# Multi-Mission Remote Sensing Ground Processing Algorithms


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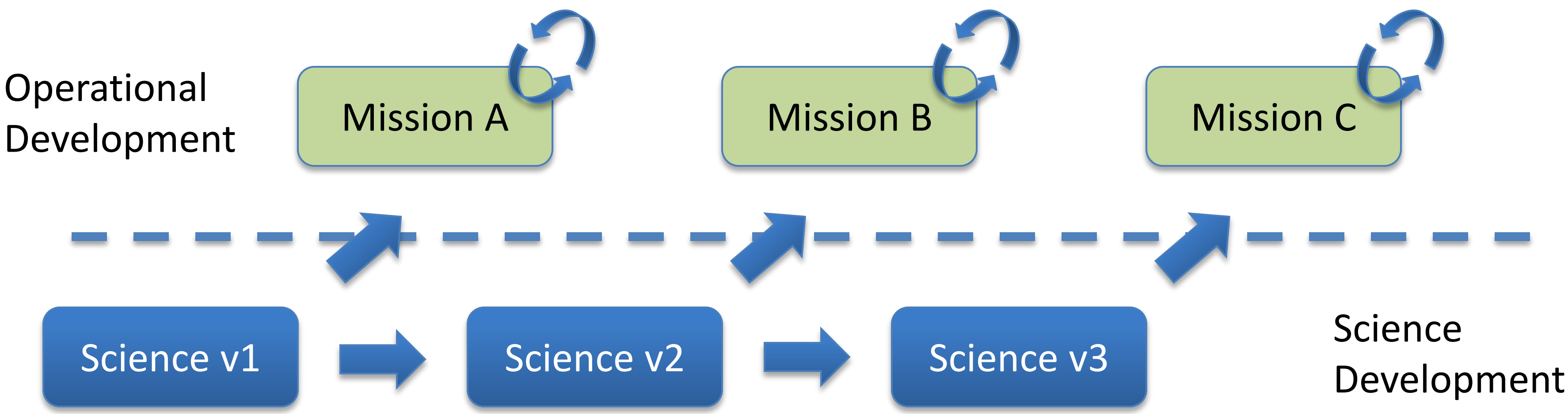
# Introduction and Motivation

- New missions typically dictate newly developed ground processing systems and science algorithms
- Each new system then evolves software infrastructure and operational algorithms independently over its life-cycle

***Evolution of Operational Ground Processing Systems***



# Approach

- Problems with current paradigm
  - Costly to roll out each new system
  - Lack of synchronization between operational environments
  - Lack of synchronization between current (best) science baseline and the algorithms in operational systems
- Mitigating these problems requires a multi-faceted approach

| Factor | Approach |
|---|---|
| Infrastructure | Component-based ground processing architectures |
| Algorithms | Multi-mission approach to algorithm design |
| Process | An integrated science & operations algorithm paradigm: development, transition, maintenance |

# Demonstration: Cloud Algorithms for GEO and HEO Missions

- Algorithms originally developed for a geosynchronous (GEO) satellites with multi-spectral sensors
- Modified to create a generic multi mission algorithm version that simultaneously works with both HEO* and GEO systems

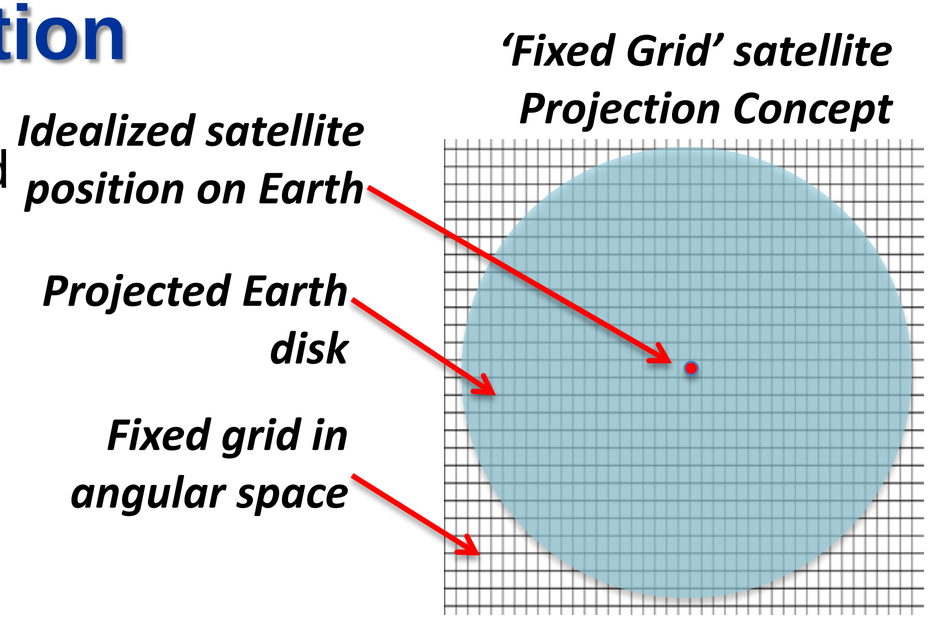
***Order of processing*** ↓

| Algorithm | Output products |
|---|---|
| Cloud mask | Cloud/ no cloud + additional cloud detection parameters |
| Cloud phase | Cloud ice/ water/ mixed state |
| Cloud top properties | Cloud top temperature<br>Cloud top pressure<br>Cloud top height |

