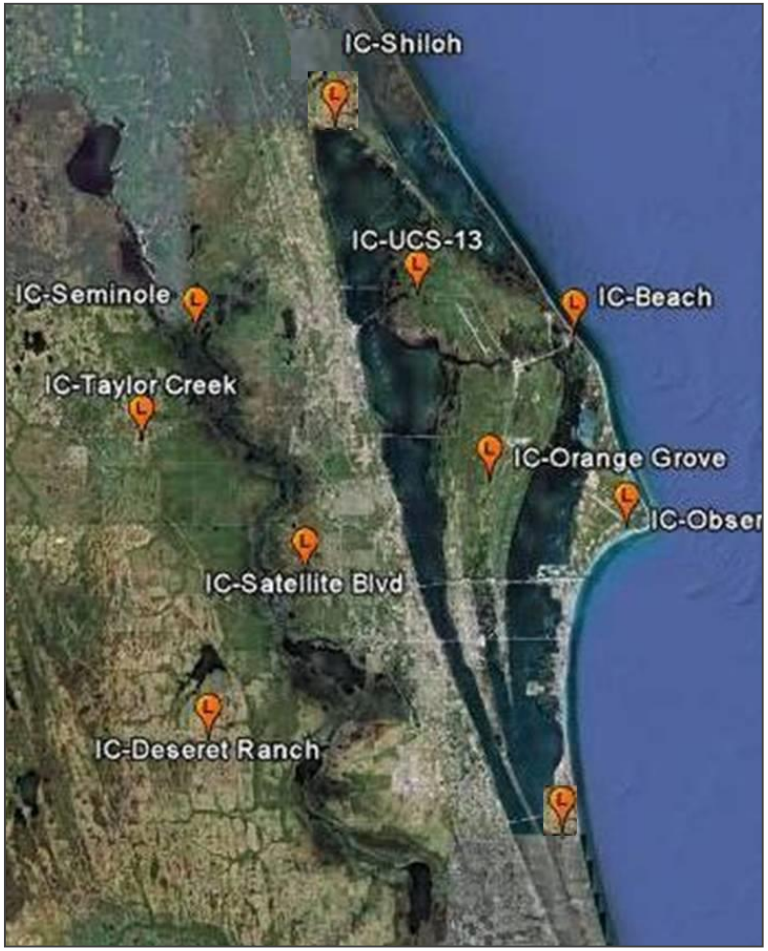
Ten TLS-200 Sensors



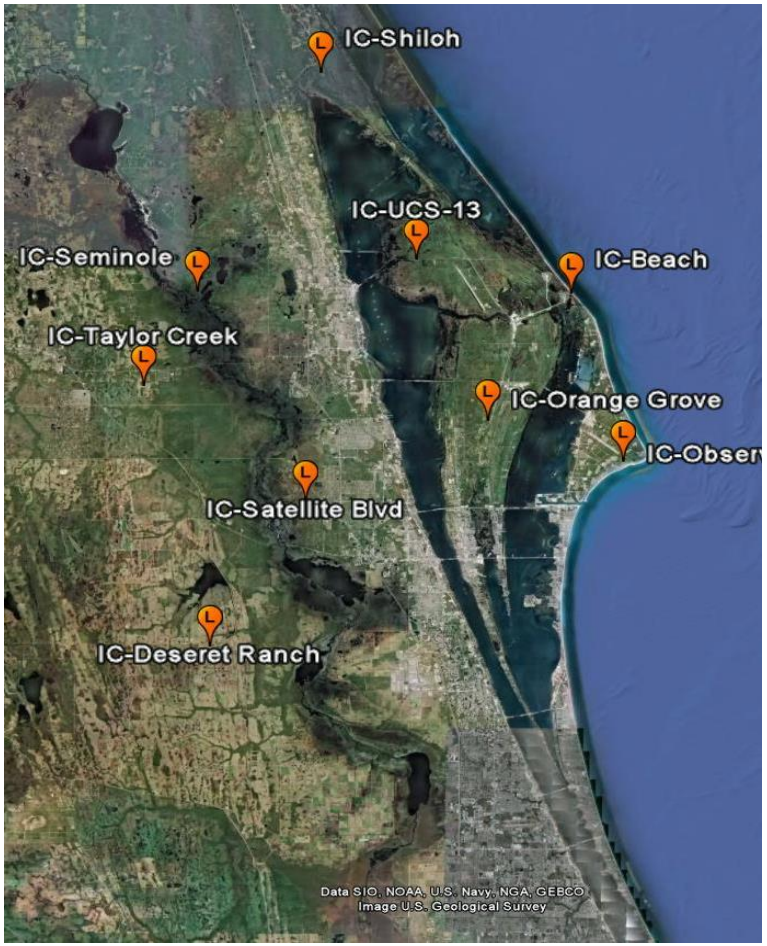
Six Sensors (four IMPACT & two LS-7001 (five operational—no spares)

