Multi-Mission Remote Sensing Ground Processing Algorithms

David Hogan, Alex Werbos, Jordan Bentley, Edward Kennelly, Pam Puhl-Quinn, Greg Tully, Erik Steinfelt, T. Scott Zaccheo

Atmospheric and Environmental Research, Inc.

William Davis

Harris Corporation, Government Information Systems Division

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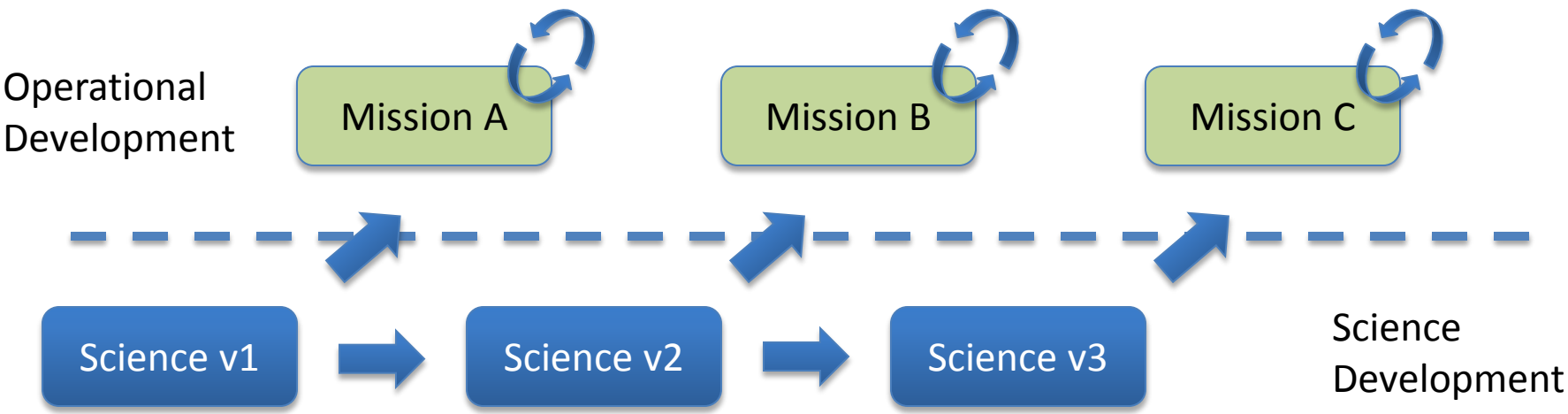
Introduction and Motivation

- 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

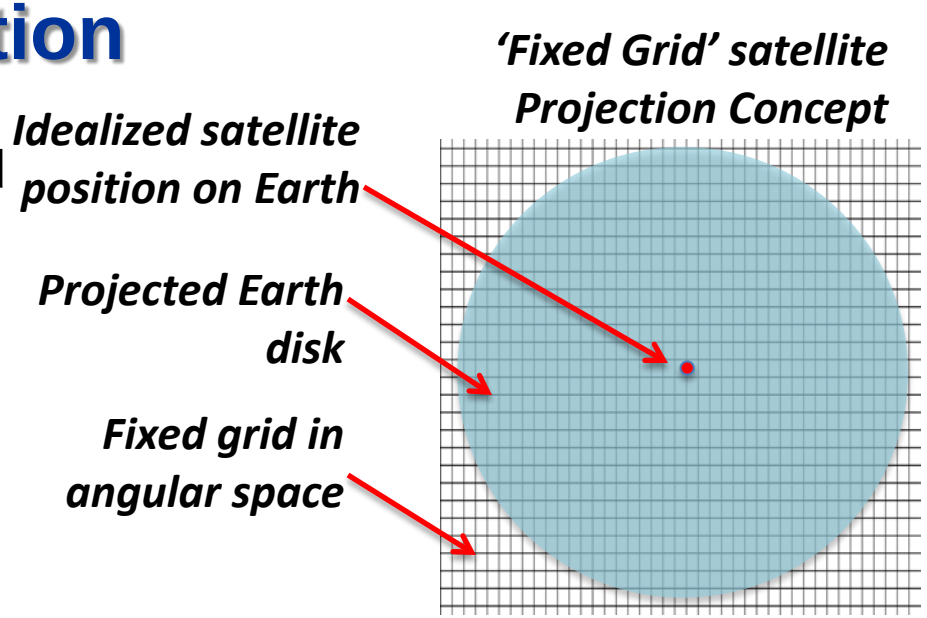
Order of processing

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 Cloud top pressure 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