**** Highly Elliptical Orbit (HEO) in a high inclination orbit for quasi-persistent observations of high latitudes***

# Geosynchronous Algorithms and the 'Fixed Grid' Satellite Projection

- Geosynchronous Level 1b data typical provided in a "fixed grid" – a fixed angular projection of the earth disk
- Next generation systems (e.g., GOES-R, Himawari) will provide data on this fixed grid by spatial resampling of the imaged data in the ground processing system




- Fixed grid approach offers many advantages
  - Spatial scale of each pixel on the grid is matched to the corresponding instrument resolution at that point
  - Time differencing algorithms are very simple to implement
- Assumption of a fixed grid is embedded in many geosynchronous algorithms

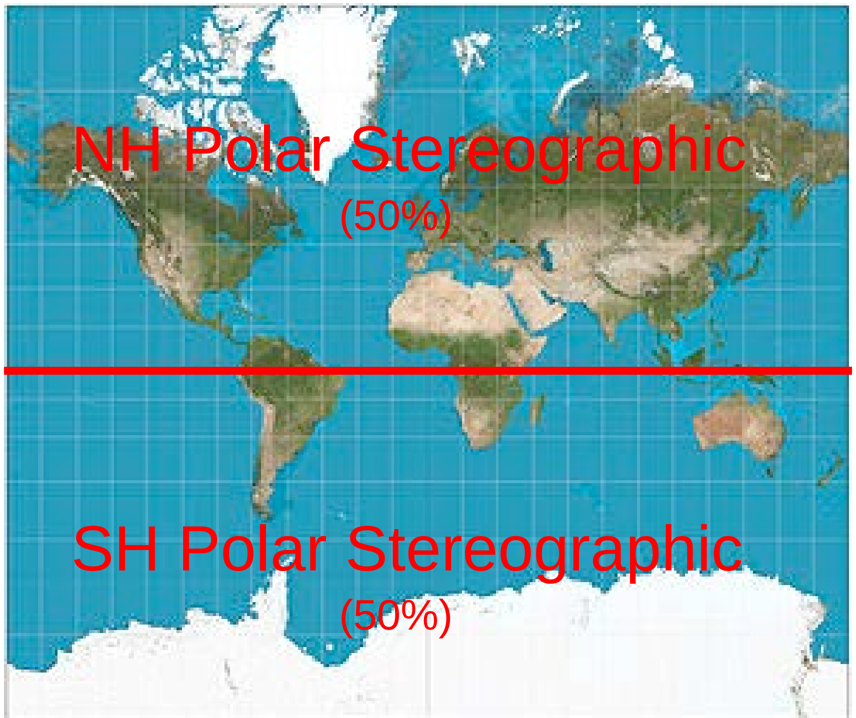
# HEO Remote Sensing Missions

- Three types of orbits have been proposed for high latitude monitoring missions
- All provide quasi-persistent observations of the high latitudes with a maximum altitude somewhat greater than that of a geosynchronous satellite
- Beneficial to employ a standard map projection as for GEOs
- Differences from GEO
  - Sub-satellite point not fixed
  - Instrument spatial resolution at any given point varies with time based on orbit position

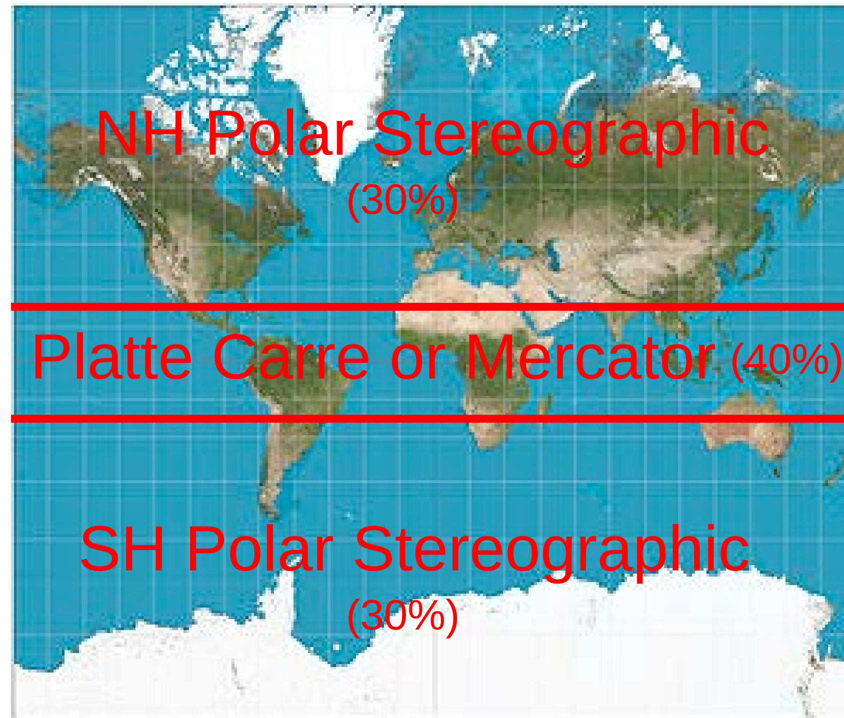
| Orbit Type | Period (hrs) | Typical Apogee (km) | Typical eccentricity |
|---|---|---|---|
| Molniya | 12 | < 40,000 km | >0.7 |
| TAP | 18 | ~45,000 km | ~0.5 |
| TUNDRA | 24 | >45,000 km | <0.5 |
| Typical inclination for high latitude observation is 63° or greater | | | |