System Description of MERLIN

- **System Description – Comparison with CC-4DLSS**



Ten TLS-200 Sensors



Nine LDAR-II Sensors
(no spares)

- **System Description – CG-Lightning**

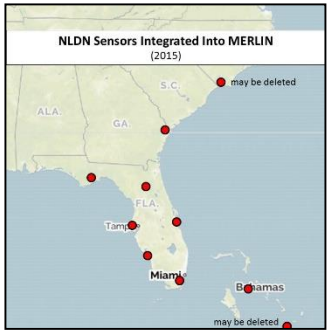
Green Shading = advantage over other system	MERLIN	CG-4DLSS
Number of Local Sensors	10	6
Local Sensor Type	TLS-200	IMPACT/LS-7001
Number of NLDN Sensors	10	0
Typical Phenomenon Detected	return stroke	return stroke
Detection Method	MDF/TOA	MDF/TOA
Frequency Band	LF/HF	LF
Reports	• location (x, y) • date/time • peak current • polarity • location error ellipse	• location (x, y) • date/time • peak current • polarity • location error ellipse
Processor Model	TLP	CP-8000
Signal Processing	digital	analog

System Description of MERLIN

- **System Description – Lightning Aloft**

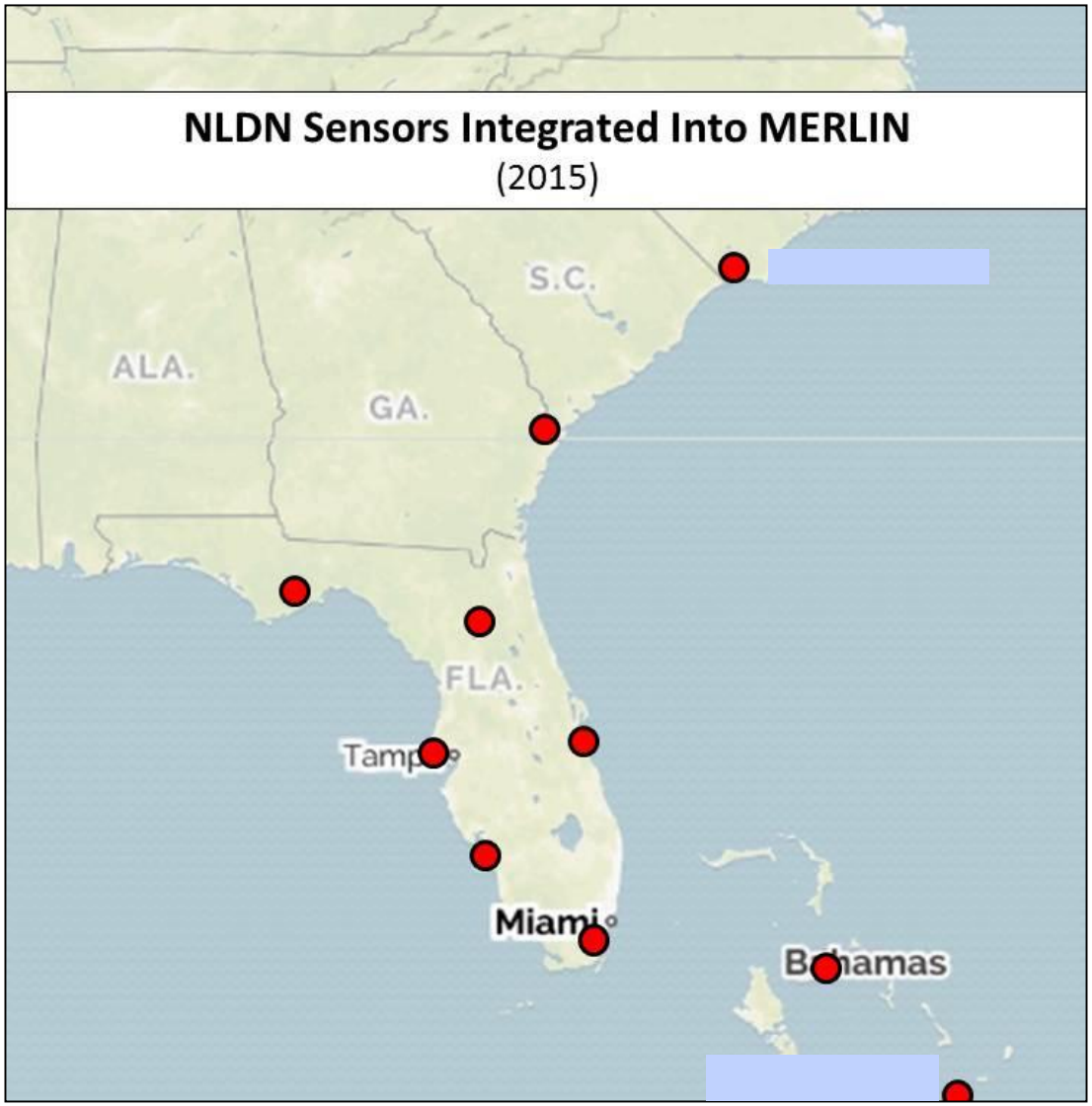
Green Shading = advantage over other system	MERLIN	CC-4DLSS
Number of Local Sensors	10	9
Local Sensor Type	TLS-200	LDAR-II
Number of NLDN Sensors	N/A	N/A
Typical Phenomenon Detected	recoil streamer, dart leader	stepped leader
Detection Method	interferometry	TOA
Frequency Band	VHF	VHF
Reports	• 2D location projected onto ground (x, y)	• 3D location (x, y, z) • date/time