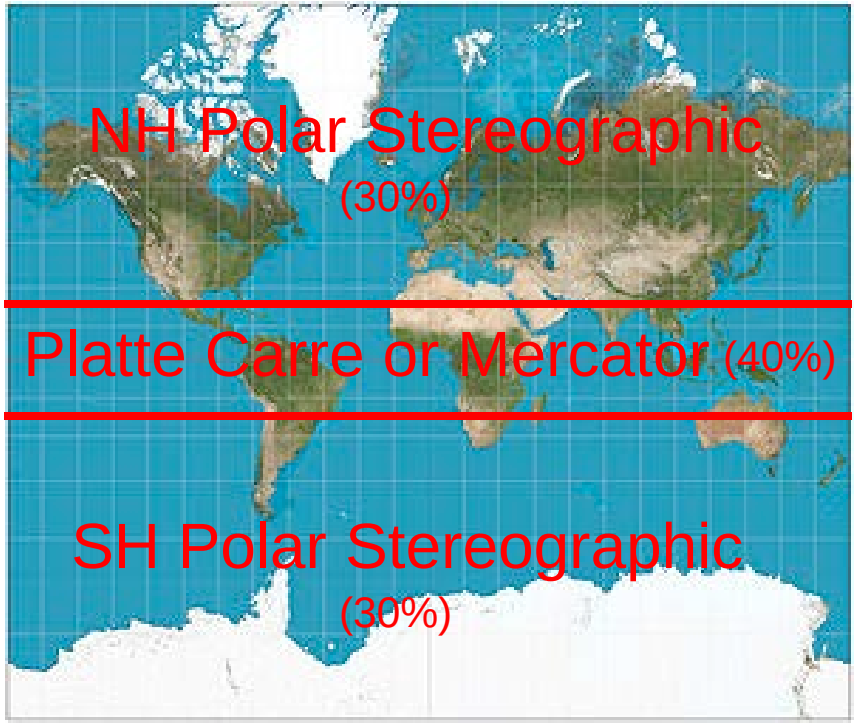
- Three types of orbits have been proposed for high latitude monitoring missions
- All provide quasi-persistent observations of the high latitudes with a maximum altitude somewhat greater than that of a geosynchronous satellite
- Beneficial to employ a standard map projection as for GEOs
- Differences 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