# Example HEO Grid Alternatives

Option A – Polar Stereo




Option B – Polar Stereo plus Mercator or Platte Carre




Values in parenthesis are the % Earth's area covered (this view distorts apparent sizes of polar regions)
NH – Northern Hemispheric, SH – Southern Hemispheric

# HEO Orbit and the Polar Stereographic Projection

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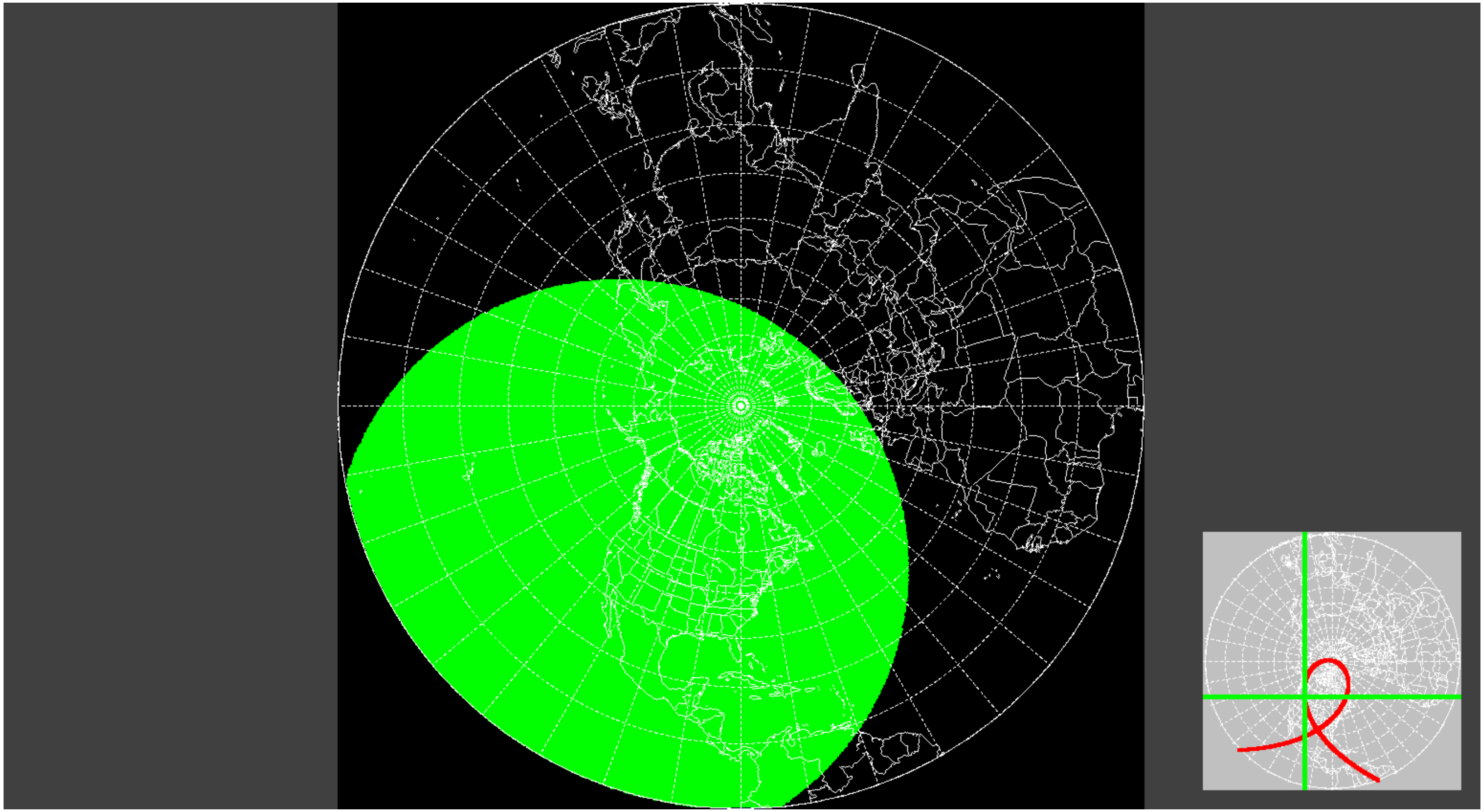
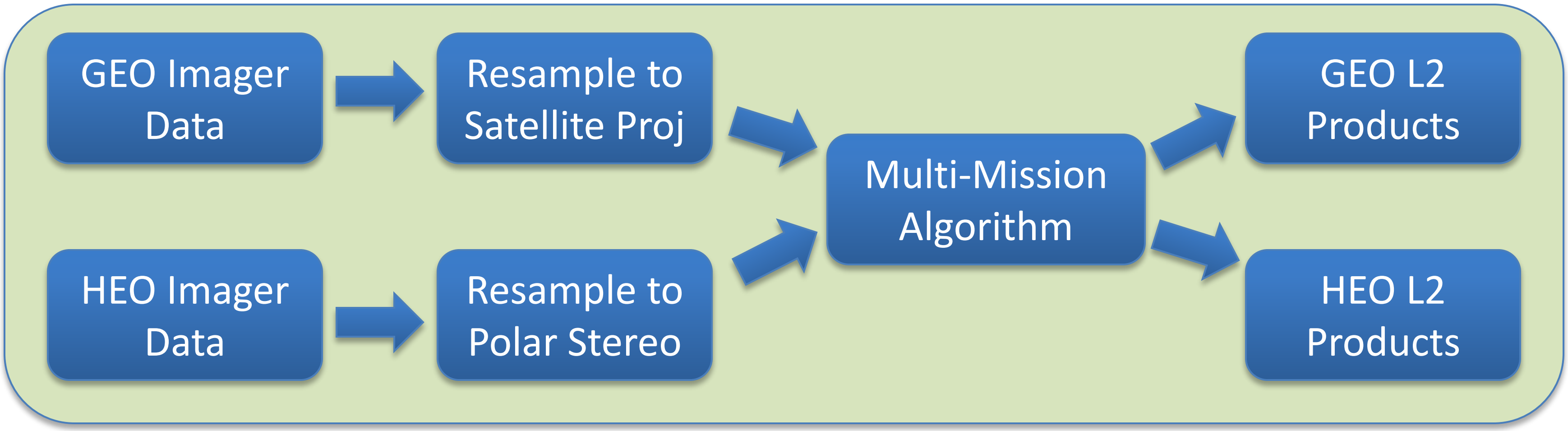