Processor Model	TLP	CP-8000
Signal Processing	digital	analog

System Description of MERLIN



- **NLDN integration**
  - **10 in-range NLDN LS-7002 sensors integrated in real-time into TLP**
    - **NLDN raw observations, <u>not</u> lightning solutions**
    - **MERLIN: hybrid local-regional lightning system**
  - **Farther older NLDN sensors do <u>not</u> significantly degrade MERLIN's CG performance**
    - **TLP always provides optimal solution given available data**
  - **MERLIN's long-range CG performance degrades to NLDN rather than degrading to zero performance**
  - **MERLIN's local CG performance degrades to NLDN as local sensors are lost**
  - **NLDN lightning aloft data <u>not</u> compatible with MERLIN**

System Description of MERLIN



Performance of MERLIN

- **MERLIN Performance – CG-Lightning**

Green Shading = advantage over other system	MERLIN	4DLSS
Stroke Detection Efficiency	92%	82%
Flash Detection Efficiency	99.6%	96%
Location Accuracy	58 m	350 m
Peak Current	± 10%	± 20%
Polarity Identification	100% correct	100% correct
CG/Lightning Aloft Identification	95%	95%
Median Location Error Ellipses Contain X% of Strokes (perfect = 50%)	92%*	26%
False Detections	0%	0%
Signal Processing	digital	analog