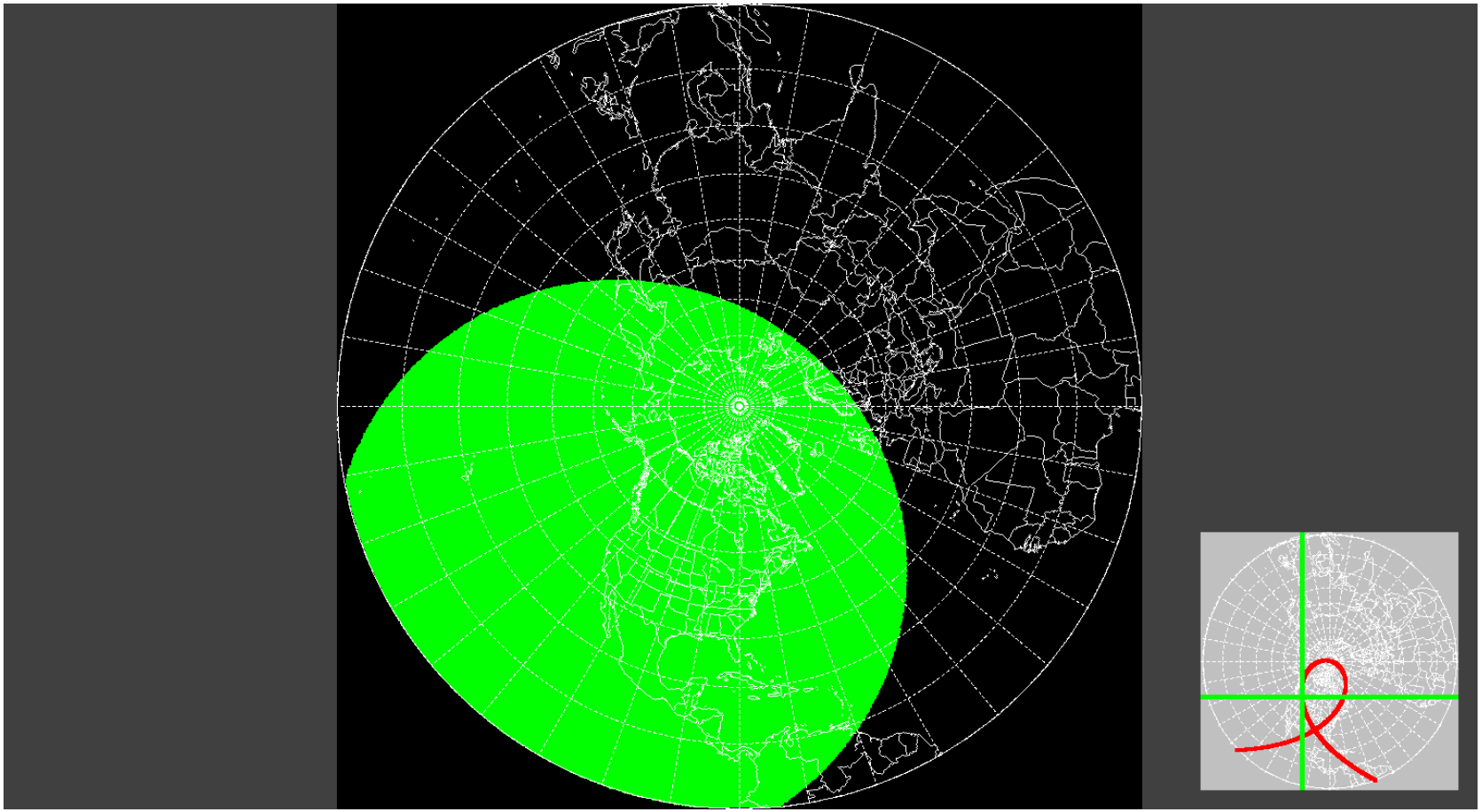
Option A – Polar Stereo

Option B – Polar Stereo plus Mercator or Platte Carre

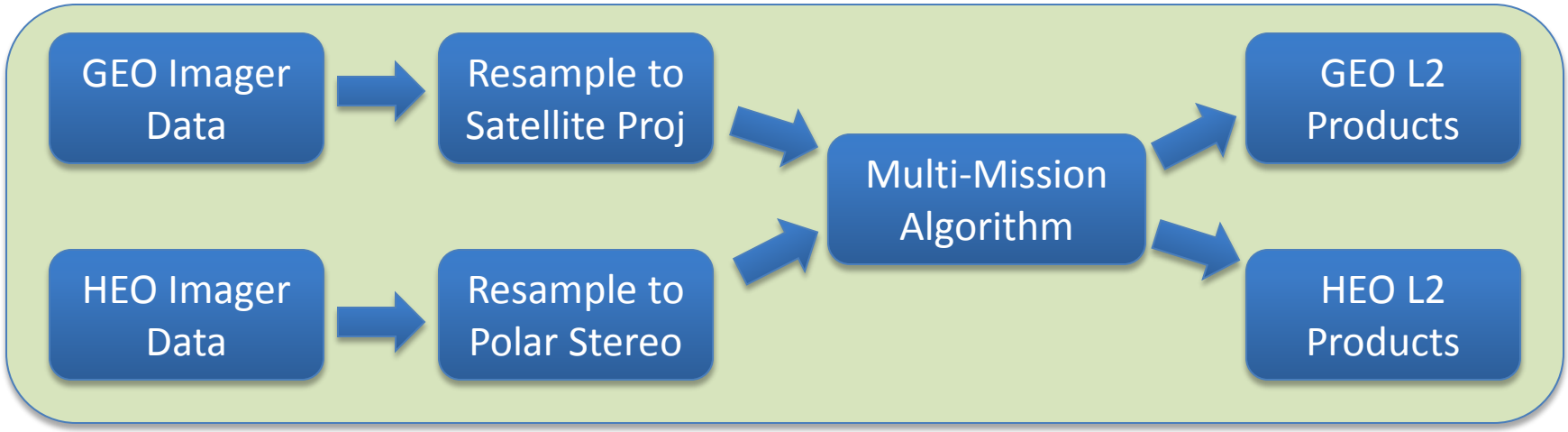


Values in parenthesis are the % Earth's area covered (this view distorts apparent sizes of polar regions)
NH – Northern Hemispheric, SH – Southern Hemispheric

HEO Orbit and the Polar Stereographic Projection

- 

Adapting the GEO Cloud Algorithm for Multi-Mission



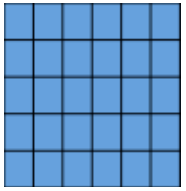
- Key algorithm features for multi-mission applications
  - Block oriented processing mode
  - Dynamically adapts to different map/ image projections
  - Channel changes via LUTs and adaptive logic for spectral tests
  - Optimized for sparsely populated grids
  - Configurable algorithms