# Adapting the GEO Cloud Algorithm for Multi-Mission



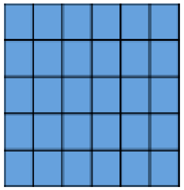

- Key algorithm features for multi-mission applications
  - Block oriented processing mode
  - Dynamically adapts to different map/ image projections
  - Channel changes via LUTs and adaptive logic for spectral tests
  - Optimized for sparsely populated grids
  - Configurable algorithms

# Spatial Processing – Uniformity Tests

- The GEO cloud algorithms include a number of spatial processing tests and metrics – these initially assumed use of a GEO fixed grid where the instrument resolution is matched to the map grid scale at every point: $R_{inst} \sim R_{map}$
- For HEO the ratio $R_{inst} / R_{map}$ varies significantly point to point and image to image – also differs in the x and y axes
  - Map projection/ scale is design so that for areas of interest the $R_{inst} \geq R_{map}$ , i.e., that data are critically sampled or oversampled at all points
- Changes required
  - Compute oversampling at each point
  - Adjust spatial tests to account for oversampling

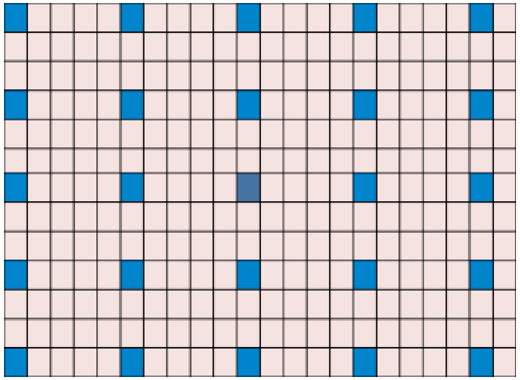
***5x5 spatial uniformity test applied to all adjacent pixels***