* misleading, an artifact of 100 m reporting increment in TLP software (fix under development)

Performance of MERLIN

- **MERLIN Performance – Lightning Aloft**

Green Shading = advantage over other system	**MERLIN**	**4DLSS**
Events Detected - MERLIN: recoil streamers, dart leaders - 4DLSS: stepped leaders	92% estimated	70%
Flash Detection Efficiency	100%	100%
Location Accuracy	500 m*	100 m*
Peak Current	No	No
Polarity	No	No
CCG/Lightning Aloft ID	100%	100%
False Detections	0%	Rare (and easily identified)

* not comparable since detecting different phenomena of very different sizes

Performance of MERLIN

- **Comments on MERLIN performance**
  - **CG-Lightning**
    - **Timing error much smaller in TOA solutions**
      - **TOA now contributes as much as MDF to short-range solutions**
      - **More robust performance (less degradation with lost sensors)**
    - **More waveforms count as valid lightning**
      - **Less missed detections due to strong strokes**
        - **4DLSS missed ~5% of CG strong local strokes**
        - **MERLIN misses ~0.5%**
      - **Less missed detections from strokes from tall structures**
        - **Preliminary analysis shows less improvement than expected**
        - **Further verification needed – may be due to interaction of Vehicle Assembly Building with propagating signal**

Performance of MERLIN

- **Comments on MERLIN performance**
  - **Lightning Aloft**
    - **Single location of larger phenomena could be problematic**
    - **But those phenomena are stronger so higher detection rate**
    - **Higher detection rate wins slightly inside network**
    - **Lightning aloft detections 30% more than CC-4DLSS inside network. Less than CC-4DLSS beyond ~30 nmi.**
  - **Test For Operations:**
    - **Lightning warnings: MERLIN as good or better than 4DLSS**
    - **LLCC evaluation: MERLIN as good or better than 4DLSS inside the network**

Future Work

- **Future Work**
  - **Use left-over LS-7001 sensors at Melbourne Airport**
    - **One installed; two as spares**
  - **Upgrade the LS-7001 sensors to LS-7002 (in-progress)**
  - **Annual Network Performance Evaluation Program**
  - **Upgrade software to 10 m location reporting increment**
    - **Under development by Vaisala**
    - **Reevaluate performance to get true location accuracy**
  - **Evaluate performance vs. distance for lightning aloft**
  - **Evaluate value-added of NLDN integration**
  - **Improve MERLIN lightning aloft detections with range**
    - **Some frequency bands reset to more sensitive (13 Jan 17)**
  - **Add 1-4 additional sensors to MERLIN at optimal sites**
  - **Change NLDN sensor at Palm Bay to TLS-200?**
  - **Others (see paper)**

Summary

- **Mesoscale Eastern Range Lightning Information Network (MERLIN)**
  - **Replace unsustainable lightning detection system**
  - **More sensors:**
    - **CG Lightning: 10 vs. 6 (5 operational) sensors**
    - **Lightning Aloft: 10 vs. 9 sensors**
  - **New sensor model:**
    - **CG Lightning: TLS-200 vs. IMPACT and LS-7001**
    - **Lightning Aloft: TLS-200 vs. LDAR-II**
  - **New processor model: TLP vs. CP-8000**
    - **Several performance gains**
  - **Improved performance:**
    - **Especially CG location accuracy -- 58 m!**
  - **Future work**

New Sensor Requirements

- **New Sensor Requirement (AMS request)**
  - **Priority-1: Remote detection of rise time of CG Lightning peak current**
    - **Needed to properly assess risk of induced current damage from nearby CG lightning**
  - **Priority-2: Improved detection of lightning peak current and peak current error tailored to each stroke**
  - **Priority-3: CG Lightning and Lightning Aloft signal generator**
    - **Needed to better test lightning detection in many locations**
    - **May be partly superseded by new verification approach based on Bayesian statistics**

The New Mesoscale Eastern Range Lightning Information Network (MERLIN)

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