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

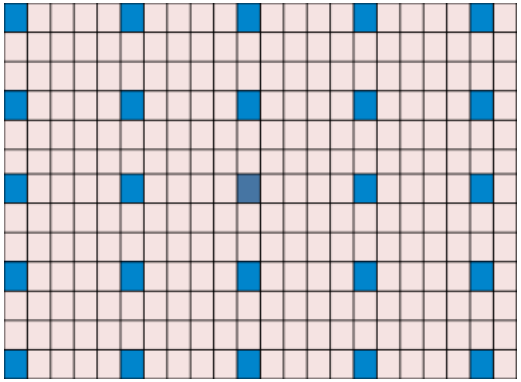
5x5 spatial uniformity test applied to all adjacent pixels

GEO



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

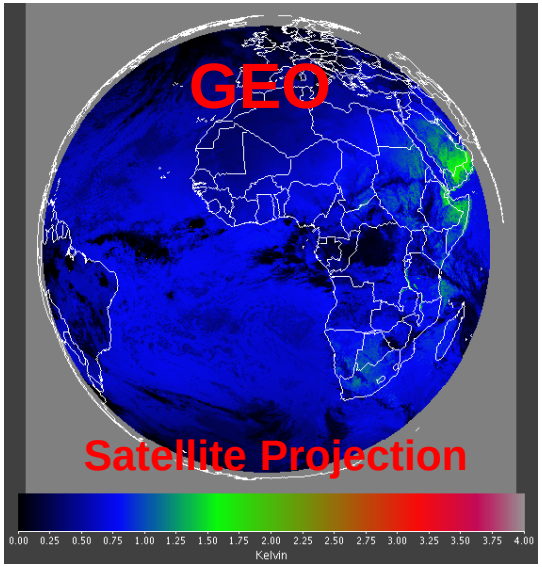
HEO

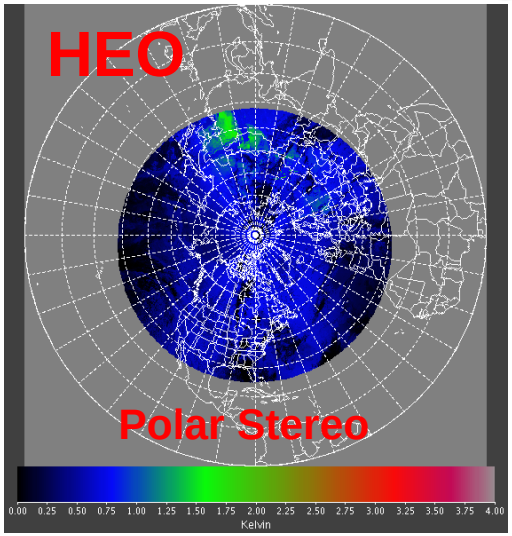


Spatial uniformity applied to every 5th point in x and 3rd point in y

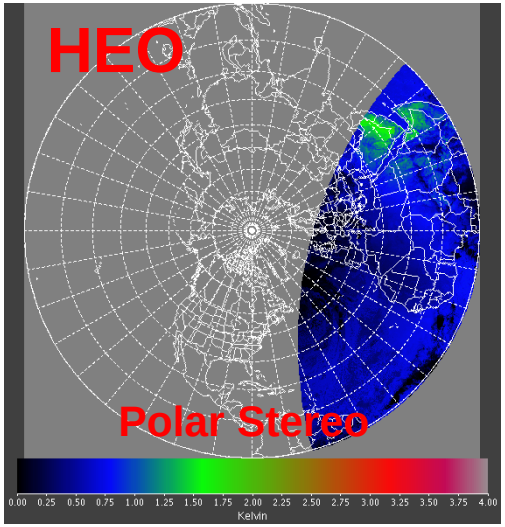
Multi-Mission Algorithm – Proxy L1b Data