***GEO***



***5x5 spatial uniformity test applied to sparse points based on*** $R_{inst} / R_{map}$

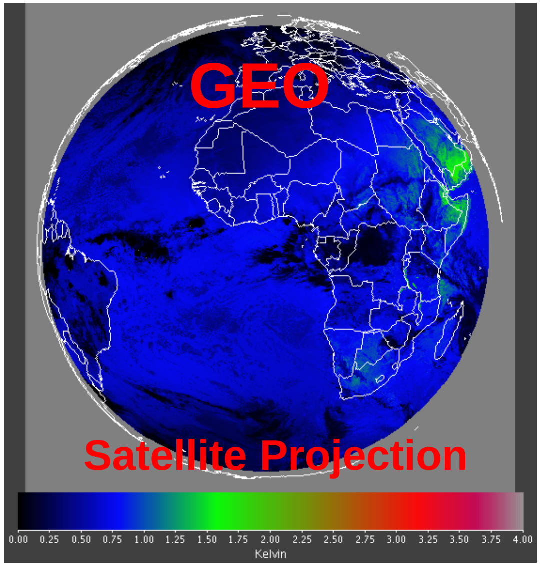
***HEO***

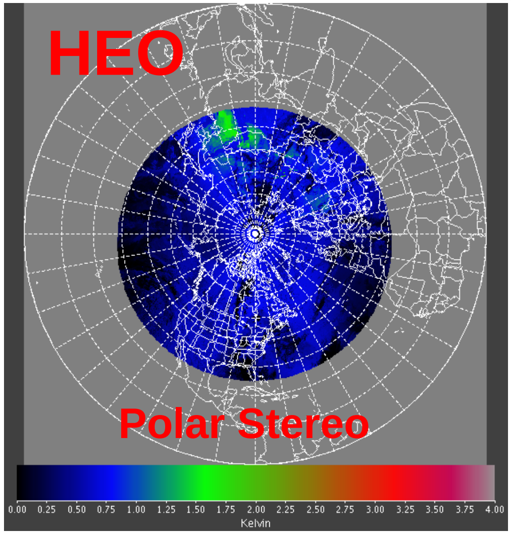


***Spatial uniformity applied to every 5th point in x and 3rd point in y***

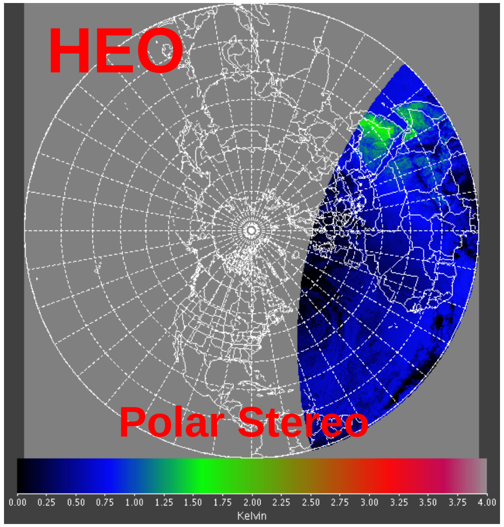
# Multi-Mission Algorithm – Proxy L1b Data