SEVIRI 3.9 µm Channel





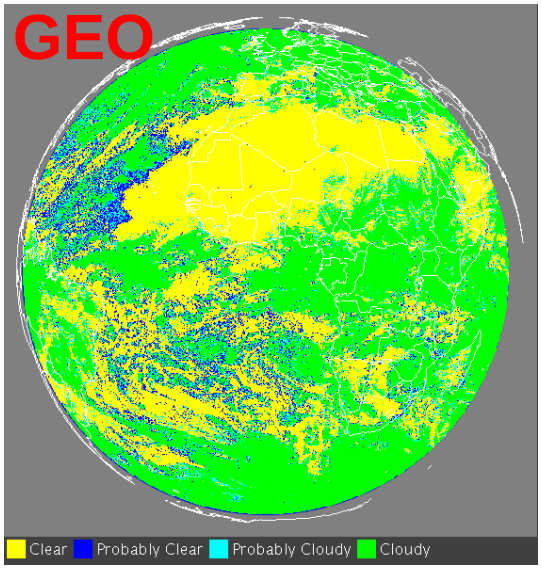
- Rotated and resampled to Polar Stereo projection

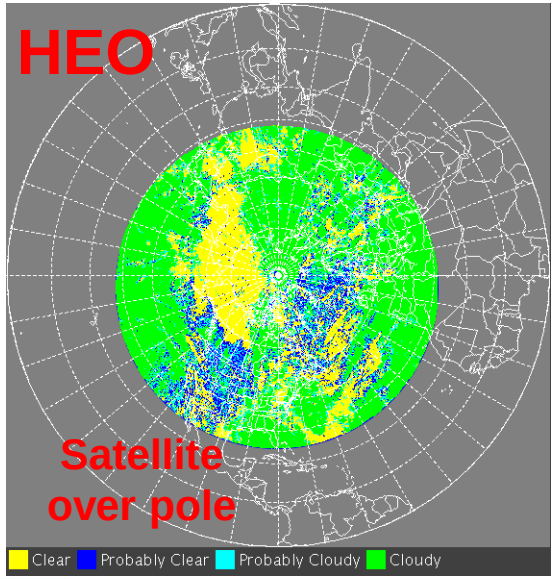


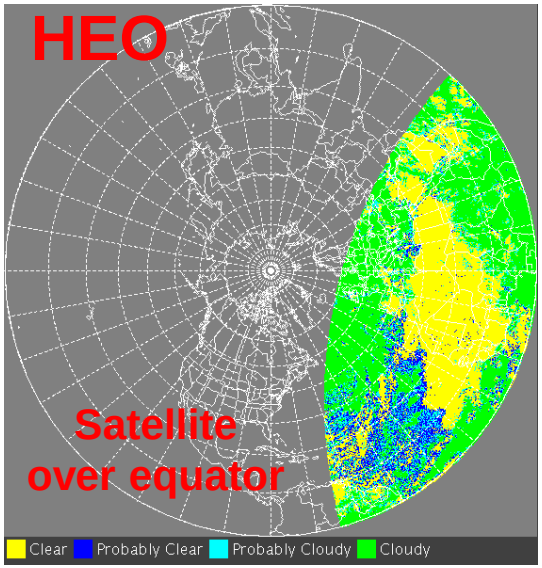
- Resampled to Polar Stereo projection

Cloud Mask

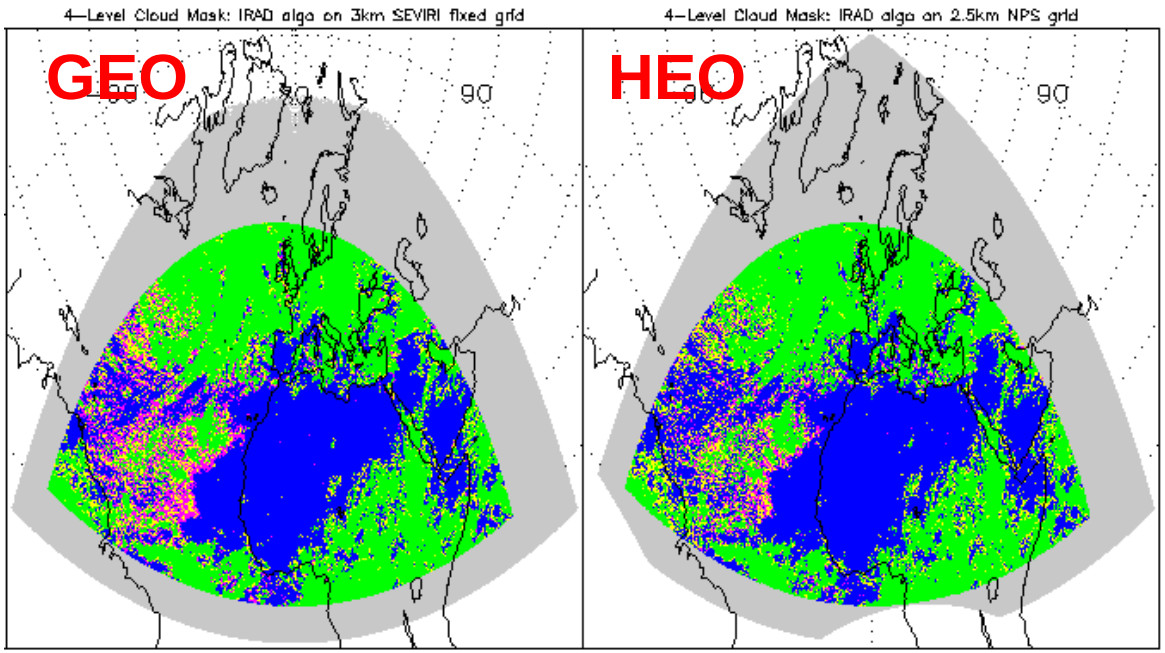
- Multi-mission algorithm used to produce cloud mask from SEVIRI proxy data
- HEO data projected over equator and pole







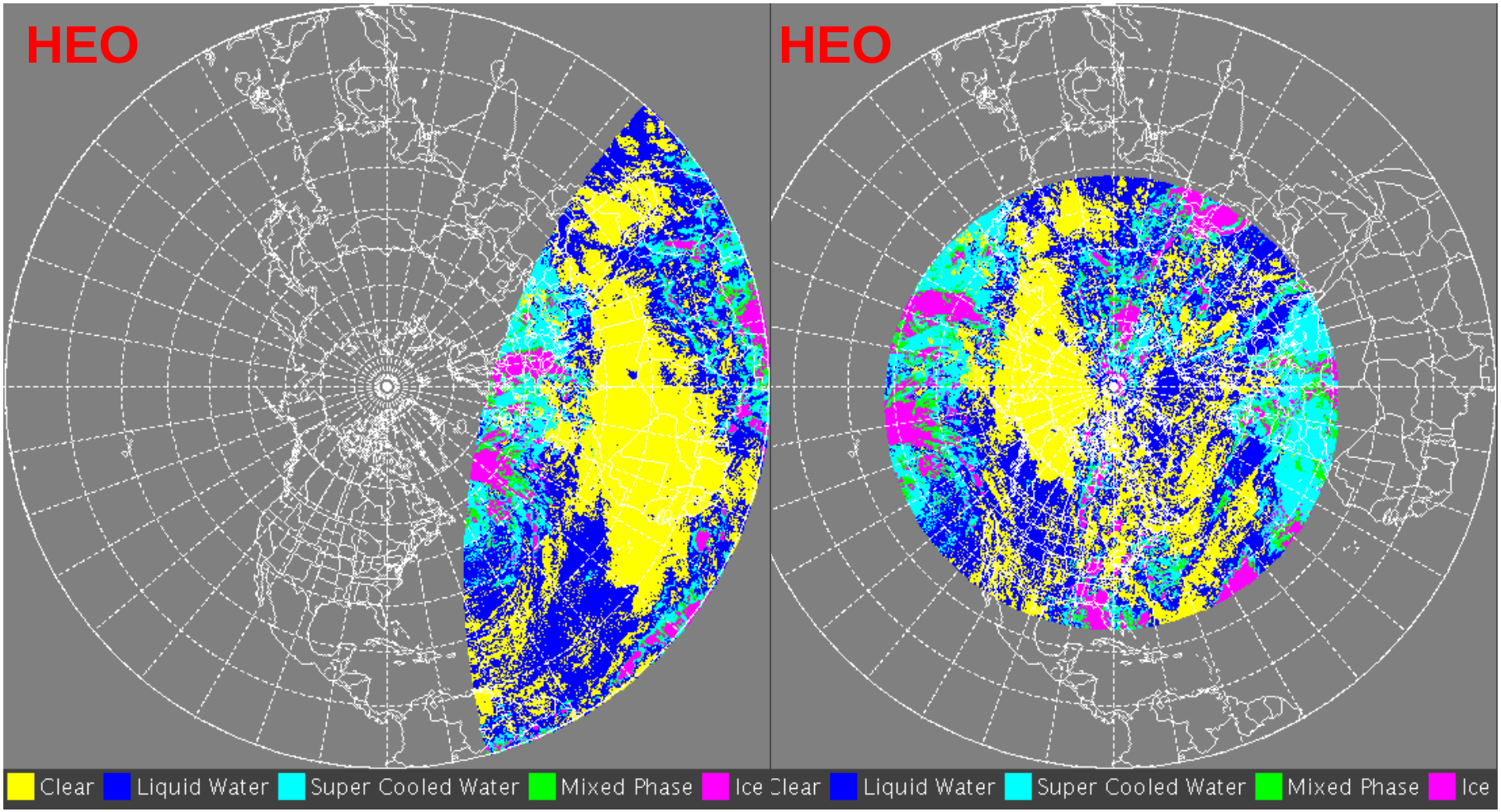
Cloud Mask Validation



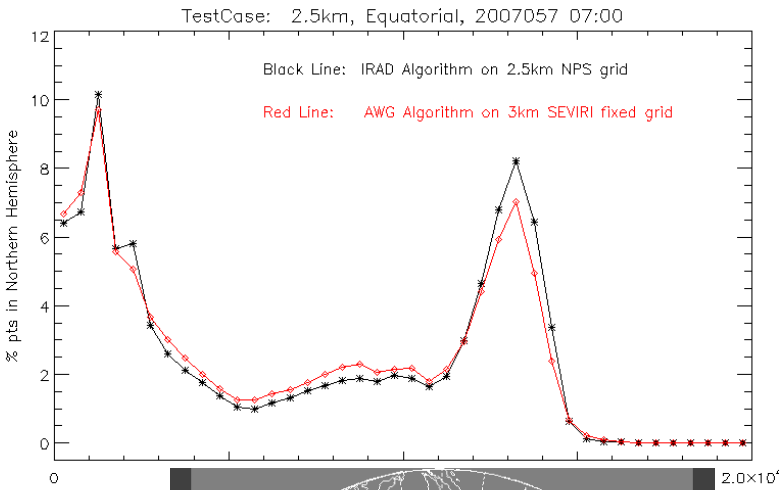
Category	% by Category	
	GEO	HEO
Clear	45.9	45.2
Partly clear/ cloudy	14.5	14.3
Cloudy	39.6	40.5

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