**SEVIRI 3.9 µm Channel**



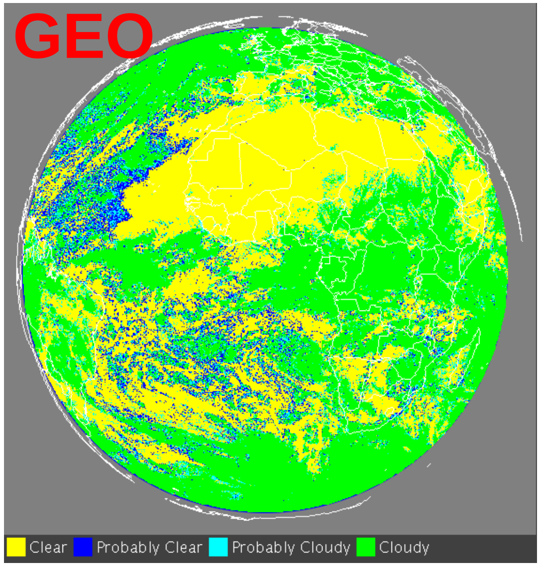

- Rotated and resampled to Polar Stereo projection

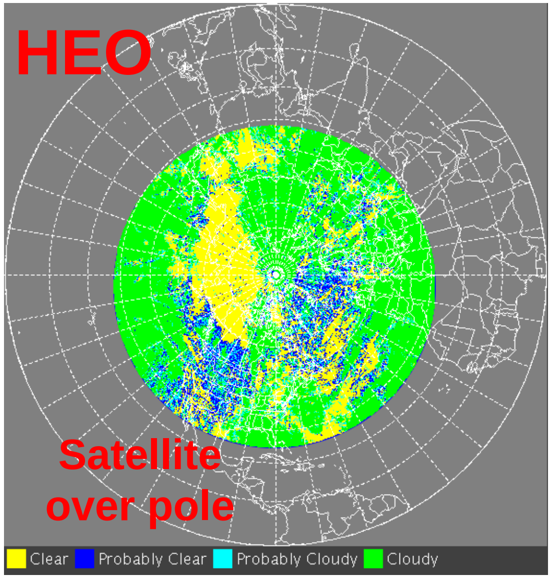


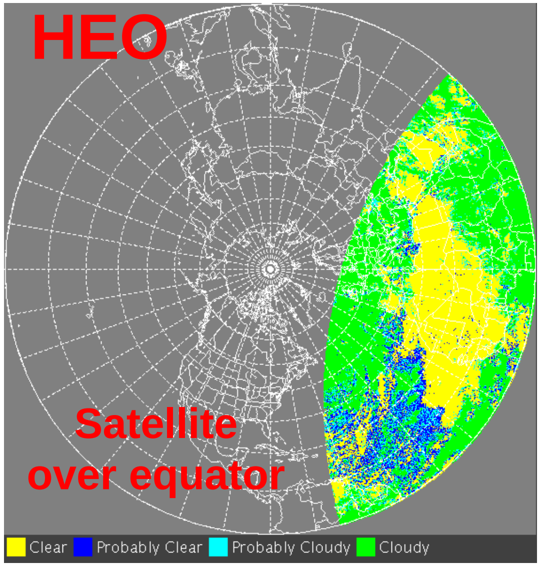

- Resampled to Polar Stereo projection

# Cloud Mask

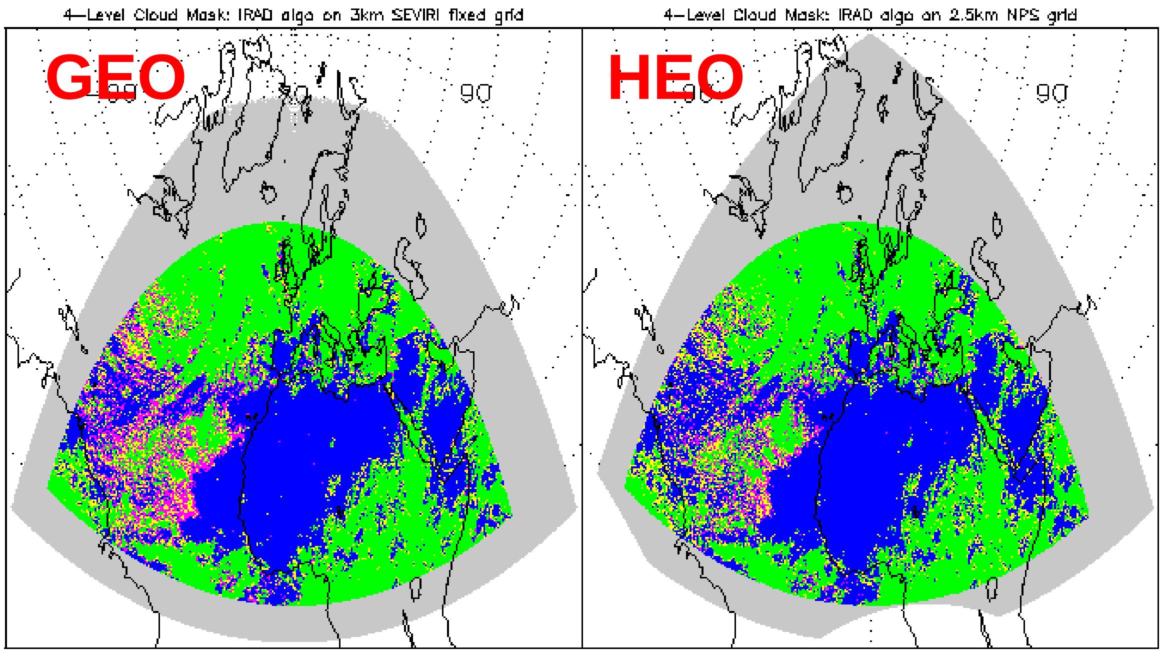
- Multi-mission algorithm used to produce cloud mask from SEVIRI proxy data
- HEO data projected over equator and pole