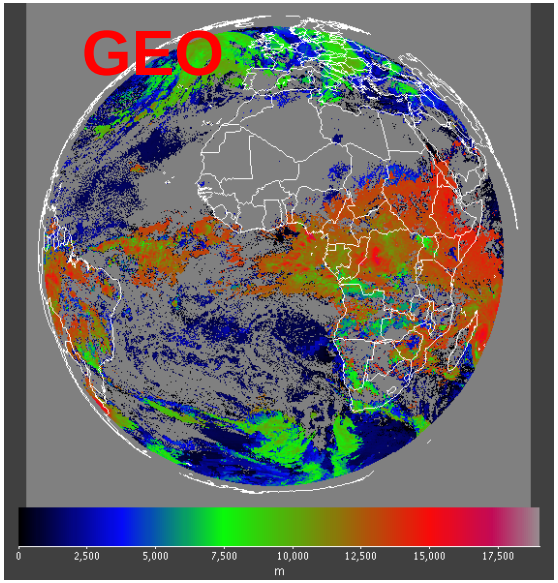
Cloud Phase – HEO

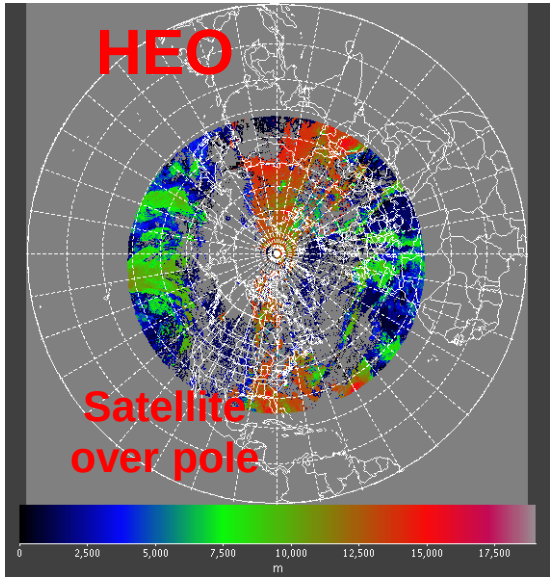


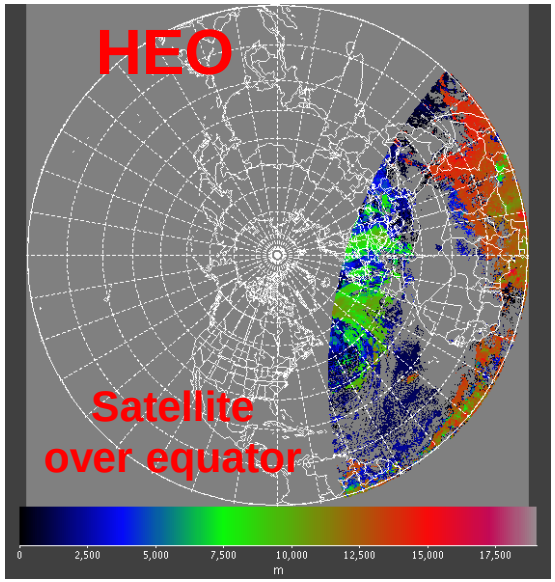
Cloud Top Height – Multi-mission Algorithm for GEO and HEO Tests