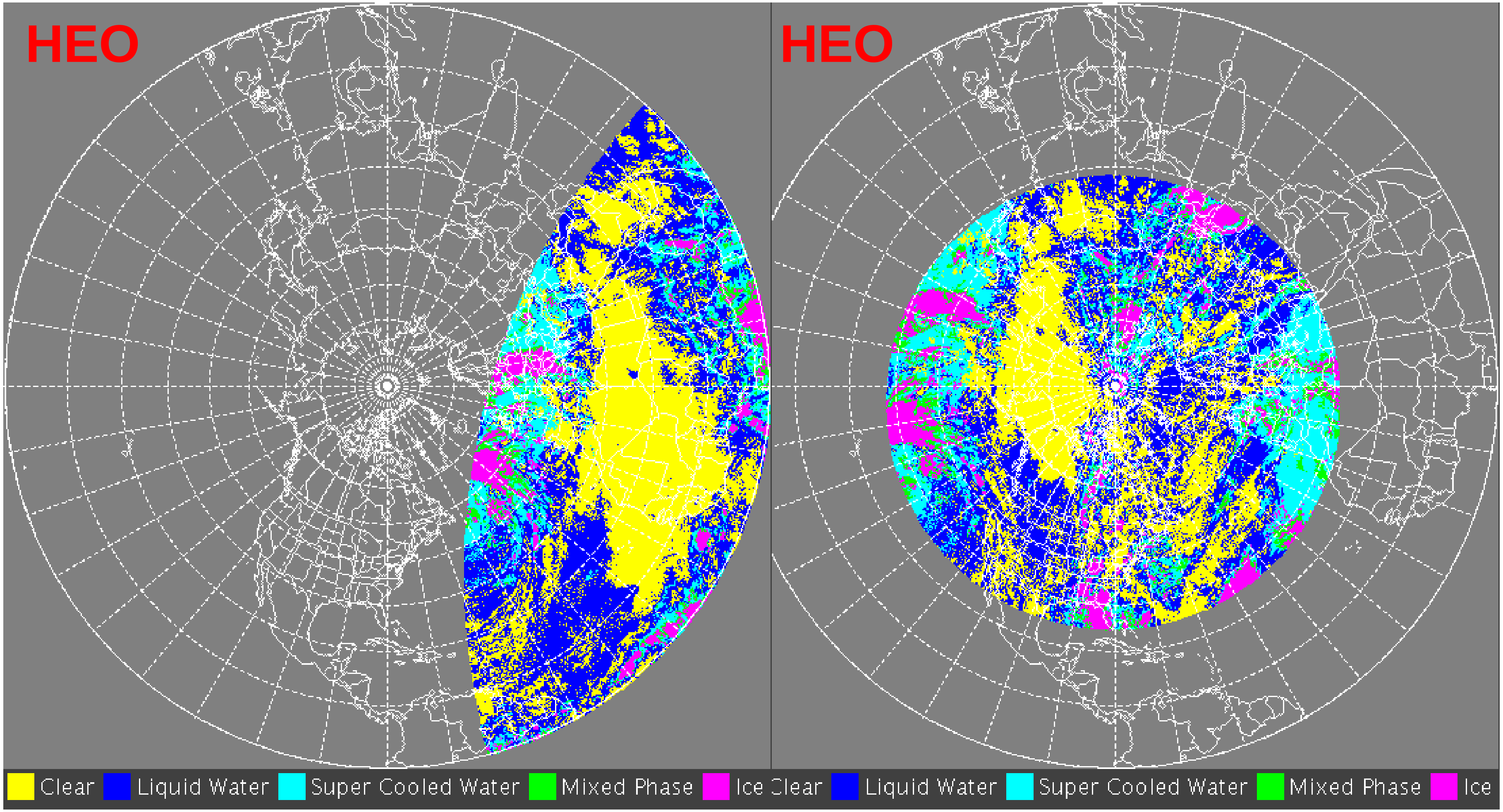
# Cloud Mask Validation



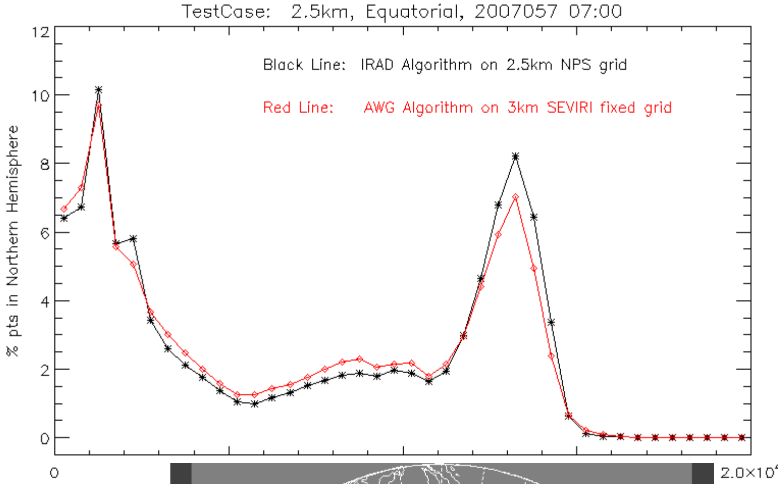

| Category | % by Category | |
|---|---|---|
| | GEO | HEO |
| Clear | 45.9 | 45.2 |
| Partly clear/ cloudy | 14.5 | 14.3 |
| Cloudy | 39.6 | 40.5 |

- Compare GEO cloud mask (remapped to PS) with HEO data (already generated in PS)
- Compare frequency statistics
- Good match