Algorithm verified via comparison of GEO and HEO (remapped)



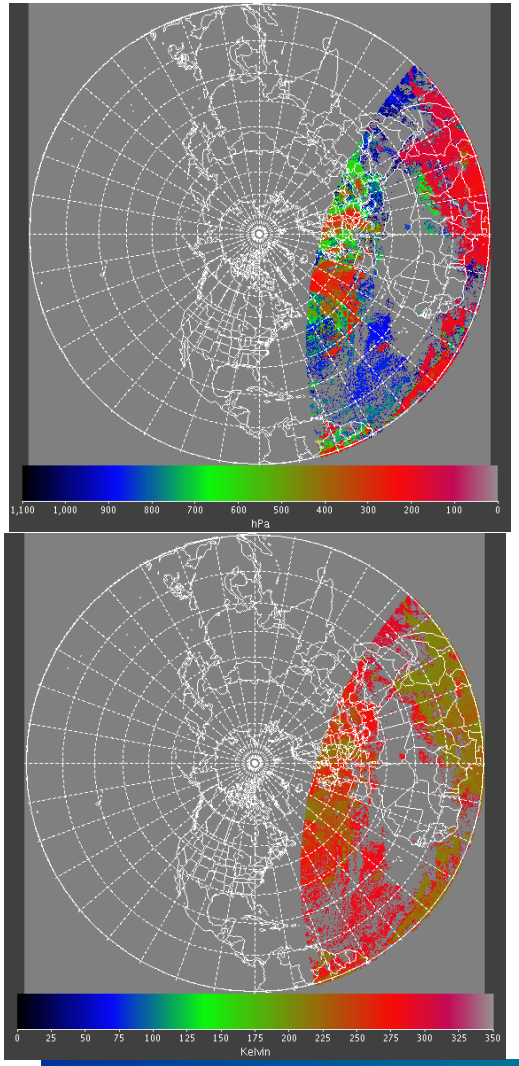


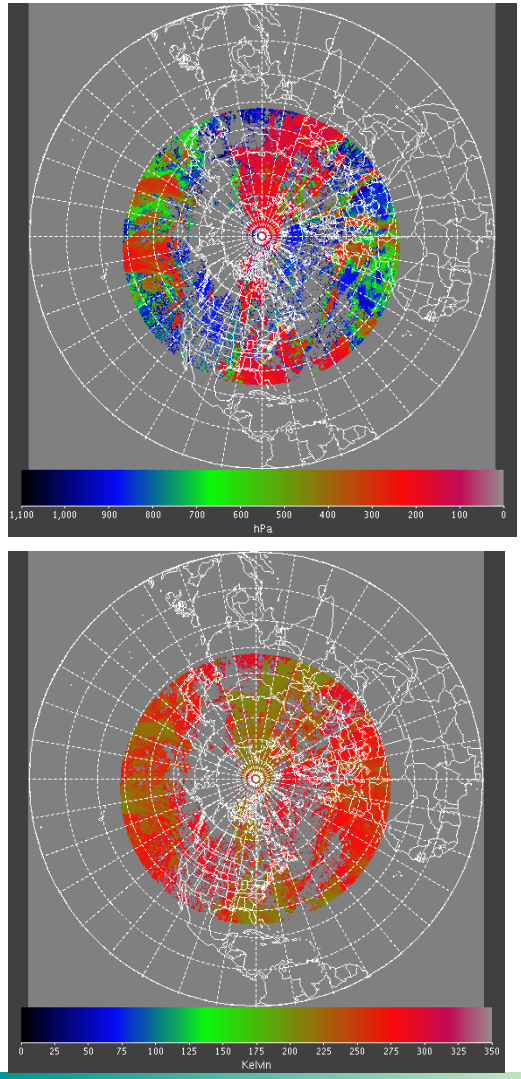


Cloud Top Temperature (CTT) and Pressure (CTP) – HEO

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
  - Harris Government Information Systems Division
  - Algorithm Working Group