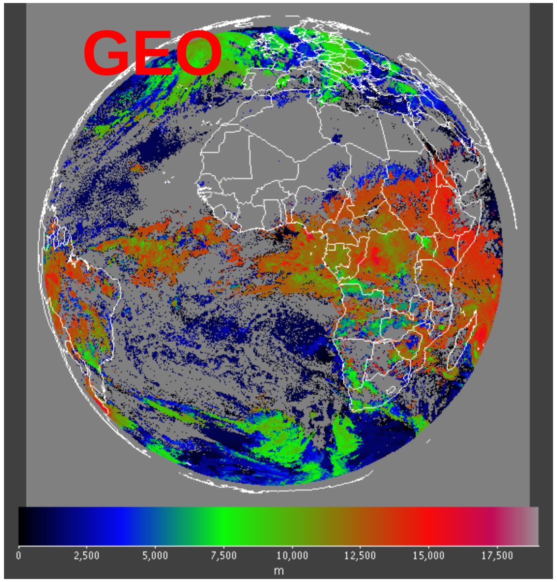
# Cloud Phase – HEO

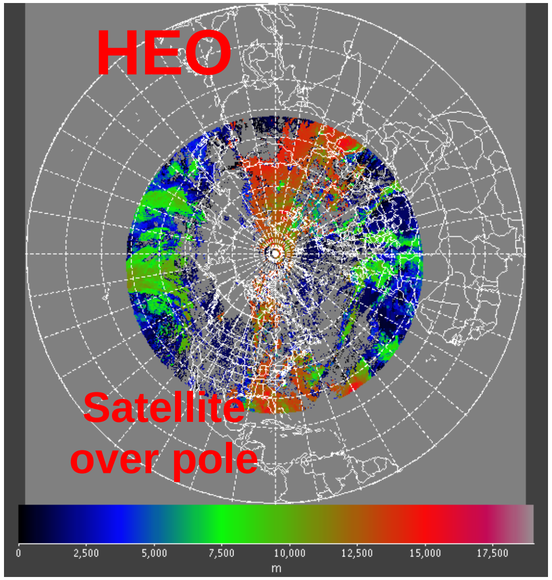


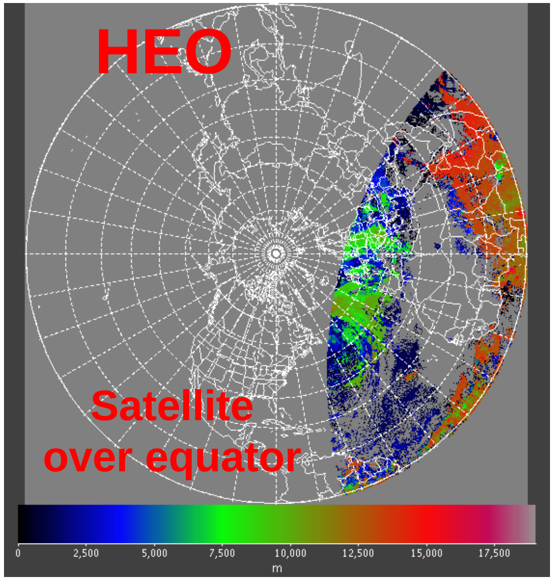
# Cloud Top Height – Multi-mission Algorithm for GEO and HEO Tests




Algorithm verified via comparison of GEO and HEO (remapped)

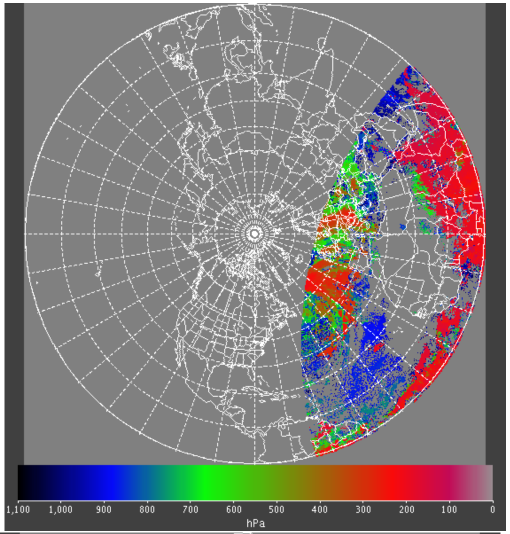


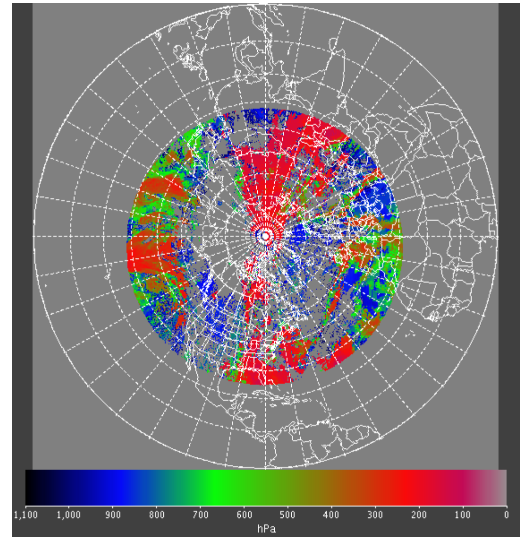



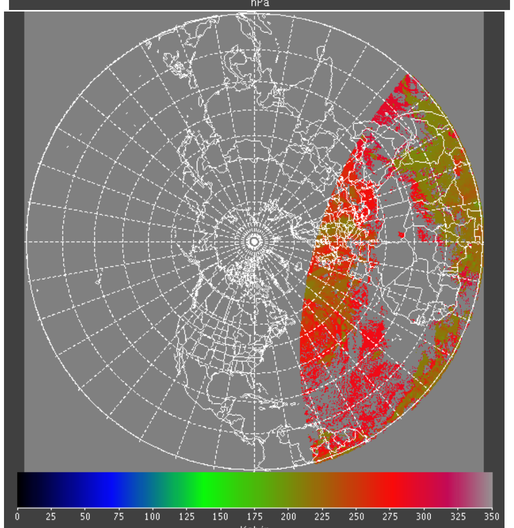
# Cloud Top Temperature (CTT) and Pressure (CTP) – HEO

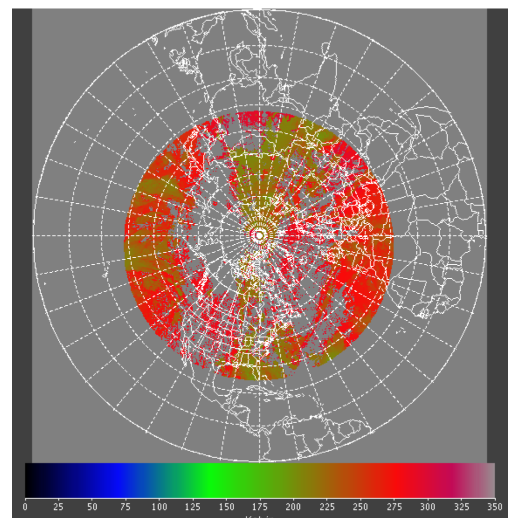
**CTP**




**CTT**



# Summary and Conclusion

- Demonstrated multi-mission cloud algorithms that are interoperable with both GEO and HEO data
- Initial testing with SEVIRI data to establish functional behavior of algorithms
- Multi-mission design approach facilitates continuing evolution and maintenance
- On-going developments
  - Test with MODIS mosaics to explore both functional and scientific algorithm behavior with polar backgrounds
  - Extend to GEO-HEO-LEO interoperability

- Acknowledgements
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